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UTILISATION OF LOCAL INDUSTRIAL RESEARCH FACILITIES BY LOCAL BUSINESS COMMUNITY AND INDUSTRIAL ENTERPRISES [1]

by

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I.- INTRODUCTION

The task given to me is to write a paper on "Utilization of Local Industrial Research Facilities by Local Business Community and Industrial Enterprises" to cover an Asian country, in this case Singapore. To write on the above topic is a little dicey in such a distinguished gathering because there are several members here who know much more about this subject than I do and I hope they will bear with me if they find me confining myself too much to the Singapore experience.

II.- GENERAL

1.- Need for Industrial Research Services

For the past decade, the Asian economy has undergone a steady transformation. A sector that is continuing to change is the industrial sector, the growth of which is mainly necessitated by the need to:

- promote job opportunities for the teeming millions
- create economic growth
- save foreign exchange by import-substitution.

In the initial state of industrialisation efforts in the developing countries in Asia, whose economy is predominently based on agriculture, it was inevitable that the industrial progress so far achieved was almost completely dependent on importation of foreign technology. This dependence on foreign technology has arisen from the traditional neglect of science and technology, and this dependence will continue unless the developing countries consciously make efforts to develop their own scientific and technological capability. A prerequisite for creating a healthy and active industrial community is a planned programme of organised and disciplined industrial research efforts.

In industrial development, new materials, new processes and new components, have created many new manufacturing process and new products. This development has been made possible by the creation of new technology through research. It must be realised that the present day technological explosion is many times faster than the population explosion. It is believed that 80% of all the scientists and engineers that ever lived are still alive today. The shaping of the industrial future of a nation, to my mind, depends on how well and how much grey matters it can mobilise when the need arises.

There is no standard pattern for the gathering of this brain power. The type of research and technological organisation to be established must be designed to meet the conditions and needs of the country concerned.

2.- The Role of Industrial Research Institutes in Industrial Development

In most of the developing countries, it would be fairly accurate to state that scientific edifice for supporting a rapid industrial development is weak as they are highly dependent on imported technology. A positive move to develop local technological and industrial research capability is therefore essential.

What should be the main role of industrial research organization in a developing country ?

Industrialisation can succeed only when there is a ready market for its products. In most of the developing nations the new industries that are set up initially are inevitably those of relatively low technology which are there to exploit the relatively cheap labour and usually well protected internal market. Such industries do not contribute much to the nation's economy. It is therefore the aim of all industrialising nations to sell their products and services ultimately in the competitive world market. This would require that it has the capability to introduce innovations (develop new products or less costly methods of production) based on existing or new technology. It must be able to produce products of to-morrow instead of products of yesterday. Before it can achieve such capability, a developing country must possess a certain critical number of trained scientific, technical and technological personnel who know what usable technology exists elsewhere, to understand it, to adapt and modify it to the special needs or peculiar conditions of the country, to repair and maintain the necessary equipment and eventually to operate them. In the initial stages of industrialisation, therefore, the indigenous efforts in the industrial application and research programme should be concentrated on adapting and modifying imported technology to local social, economic and technological conditions, and on solving or "debugging" the numerous little but thorny problems which are being constantly confronted by the new industrial establishments where technical facilities are lacking. The other essential technical services should include the testing of raw materials and finished products, the quality control of products, and the compliance with recognised industrial standards or industrial specifications, and provision of technical information and scientific and engineering services.

The industrial research institutes, therefore, should be a channel where industries could go for technical advice or a contact point to other sources of technical and scientific information and advice. It should be an important function of industrial research institutes to stimulate and encourage industry to be development conscious, especially the early stages of industrial development. This is by no means an easy task and results can only be accomplished when the industrial research institute has gained the confidence of the industries and the industries themselves (especially the top management) realise the importance of research to their organisations' continued existence if not its very own survival.

Industrial research in developing countries usually stretches beyond science and technology and involves many activities such as market and feasibility studies, industrial design, work studies, quality control, loan services, etc. Industries usually do not know all their own problems which have to be identified before research can be instituted. It has been our experience that only when the above activities, which may involve several government departments, are integrated or well co-ordinated, can conscious efforts be made to introduce proper research and development programmes in the new industries.

3.- Types of Industrial Research Institutes

In the more advanced countries, private industries usually set up research facilities to meet their specific interests. Giant corporations in the U.S.A., Europe and Japan set up their own research components to develop their own technology in a big way usually in their own countries. National research institutes have also been set up by Governments of a number of countries. In Australia, there is the CSIRO and in New Zealand the DSIR. These two organizations have many smaller specialised institutes which cater either for their primary or

secondary industries under their set up. In other developing countries in Asia specialised research institutes exist. Most of these deal with major raw materials produced by the country. Examples of this category or research institutes include the Rubber Research Institute of Malaysia and the Philippines Sugar Institute.

The establishment of specialised research institutes such as above are feasible only when the countries concerned have some major raw materials or some of the industries have reached a certain level of sophistication in science content and sizeable volume for export. In the newly industrialising nations where the industries are still diversified, the setting up of multi-purpose and multi-disciplinary research institutes are more appropriate. Examples of this type of research institutes include:

- the Korean Institute of Science and Technology (KIST)
- Union Industrial Research Institute of China
- the National Institute of Science and Technology (NIST) of the Philippines
- the Applied Scientific Research Corporation of Thailand
- the newly formed National Institute of Science and Industrial Research of Malaysia (NISIR)

The Singapore Institute of Standards and Industrial Research (SISIR) belongs to this category of multi-purpose institutes and it caters for a number of industries.

These multi-purpose institutes may concentrate on certain industry until it reaches a certain capability and volume resulting in the creation of a separate specialised institute.

There is, therefore, no single pattern or organisation for industrial research applicable to all countries. The type, size and scope of industrial research set-up are dependent on many contributing factors which are closely related to the stage of the economic, technical and social development and the local conditions.

4.- Financing of Industrial Research Institutes

In the developing countries, where the industries in the private sector are small business, the Government themselves play a paramount role in funding Research and Development activities. The Government policy should be that industrial research institutes primarily exist to service the industries, in particular the smaller and new industries which are lacking in expertise and equipment to solve their industrial problems.

The Government funding is, in most cases, obtained on the annual basis approved by Parliament. Besides Government subsidy, industrial research institutes recoup some of the expenditure from fees received for jobs done or contract research performed. A recovery of 30-40% of current expenditure within the first 10 years could be considered as indication of healthy growth.

Another device of obtaining funds from Government is the tax levies on the exports of certain products, the proceeds of which are utilised to run the specialised research institutes. The research units on rubber, coconut and pine-apple, for example, in many developing countries, have such sources of funds to finance their activities. This funding system has a built-in advantage that the volume of export, which is invariably influenced by the resourcefulness and preference of the research institute, will determine the amount of funds available.

In the Philippines a science stamp tax is levied on privately-owned passenger automobiles. This special Science Fund is administered by the National Science Development Board, and the National Institute of Science and Technology is partly financed by this fund.

Government funding is based on annual Parliamentary appropriations. Increases in funds usually depend on the priority the Government places on science and technology as a tool for economic development and more important on the ability of the research institution to prove its worth to the nation's leaders. Government funding has a lot of restrictions because of the need for accountability of public funds, but it does provide in most cases a stable basis for management to plan its programmes. When funding is based on special taxes difficulties may arise when there are cyclical fluctuations.

III.- INDUSTRIAL ENTERPRISES IN SINGAPORE

1.- Historical Development of Local Industries

Planned industrialisation in Singapore began only in 1961. Prior to this, Singapore, a small country with marginal natural resources, depended mainly on its traditional entrepot trade. Industrialisation was embarked upon for three main reasons - to provide employment opportunities, to create economic growth and to earn/save foreign exchange. The detailed planning and implementation of the industrial programme were entrusted to the Economic Development Board which came into full operation in 1961.

In the early stages of the industrialisation programme, efforts were mainly devoted to the development of the various essential facilities, including physical planning and building up of infrastructure. Fiscal policy as a whole was directed towards the creation of a highly attractive investment climate for manufacturing industries in Singapore. A series of concrete measures continued to be taken to improve the incentives of investment.

A statistical summary of the progress of manufacturing establishments from 1959-1969 is at Appendix A.

The manufacturing sector, as seen from the summary, has grown rapidly during 1959-1969 whether measured in terms of output, employment or exports. In 1969, the manufacturing sector (excluding the rubber processing industry) accounted for 17% of the G.D.P. as compared with only 9% in 1960.

2.- Sectors of Industry - Importance and Size

Within the manufacturing sector, different industries perform differently. Growing diversification in range and scope continues to be a recurrent feature in the major industrial groups. The measure of importance of each industrial group is found in Appendix B. The statistics given in Appendix B cover up to 1969. The last one and a half year has seen even more rapid expansion of the industrial sector particularly in the precision engineering and metal fields.

a) Shipbuilding and Repairing

Ship repairing continued to grow rapidly and vigorously, with turnover increasing at more than 30% in the last few years to reach the 1969 figure of some $ 120 million. The sector now employs some 14,500 workers. While a versatile range of services, including floating repairs and voyage repairs is available to international shipping, there still exists scope for further development.

In shipbuilding new opportunities are evident. There has been incessant activity in the construction of small tugs, barges, and pleasure craft. A firm foothold is established in the construction of more complex vessels and structures for offshore activities, such as rigs and supply boats, travellers and larger patrol boats.

b) Electronics

In little more than three years, the electronics industry had already made a flying start in Singapore. Since the end of 1968, about a dozen local and foreign firms have commenced production of various types of component such as transistors, diodes, integrated circuits, capacitors, resistors, rotary and magnetic components, as well as transistor radio sets. Currently, and as a modest beginning, some 10,000 workers are involved. As the range and variety of components and supporting services increase, this will lead to further integration and paralleled development into electronic equipment systems, such as communications equipment, industrial instrumentation, calculators, computer terminal and peripheral equipment, and medical instrumentation.

c) Petroleum

This sector also shows high growth. Singapore is currently the largest petroleum refining, blending and distribution centre in South-East Asia, capable of a combined capacity in excess of 180,000 barrels per day valued at S$ 564 million in 1969. With another refinery ready in 1970 and the fifth one in the stage of advanced planning, the refining capacity is expected to grow to some 500,000 barrels per day within the next two or three years. Product range would be diversified to include base lubricants and solvents; and further diversification in downstream petrochemical products was under study, especially in view of the relatively low cost of naphta available.

Even further downstream, but leaving an interesting gap, developments include projects in the pipeline for the manufacture of PVC (from monomer), polyester, nylon and other synthetic resins for the adhesives and paints industries. There should be good linkage possibilities. In plastics fabrication there has been renewed activity to meet changing needs. Projects are in hands for some large scale plants for packaging material such as woven sacks and shrink film. In the plastics moulding field, there will be expansion in fibreglass mouldings for boats, furniture and other industrial applications; industrial mouldings required by the expanding electronic equipment industry and other applications. The new electronics industry also led to growth in industrial gases.

d) Metals and Engineering

The base metals, metal fabrication and general engineering industries (exoluding shipbuilding) currently have an output of some S$ 260 million a year, and employ 11,000 workers.

Intense activity in the building industry during 1969 placed severe strains on the supply of steel. Plans were therefore in hand for immediate expansion of capacity, it being obvious that further expansion to meet growing requirements would be inevitable probably involving a fully integrated steel mill. Advanced plans were under intensive study.

Further development is also foreseen and required for modern production ferrous and non-ferrous foundries, forging operations, die casting, and a diverse range of metal fabrication. This will tally with good prospects for an expansion in the general machinery and machine tool industries, construction and material handling equipment, engines, other automotive products, and for the provision

of intermediate materials and components for a wide range of engineering industries. This sector is accorded high priority, being basic to industrial development as a whole, and to the acquisition of versatile technical skills.

An intensified effort is also directed at the development of precision engineering operations, especially the making of tools, dies, jigs and fixtures, gauges and measuring instruments. For this reason, the scope of the Engineering Industries Development Agency has been expanded to provide not only training and supporting services, but also basic requirements in metrology, metallurgy and consultancy services.

e) Food Industry

The food industry has grown significantly, with a total output of about S$ 460 million in 1969, as compared with only S$ 103 million a decade ago. Currently employing some 10,000 workers, the industry's 240-odd establishments turn out a wide range of food products such as canned meat, fish and other sea foods; processed poultry; canned food, food preserves and vegetables; dairy products; refined sugar; chocolates and sugar confectionery; beverages; cereals; and other food preparations. Already firmly established in the local market, the food industry is poised for an inroad into markets in the developed countries. Locally canned oriental delicacies are fast gaining popularity in markets as far away as Europe and America.

A number of large-scale projects in deep-sea fisheries, and related processing and canning operations, are in the pipeline. This will not only reduce Singapore's import of fish products but will also earn foreign exchange through exports of canned and deep-frozen sea foods.

There exists buoyant prospects for the manufacture of instant and packaged foods, high-quality cereal products and sugar confectionery, protein products, and certain exotic food preparations for world markets. Future development in the food industry is expected to be in these specific areas with the emphasis on quality and good value.

3.- Companies linked to Foreign Concerns

The favourable climate of Singapore as manufacturing and distribution centre for international investment continues to attract both the foreign and domestic investors and business.

Priority is given to those categories of industrial activities that could provide positive contribution to personnel development and good potential for technological advancement. Recent investments include such companies like Philips of Holland and Plessey of United Kingdom, and Rollei of Germany.

The foreign participation of the pioneer and non-pioneer establishments at 31 December 1969 is given in Appendix C. These foreign concerns bring with them a variety of technology ranging from simple process of manufacture to relatively higher level of technology. Attracting the right type of foreign concerns into a country is one of the fastest way of upgrading technology in most developing countries.

IV.- SCOPE OF SERVICES OF INDUSTRIAL AND OTHER SCIENTIFIC INSTITUTES IN SINGAPORE

In Singapore, the need for Government support in providing industries with a wide range of technical and scientific services as an essential part of the infrastructure was recognised on the onset when the Government embarked upon its industrial development programme. As a result, when in August 1961 the Economic Development Board (EDB) was established to implement the Government's industrial programme, a major division was set up within the Board to co-ordinate and to provide industries with a convenient source of technical and scientific services. This division comprised the following units:

- Industrial Research Unit (now renamed the Singapore Institute of Standards and Industrial Research)
- Light Industries Services
- National Productivity Centre
- Engineering Industries Development Agency

The relation of these organisations to the EDB is shown in Chart I.

In developing the range of technical services, the Government has always attempted the most pragmatic approach. During the course of the formative years, it established quite flexible organisations to meet with what it thought were the most immediate requirements of the industries. There were also occasions in the past when EDB started to develop and to provide services which subsequently were handed over to the private sector for management and further development.

In addition to the technical and scientific services offered by the EDB, there are scientific research and allied activities carried out in the various specialised governmental institutes. These research activities are directed towards the interest of these particular institutions. The more established of these institutions include the Primary Production Department and the Government Chemistry Department.

The scope of the service offered by these institutions is summarised below:

1.- Singapore Institute of Standards and Industrial Research (SISIR)

In keeping with the progress and changing pattern of Singapore industries, the Industrial Research Unit which was first set up in 1963 was re-organised to form the Singapore Institute of Standards and Industrial Research in 1969. In the past years, the Industrial Research Unit provided mainly testing facilities for the local industries. In 1969 it was decided that the time had come to go to the next stage of the development which involves quality control, standardization, improvement in design of products and processes and the development of new products. The objective of the re-organisation of the Industrial Research Unit therefore is to provide these additional facilities to local industries in their expansion programme and to build up a permanent standards and industrial research organisation.

The Institute operated as an autonomous technical and consultant agency with the following objectives:

a) Help in the introduction, development and adaptation to local conditions of new processes and methods
b) Research into locally and regionally available materials with a view to discovering new applications and improving current applications.

c) Transfer of laboratory processes for industrial applications, e.g. by undertaking pilot plant operations
d) Testing of raw materials and finished products to ensure that quality is being maintained
e) Maintenance of accurate standards and award of quality certificates and certification marking
f) Servicing of a wide range of industrial and laboratory optical, mechanical, electrical and electronic instruments for the more sophisticated industries and Government departments
g) Offer advice on modernisation in food processing techniques and improvement of quality.

The Institute, through its own Standards Council, is responsible for the preparation and promulgation of Singapore standards and the promotion of their use by industry and commerce in the Republic. SISIR only provides the Chairman and the Secretariat; the members of the various Industrial and Technical committees are drawn from industries and Government departments and the consumer public.

With the growing emphasis on production for export markets, industries are encouraged to be quality conscious and to meet acceptable standards for world markets. This quality certificate scheme awarded by SISIR serves as a recognition that products conform to certain standards.

By the quiet, sustained and effective application of the expertise to the practical problems of our industry, SISIR has made a reasonable contribution to the industrial progress of Singapore. The technical services rendered to the industries increased from 147 jobs in 1963 to 6,000 jobs in 1970.

In 1963 there were only 23 staff members. Today SISIR has 196 staff members of which 57 are University graduates who are scientists, engineers or economists. In 1963 the percentage of income over expenditure was 6%; in 1970 this ratio was increased to 43%. Eighty-eight percent of SISIR's income were derived from industry, the remaining 12% were from other statutory Boards in Singapore. Singapore is one of the few countries in the region where the local industries have voluntarily accepted quality control and SISIR as their inspector without legislation by Government. This Quality Certificate Scheme was started only one and a half years ago and up to now SISIR has issued 67 Certificates and there are more applicants than SISIR can cope with.

SISIR together with the National Productivity Centre and the University of Singapore offer courses and technical consultancy services on quality control. In this way it is hoped that the technology of existing industries will be up-grated and more industries will come to appreciate the advantages of associating themselves with SISIR and what industrial research can offer them.

2.- Engineering Industries Development Agency (EIDA)

The intensified promotion of engineering development services is vital for accelerated industrial development, particularly the engineering industries. It is with the above aim that EIDA was set up in 1968 from the workshops of the Light Industries Services Unit and its main objectives are:

a) To promote and stimulate the development of more sophisticated engineering industries, particularly in metal and precision engineering, electronics, machinery and shipbuilding

b) To provide necessary supporting services, including the production of tools, dies, jigs and fixtures; metal working and finishing, including precision die-casting, foundry, heat-treatment and plating; metallurgical and metrological services
c) To undertake product research, design and development, and to build up a pool of designers for continuing technological progress
d) To provide training and upgrading facilities under actual production conditions, for skilled workers, technicians and young engineers, in the related fields
e) To support the national programme for technical education and training, including the provision of in-plant experience for teachers and instructors.

The Agency has the following six operating units:

- Metal Industries Development Centre
- Prototype Production and Training Centre
- Electro-Mechanical Training Centre
- Electro-Chemical Engineering Centre
- Precision Engineering Development Centre
- Woodworking Industries Development Centre

At present EIDA has 383 staff and has 400 trainees mostly in the metal industry workshops. This is part of the Agency's staff development programme although the Agency also provides training for industrial personnel for selected industries.

3.- Light Industries Services (LIS)

Light Industries Services, as the name suggests, was set up in 1963 to provide a programme of assisting and stimulating development in the light and small industries sector. It works closely with SISIR and EIDA. Briefly, LIS offers the following types of assistance to the industry:

a) Economic Research and Investigation:
   - carries out feasibility studies on products which might be profitably produced locally
   - supplies economic and statistical information to individual request.
b) Industrial Design:
   - designs promotional and advertising materials
   - advises on product displays and exhibitions
c) Project Development:
   - encourages new investment into small and medium scale projects
   - provides advice and assistance to industrial investors on the choice and acquisition of suitable factory site and on their applications for pioneer status or tariff protection.

4.- National Productivity Centre (NPC)

The National Productivity Centre, which was set up in 1966, functions as a technical unit of the Economic Development Board with a high degree of autonomy guided by an Advisory Council with equal representatives from Government, management and labour unions.

In the field of technical services, the contribution of the National Productivity Centre is mainly in the areas of industrial engineering, management accounting, general management and supervisory training, and workers' education.

It is hoped that in the near future the range of the NPC's technical advisory services would be extended also into the fields of electronic date processing, industrial health and safety, and industrial psychology. In each of these fields, industrial establishments can obtain the services of the NPC on a consultancy basis.

The NPC also conducts various training courses for middle-management and trade union officials in the various areas of Industrial relations and industrial engineering. These courses are usually followed up with practical case studies of the participant's own organisation.

5.- The Department of Primary Production, Ministry of National Development

This Department provides veterinary and other biological sciences services to the farmers and related industries like animal feed, pigs and poultry farming, agriculture including orchid growing and meat canning. It also has a very big fishery department which like the other divisions also provides training besides research and technical services. This department works closely with SISIR and is very active in research and development of the pig and poultry industries in Singapore as well as the tropical fish and orchid industries.

V.- UTILISATION OF INDUSTRIAL RESEARCH SERVICES

Since all industrial research organisations are set up to meet specific needs of the country at Government expense, one of the most important functions of these institutes is to serve as scientific and technical advisers to the Government. In some countries the industrial research institutes are often consulted before licenses are issued or incentives given to new industries. These institutes are often called upon by Government to advise on conflicting propositions made by local or foreign interests concerning the setting up of certain new industries.

An industrial research institute fails in its functions or intentions unless its research results and services are utilised by industry or influence Government policies. Managers of industrial research institutes must be aware and be alive to the needs of industry at all times if he is to be a good manager or director. He and his staff must pay particular attention to establishing contacts with industries in order to identify problems for research and to involve these industries, the potential users of the institutes' research results, at an early stage in the work.

It has been estimated that costs for comparable stages of scientific research, technological research and development activities are in the ratio of 1 : 3 : 20. In Singapore we have often found it necessary to scale processes up in several of the new or improved process SISIR has developed, as, for example, the manufacture of zinc oxide from zinc wastes, recovery of tin from de-tinning solutions and the fermentation of certain food products. It is the policy of SISIR not to involve itself in this expensive stage of development unless interested industrialists or entrepreneurs can be found to join in the venture and meet all, if not a large part, of the cost. In this SISIR can be considered to be quite successful.

In the development of its research capabilities, most industrial research institutes also develop its engineering and other supporting services which can be very useful to Government, local industries and even foreign concerns.

Take, for example, the field of industrial application of nuclear energy which includes non-destructive testing and use of radioisotopes to study and improve industrial processes. SISIR has developed together with some university staff a fairly strong team of workers in this field. The projects that we have done or are doing include the following:

a) for the Government:
   - hydrological survey and possible silting of the Singapore harbour by land reclamation
   - assisted in the feasibility study of sewerage disposal
   - obtained contract in open tender from the Public Utilities Board to supervise and test the manufacture and installation of several miles of steel pipes

b) for local and foreign industries:
   - the testing of welds for the ship repairing and ship building industries
   - the improvement of processes and hence the quality of asbestos sheets and cement pipes
   - the improvement of the process and quality of plywood
   - the saving of cost in the glass manufacturing industry
   - the detection of leaks and blockages in the oil refineries
   - the approval of welders for the aircraft maintenance group.

The IAEA has requested Singapore to conduct a special six-week course on non-destructive testing for 30 scientists from Asian countries in October this year. Singapore has accepted this invitation and honour to run this course and do whatever it can to promote regional co-operation especially in the field of science and technology.

Similarly the testing of building materials, including paints, have also led to the development of better types of building materials which have benefitted the building industries in Singapore. As the building industry is a very important industry in Singapore, any significant improvement made will benefit not only the private sector but also the Government.

Foreign companies also make use of the services of the local industrial research institutes. However big these foreign concerns may be they are never self-sufficient when they start operation in any foreign country. They need a large number of sub-contractors, many of these are usually small local industrialists who may not have the expertise required to produce the parts or products the foreign firms require. Sometimes the raw material parts supplied are not of consistent quality and these usually affect the quality of the final products. Furthermore, there are certain local conditions which the the foreign concern may not be familiar with and this can sometimes cause serious losses unless the causes are identified, and remedial action taken immediately. For example, certain electronic industries are very sensitive to the presence of certain gases like Hydrogen Sulphide or Sulphur dioxide in the air. These gases can tarnish silver-plated integrated circuits and cause considerable loss in material and labour to any company.

It is generally accepted that not all foreign technology can be transferred directly without any adaption to local conditions. It is in this adaption of foreign technology that most industrial research institutes of developing nations will have an important role to play.

VI.- CONTRACTING OF WORK TO LOCAL INDUSTRIAL RESEARCH INSTITUTES BY LOCAL BUSINESS COMMUNITY AND INDUSTRIES

Client-sponsored research is usually undertaken on an institutional contract basis for government or industry to assist in the solution of specific problems. Such research and investigation are usually paid for by the client under a contract with the institution. The object of the project, the scope, the cost and the time limitations must all be approved by the client before the contract is signed. These important items are usually developed in consultation with the client. This type of contract limits the independence and freedom of action of the research project leader. However, this is not serious provided he is involved in the negotiations and that he is satisfied with the conditions laid down before committing himself and for that matter the institute to responsibility for the project.

The practice of awarding contract research to industrial research institutes in most developing countries in Asia is the exception rather than the rule. This is because most of the local industries are not sufficiently sophisticated enough to appreciate or to have funds for research activities. The charges for work done is usually subject to negotiation for many of the institutes in Asia. This negotiation usually takes place after the completion of the project and is based on the results obtained. In most cases the compensation may not even cover the direct expenses incurred, not to say the other overhead expenditure. Furthermore most industrial research institutes are not sufficiently developed in terms of manpower and resources to cope with problems of the foreign companies. As a result many of these institutes do the more mundane type of work such as testing, and simple trouble-shooting for a long time.

1.- . Future Trend

There is a strong and increasing tendency on the part of Government in most of the developing countries to insist that local and foreign concerns pay more attention to the possibility of conducting R + D locally, both to lessen their dependence on foreign technology and to develop indigenous research programmes related to local industrial needs. The development of local research capabilities is one of the prerequisites for developing a sound and diversified industrial economy. It is therefore in the interest of both the Government and the industrial leaders to co-operate fully in making their industrial research institutes viable. A viable industrial research institute can offer employment to university graduates and reduce "brain-drain" which may otherwise develop. It will also serve as a training ground for further development and a supplier of highly trained professional personnel to industry. Such institutes will also serve as useful catalyst for the entire development process.

VII.- PROBLEMS HINDERING MORE EFFECTIVE UTILISATION OF INDUSTRIAL RESEARCH AND SUGGESTIONS OF POSSIBLE SOLUTIONS

General underdevelopment in science and technology has been the main obstacle and problem to the effective utilisation of the available and limited industrial research facilities in most countries in Asia. The industrial level must reach a "threshold" level of sophistication before the impact of industrial research can be fully appreciated.

Science and technology alone without the application and commercial exploitation by industry cannot create material wealth. Equally true is the fact that industry cannot continue to prosper in this competitive world without the assistance of modern science and technology; unless this is being appreciated by both the technical and management personnel, the industrial research unit will have a difficult time to develop.

The local management in Singapore have many teething problems associated with the transition from the traditional entrepot and commercial activities to the industrial activities. Industrial research services have to undertake certain non-technical activities such as market surveys, tariff problems, etc., in the earlier days. The industrial community, particularly the locally managed and smaller industries, are seeking advice and assistance in meeting the requirements of some of State ordinances.

The problem areas associated with Singapore's early efforts to promote and build up the industrial research services include:

1.- Technical Skills

The quality of the service rendered by industrial research institute is primarily dependent on the quality of its personnel, besides basic instruments and equipment. It is expected that by maintaining the present momentum of industrial growth, Singapore's manufacturing sector would need for the next five years approximately 300,000 personnel about 4000 of whom will be involved in industrial research activities. The type of scientific and technical personnel required for the technical services and industrial research must be determined according to the industrial development of the country. Sophisticated operations and services require highly skilled and competent scientific and technical personnel. In the current stage of industrialisation, most industrial research institutes are still in need of problem solvers and persons who can lead multi-disciplinary teams to tackle multi-disciplinary problems or projects.

The lack of competent and experienced scientific and technical personnel for industrial research is a universal problem in all developing countries. What are the general impediments against building up this critical pool of such personnel ? One reason is that higher remuneration and better career prospect in the private sector make industrial research a less attractive career. Another reason is that a number of such personnel who go to or are trained in advanced countries prefer to stay on, thus depleting further the limited talent available. This, to a great extent, is due to better research and instrumentation facilities and atmosphere abroad. The difficulty of finding stimulating and meaningful employment in line with the training abroad is another additional impediment.

Some of the constraints which make industrial research unattractive should be removed. New incentive and personnel policies should be adopted, promising better status and emoluments for the scientists, technologists and recognising the role of scientific research as the major instrument for national progress. In the developing countries, there is the perennial problem of "brain-drain" from the public sector to private sector. In Singapore we have taken steps to have the situation remedied. The staff has increased from 60 in 1968 to 196 in 1971.

2.- Promotion and Contact with the Industries

There are a variety of technical problems which are confronting Singapore, arising out of the accelerated industrial programme. The professional technologists in the factories are too tied down to their production schedules and routine maintenance jobs that they do not have time to identify the problems and let alone do research into their problems.

It is here where the liaison between industries and industrial research unit is of paramount importance. The best promotional platform is performance - i.e. the industry should have sufficient confidence in the ability of the institute in finding solutions to their queries and problems. The unit must not only know how to solve but what to solve when confronted with a problem -i.e. the ability to diagnose will give confidence to the industry. This situation is difficult to be realised specially in the earlier stages of development where the technical and professional officers, though with good academic background, are young and inexperienced. Their approach to research work was still rather speculative but nevertheless they were constantly acquiring the basic practical and diagnostic skills. Since 1968 the position has improved considerably.

The industries are naturally concerned with their production schedules to meet their orders and thus tend to ignore the need and importance of research. This is slowly being remedied as promotional campaigns instilling in the local manufacturers that quality goods and not marketing skills alone will, in the long run, be the overriding factor in securing a niche in the competitive world market. Industrial research and quality control can therefore help the private export-orientated industries to achieve their sale targets.

3.- Co-operation and Co-ordination at Regional and International Level

It has been accepted that all the developing countries industrialise through the process of "transfer of technology" lock, stock and barrel. This industrialisation process to be successful has to be reinforced by local technological capability, the main ingredient of which is sufficient pool of skilled and competent personnel who know and understand the existing technologies elsewhere, modify and adapt and eventually operate them. The existence of this local capability is a prerequisite to a successful science-based industrial community.

The resources of the advanced countries and the co-operation of developing countries with similar local conditions and stage of industrial development are of vital importance to build up or improve the local capability. The many immediate and pressing problems which the developing countries are confronted with, will be less unmanageable if there are regional or international co-operation programmes to promote the setting up

of training facilities geared to modify or adapt existing technologies to the technical, economic and social needs of the developing countries.

Regional and international co-operative movement can only be effective if the scientists and technologists of countries, both developing and developed, communicate among themselves on a personal basis. Regional and international seminars, studies, training programmes or workshops can play an extremely useful role as they serve as channels through which problems can be brought up and opinions and expertise accumulated through experience would be put to use in evaluating and finding solutions to these problems. The very fact that many of the leaders of the scientific organizations in the region are now in personal contact and share a common desire to exchange experiences and expertise augurs well for regional and international co-operative programmes in science and technology.

With all the good intentions provided by regional and international co-operative efforts, a country cannot hope to progress industrially unless it has defined clearly its industrial programmes in terms of research objectives and requirements in relation to its limited human and physical resources and incorporate them in its overall national development plans.

4.-Finance

The Industrial Research Unit in Singapore (now renamed SISIR) was founded in 1963 with assistance from the Colombo Plan. New Zealand contributed to this undertaking the basic laboratory equipment and the services of experts. Other countries such as Japan and France, either through international agencies or bilateral agreements, have similarly assisted in setting up technical institutes for the purpose of improving the basic technical and scientific infrastructure.

Through such technical assistance, the donor countries contribute significantly the capital expenditure for the equipment and initial expertise to run these outfits. The recurrent expenditure is exclusively borne by the Singapore Government.

The Government machinery for overall national development will have to consider development for science and technology in relationship with other priority projects. In the traditional pattern of things, the development of science and technology was unfortunately one of lower priority in the past In Singapore, for the past few years since independence, the military expenditure had the largest slice of the annual budget. The "up-hill" efforts of obtaining additional funds for expansion of industrial research facilities have to be seen in the light of the overall national development programme. The authorities on science and technology in Singapore are beginning to convince the planning and funding authorities of the importance of science and technology within the overall development. Efforts have been reasonably successful in obtaining funds from certain scientific international agencies to expand the facilities of the various research institutes to cater for the increasingly complex needs of the industries.

On the self-sufficiency level, clients are slowly beginning to be ware of the useful role of the research institute and their reluctance to make use of and pay for the services are being overcome. This has resulted in increasing part of the burden of running the institute being passed on to the clients. In 1963 SISIR only earned 6% of its running expenditure. However, in 1970 SISIR's earning amounted to 43% of expenditure, the bulk of which was derived from industries.

5.- Research Work - Selection of Appropriate Fields

It is important that an industrialising country that is planning to embark on a programme of industrial research, should choose fields of research activities to be carried that are appropriate to the stage of the country's industrial development.

As the aim of any industrial research unit is primarily to service the practicable needs of the industrial sector, it is impossible for obvious reasons to be competent in all fields of industrial research and activities. It is, therefore, necessary to consider what levels and fields of research to undertake.

SISIR, with its limited personnel, has adopted a policy of concentrating on day-to-day research problems and projects which relate to the immediate interest of the local industries. In-house projects are also being encouraged if they come within the Government's long-range plans for industrial development. It is the intention that wherever possible the industry should be brought in at the initial stage of long-term in-house project so that the results, if successful, will have a better chance of being commercially exploited.

The fields of research currently undertaken by SISIR include the survey, study and development of local raw materials; testing, standardization and development of products, processes, scientific equipment and instruments; and provision of technical services. These are standard types of industrial research services and any new areas of activities will depend on the types of new industries that are to be set up.

Singapore is a small island-state with slightly over 2 million population and its industrialisation is specifically geared towards an international or world-wide market. It has marginal natural resources. New industries which can contribute in skill development coupled with good potential for technological advance are being encouraged. These include the broad areas such as metal engineering and machinery, shipbuilding and transport equipment, optical instrument lenses, electrical and electronic products and aerospace engineering. The import-substitute types of industries will have to be carefully examined before they are allowed to come in.

In developing countries, where industrial development is generally still at its infancy, the realm of industrial research activities is not confined to technical problems but spilt over to all areas which are important to the growth and development of industries. These include market surveys, management and productivity studies and advice on tariffs.

6.- Universities

When one speaks about the possible source of scientific and technological manpower for industrial research, one expects to look towards the universities, where highly trained personnel tend to congregate.

The science and engineering facilities of the University of Singapore and Nanyang University, like others in developing countries, have heavy work-load in training the undergraduates. Most of the "spare-time" research work being done in these two universities is basic in nature. Opportunities are now being given to university staff to participate in the industrial research and assist in solving practical problems.

There was a lack of effective communication between the universities and industry in the past and the relationship between these two important groups have now been strengthened. The universities can play a useful role by sharing its facilities such as costly equipment and instruments and the services of highly qualified personnel for the benefit of the industries. Steps are being taken to introduce an associateship scheme where a practising technologist could be allowed to take time off from his job to do research into technical problems confronting him in collaboration with some university staff.

In strengthening governmental research activities and maximizing the effective utilisation of existing industrial research facilities, it is clear that Singapore is facing problems common to most of the developing countries. These problems include the shortage of necessary research equipment, the shortage of experienced research personnel and the shortage of financial assistance. However, it is fortunate that at the present moment, there is an increasingly closer liaison and the co-operation between the institutions of tertiary education and the other governmental technical departments in planning their research and allied activities. Industry is slowly being drawn in as there should be feedback from industries to the Government so that the appropriate authorities of the latter will be aware of what needs to be done either in the formulation of industrial research policies or in reinforcing the technical services to be provided. The Ministry of Science and Technology and the Science Council are presently studying the measures needed to systematically organise the diversified research facilities in order to make unified large-scale activities possible, particularly the industrial research and development activities and training of the appropriate scientific and technological manpower.

VIII.-CONCLUSIONS

There is a rapidly growing need for industrial research services in many of the countries in Asia. Because of the slow development of many of the industrial research institutes in this region for reasons already stated, only a few companies and government agencies enjoy the luxury of such services to a very limited extent. This situation must be remedied if the countries are to achieve any significant amount of economic growth.

Industrial research institutes must be accepted by the economic planners and industries as an essential part of the infrastructure required for national and economic development. The people in charge of industrial research institutions must work closely with and enjoy the confidence of those involved in the economic planning of the nation. The way to develop confidence is to produce results. This is often not that simple and it is felt that this is an area where UNIDO and other foreign assistance will have a very important part to play in the development of national industrial institutions in Asia.

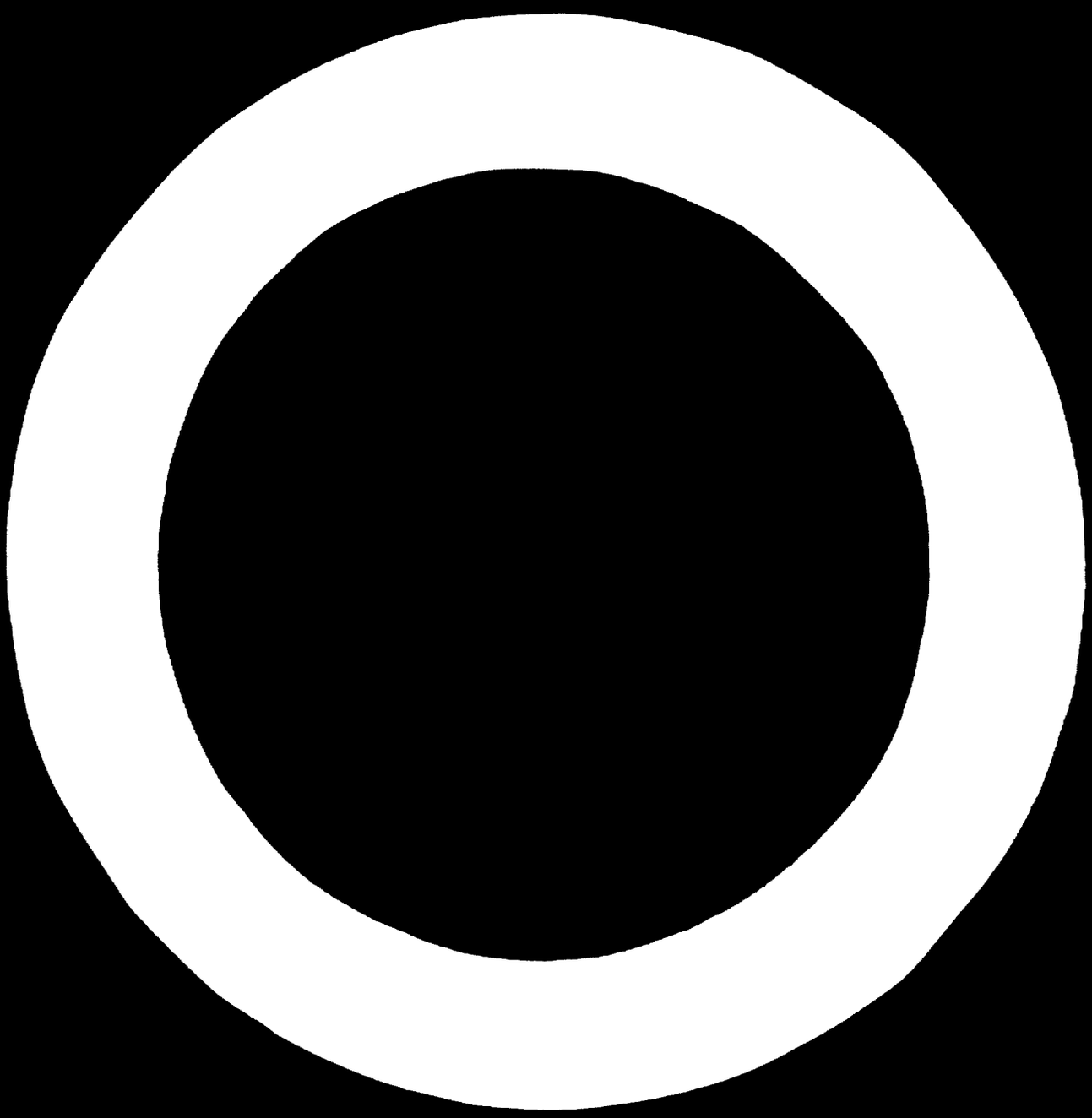
Appendix A

PROGRESS OF MANUFACTURING ESTABLISHMENTS WITH 10 OR MORE WORKERS*

Indicators	1959	1963	1965	1969	1959 to 1963	1963 to 1965	1965 to 1969
					Percentage Change Per Annum		
Total Manufacturing:							
Establishments (No.)	531	858	1,000	1,716	12.7	8.0	14.4
Employment (No.)	25,199	35,256	47,020	87,128	8.7	14.2	17.3
Output ($m)	399	844	1,086	2,636	20.6	13.5	24.8
Direct Exports ($m)	n.a.	224	349	760	3.0	24.9	21.4
Direct exports as % of Total Sales (%)	-	27	32	32	-	-	-
Net Value added per worker (productivity) ($)	4,783	5,504	5,712	6,400	2.8	1.9	2.8
Value of Physical assets per worker (capital intensity) ($)	n.a.	8,905	10,016	12,700	-	5.9	6.0
Pioneer Industry Establishment (No.)	-	29	95	236	103.5	81.0	25.5
Employment (No.)	-	2,654	10,495	35,000	231.8	98.8	35.1
Output ($m)	-	153	318	1,226	106.1	44.2	40.1

*Excluding rubber processing and small manufacturing establishment, which employ some additional 40,000 workers.

Source: S'pore Year Book, 1969

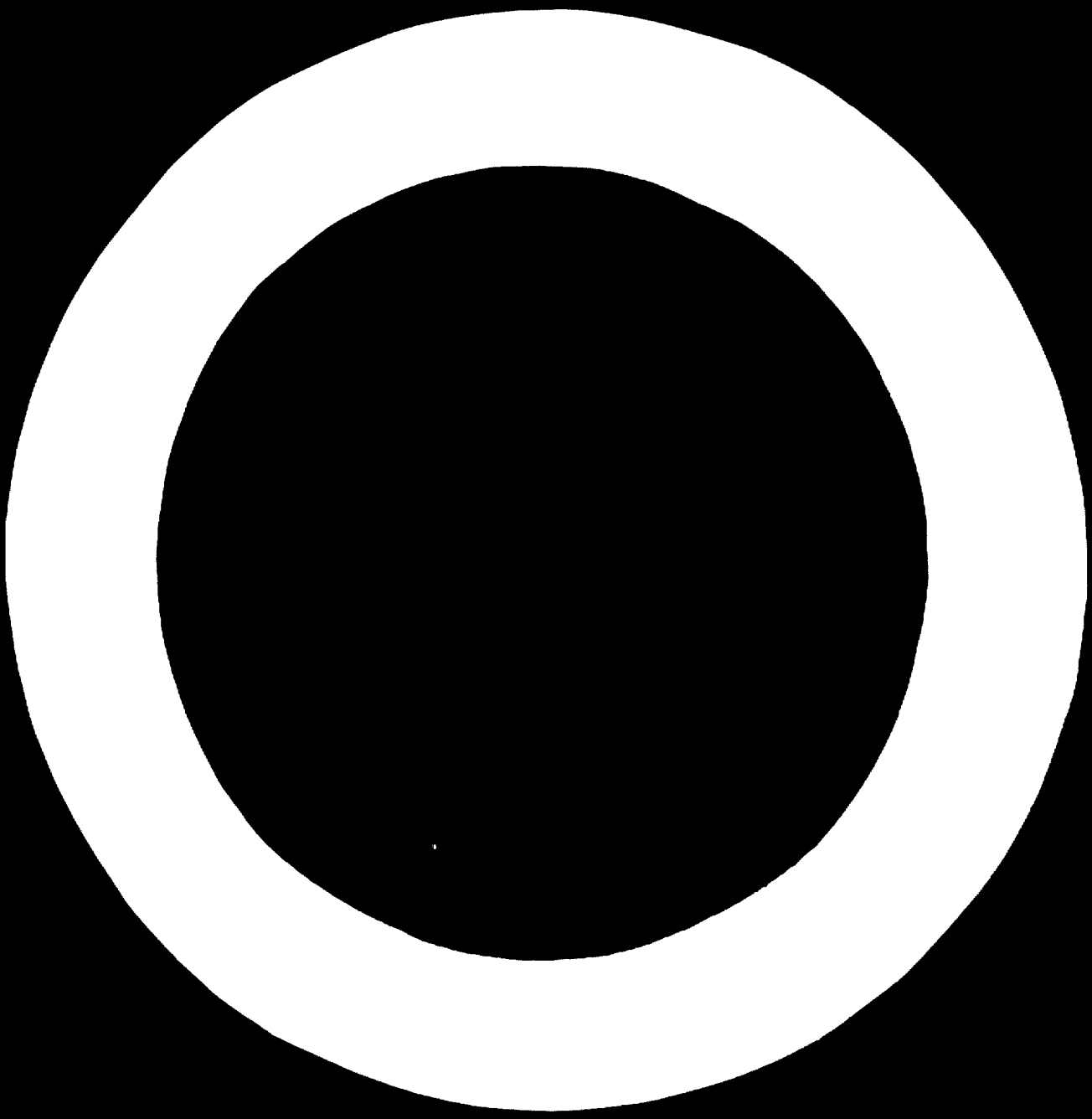


Appendix I

SOME STATISTICS ON THE INDUSTRY MAJOR GROUPS

Industry Major Group		1959	1963	1965	1969
Food Manufacturing Industries except beverage industries.	No. of Establishments	99	139	148	210
	No. of Workers	3,587	4,591	5,049	8,148
	Output $'000	69,362	136,454	185,000	401,948
	Value Added $'000	16,615	20,372	32,108	67,880
	Capital Expenditure $'000	1,532	920	7,311	21,049
Manufacture of textiles, footwear, except rubber footwear.	No. of Establishments	31	54	65	225
	No. of Workers	1 256	1,611	5,965	12,635
	Output $'000	9,470	11,898	36,112	144,082
	Value Added $'000	3,708	4,145	11,732	41,080
	Capital Expenditure $'000	157	1,208	3,202	18,328
Manufacture of wood and cork except manufacture of furniture.	No. of Establishments	38	82	104	159
	No. of Workers	2,331	3,432	4,647	8,228
	Output $'000	26,725	48,870	65,808	160,337
	Value Added $'000	9,199	13,842	19,396	52,279
	Capital Expenditure $'000	291	666	4,500	12,218
Printing, publishing and allied industries	No. of Establishments	87	124	129	189
	No. of Workers	3,523	4,578	4,637	5,096
	Output $'000	38,142	53,307	61,777	78,235
	Value Added $'000	22,451	30,021	34,782	43,318
	Capital Expenditure $'000	2,138	2,472	5,082	15,280
Manufacture of chemicals, chemical products and products of petroleum and coal.	No. of Establishments	32	44	53	107
	No. of Workers	1,421	2,047	2,249	6,270
	Output $'000	50,050	223,127	260,004	1,289,537
	Value Added $'000	9,378	38,827	59,619	202,239
	Capital Expenditure $'000	612	3,477	10,706	51,024
Manufacture of non-metallic mineral products.	No. of Establishments	23	34	36	43
	No. of Workers	2,328	3,077	3,169	4,138
	Output $'000	19,561	61,621	51,991	77,454
	Value Added $'000	9,521	24,687	23,600	29,310
	Capital Expenditure $'000	874	1,420	1,359	4,386
Ship building and repairing except building and repairing of wooden boats.	No. of Establishments	-	-	21	35
	No. of Workers	-	-	2,145	12,621
	Output $'000	-	-	23,748	166,695
	Value Added $'000	-	-	13,673	109,991
	Capital Expenditure $'000	-	-	6,072	20,954
Miscellaneous manufacturing industries	No. of Establishments	18	50	64	154
	No. of Workers	453	1,470	1,908	6,382
	Output $'000	6,519	32,307	38,068	121,736
	Value Added $'000	1,573	5,370	8,899	32,811
	Capital Expenditure $'000	186	594	2,262	13,587

Sources:- Reports on the Census of Industrial Production.

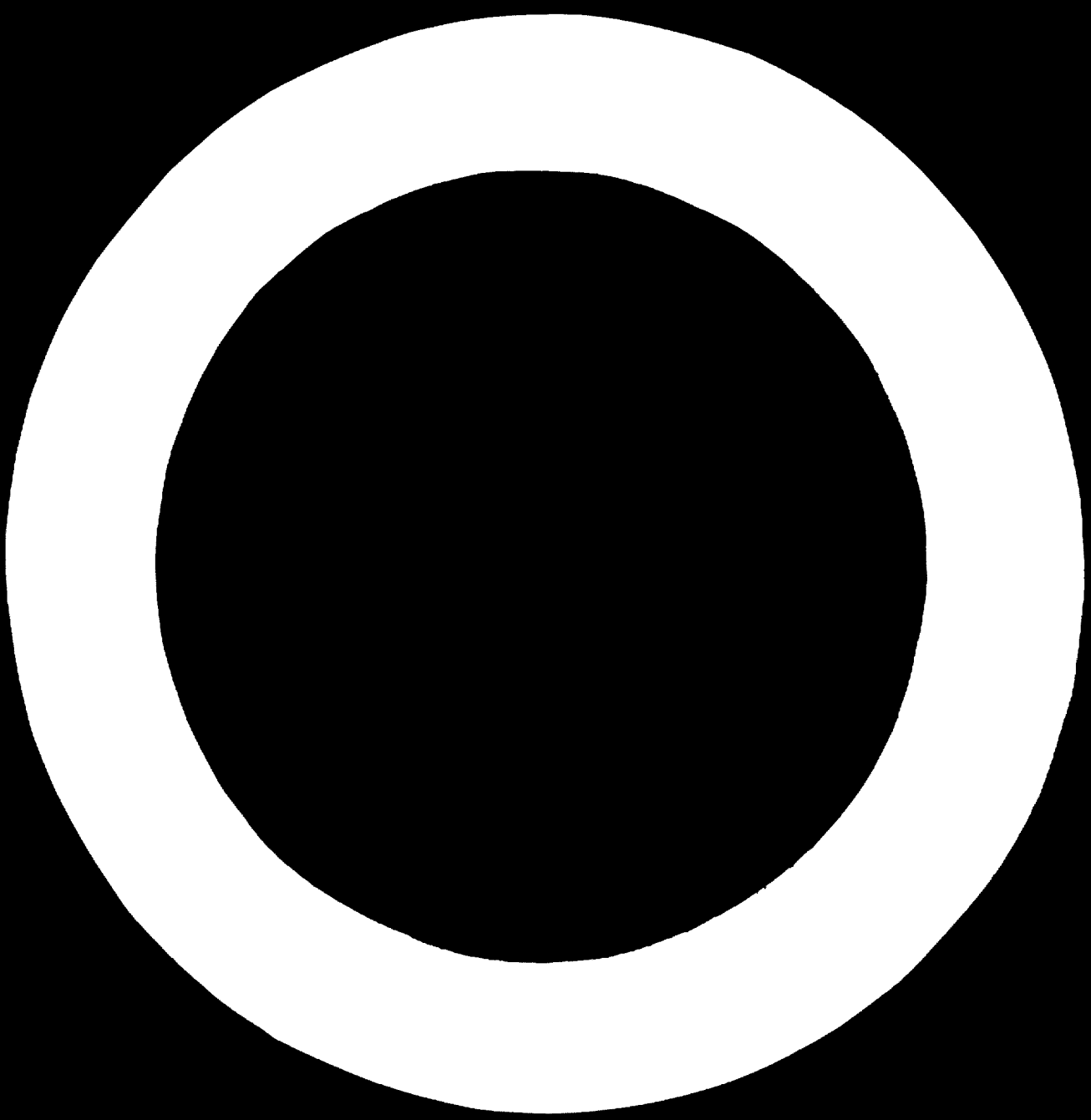


APPENDIX C

PRINCIPAL STATISTICS OF PIONEER & SELECTED NON-PIONEER ESTABLISHMENTS: BY STATUS AND LOCATION, AS AT 31ST DECEMBER, 1969

ESTABLISHMENT/INDUSTRIES ESTATE CATEGORY	No. of Establish-ments	PAID-UP CAPITAL ($'000)			OUTPUT ($'000)		EMPLOYMENT (NO. OF PERSONS)		
		Local	Foreign	Total	Actual for Jan. - Dec. 1969	Estimated Annual At Full Production	Actual at 31.12.69	Initial at 31.12.69	Estimated At Full Production
Establishments in Production									
1. Total Establishments	505	430,741	358,901	789,642	1,755,017	2,583,709	61,906	-	85,196
2. All Pioneer Establish-ments	236	221,852	249,872	471,724	1,199,824	1,765,554	36,071	-	50,504
3. Non-Pioneer Establishments	269	208,889	109,029	317,918	555,193	818,155	25,915	-	34,692
Establishments Under Implementation									
1. Total Establishments	126	40,157	107,408	147,565	-	761,946	1,372	6,377	12,276
2. All Pioneer Establish-ments	45	26,098	89,807	115,905	-	498,572	688	3,857	6,974
3. Non-Pioneer Establishments	81	14,059	17,601	31,660	-	263,374	684	2,520	5,302

Source:- Report on Census of Industrial Production.



APPENDIX D

PROPOSAL CLEARANCE FORM

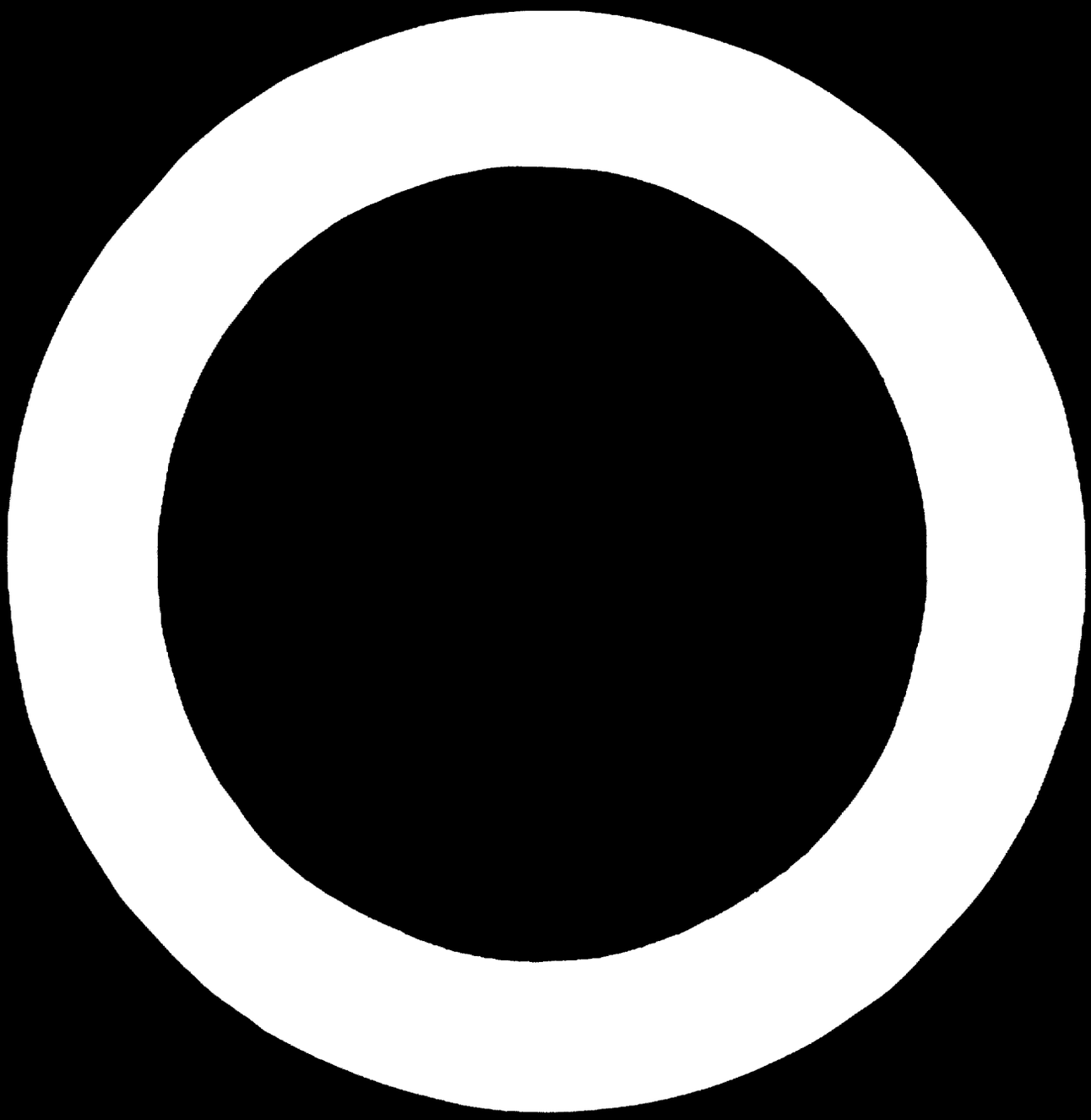
TITLE	CODE	NO.	Date to be submitted

CLIENT	Classification			
	Govt.	Statu.	Pte.	Others

CATEGORY	Chemistry	Physics	Electrical	Food	Mech/Civil	Others
TOTAL ESTIMATED CHARGE		Estimated Period of Performance	Estimated Award Date	Estimated Starting Date	Proposal Expiration Date	

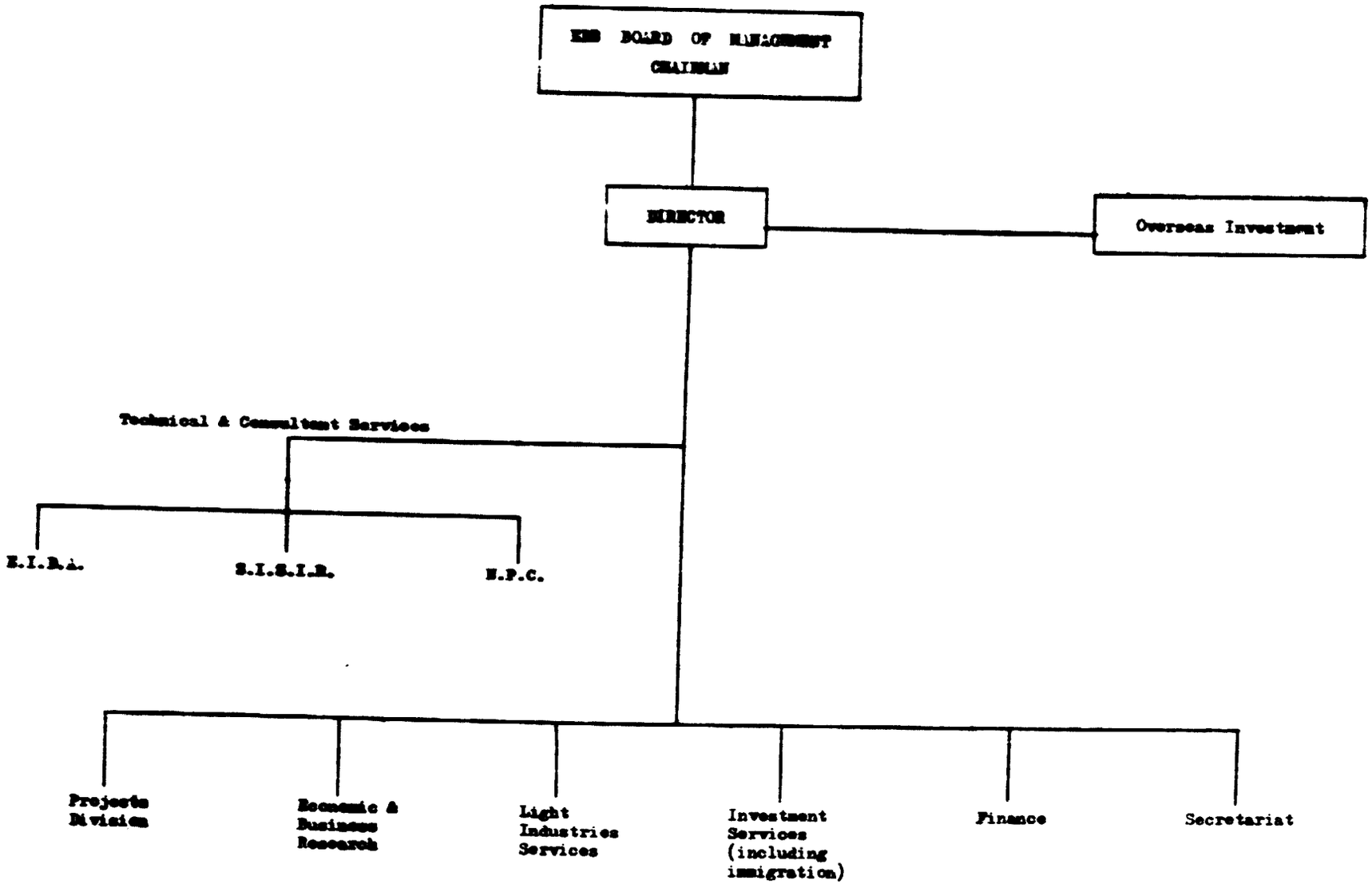
PROPOSAL PREPARED BY	SIGNATURE	DATE

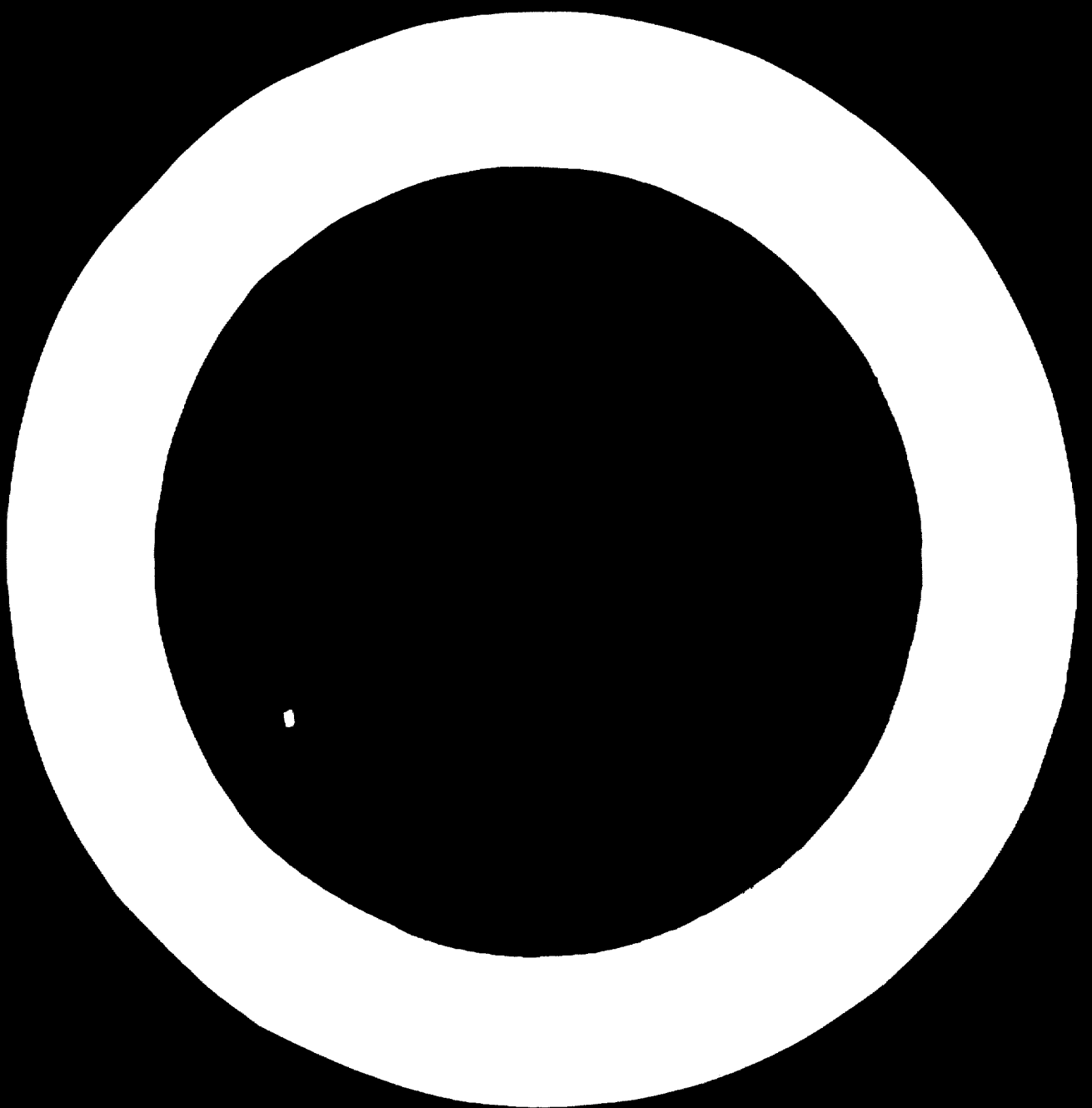
Approved/Rejected by Deputy Director (Projects)	Signature	Date	Remarks



APPENDIX E

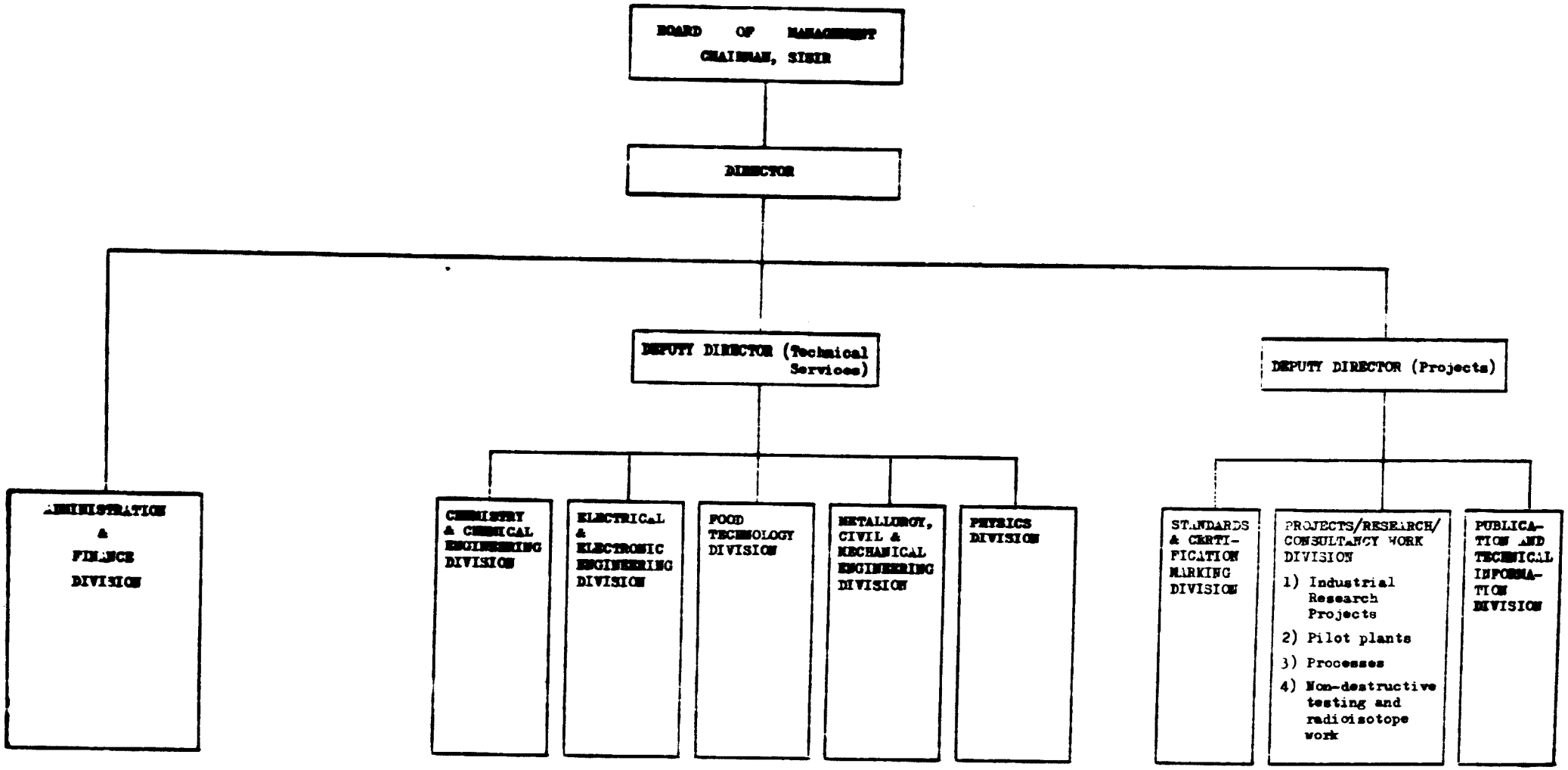
Organisation Chart of Economic Development Board

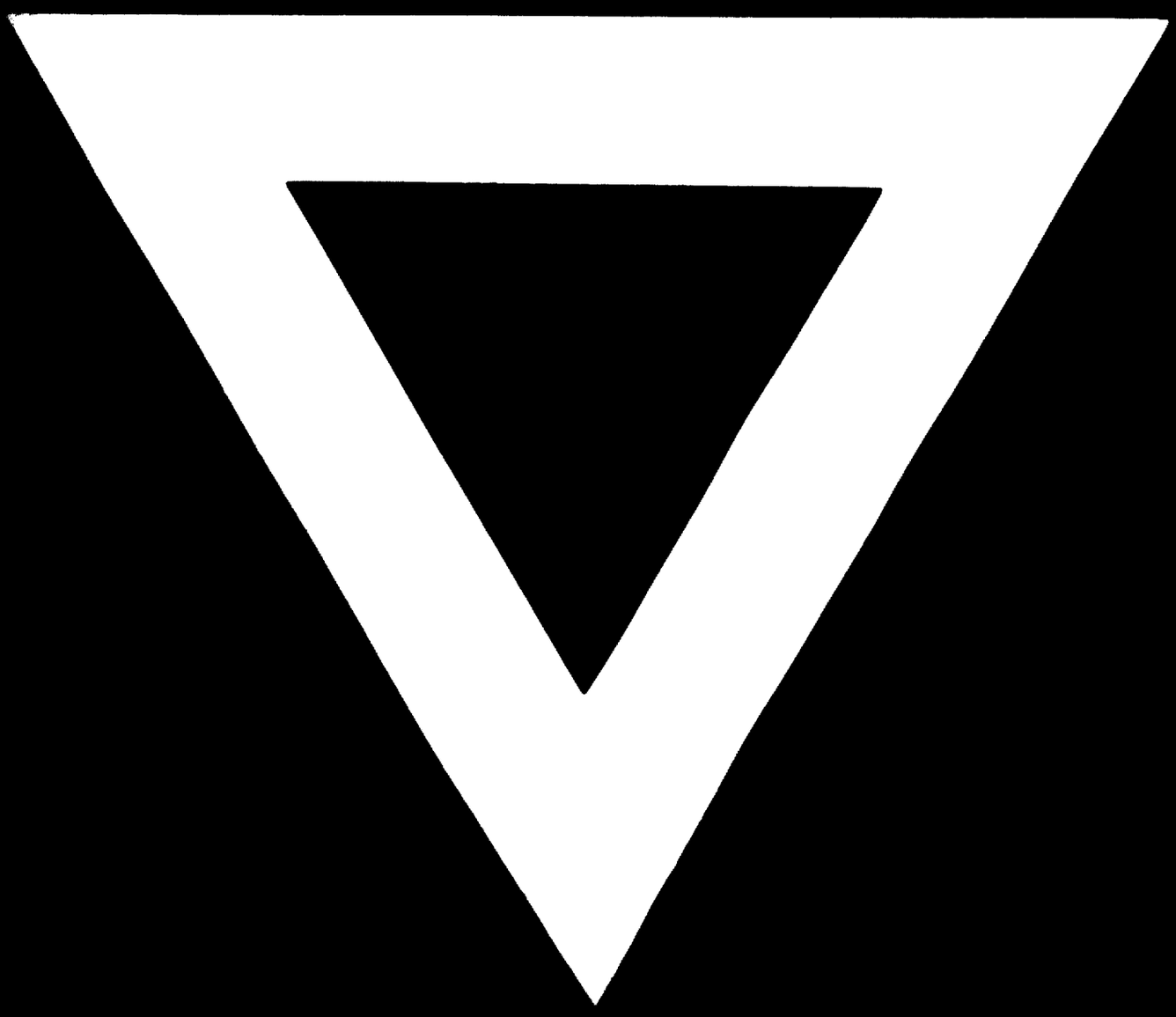




APPENDIX F

ORGANIZATION OF SIRIM





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