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06610

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Distr.
LIMITED

TD/WP.004/
13 August 1975

ORIGINAL: ENGLISH

United Nations Industrial Development Organization

Joint Commission on the Promotion of
Industrial Research and Services

Geneva, August 1975

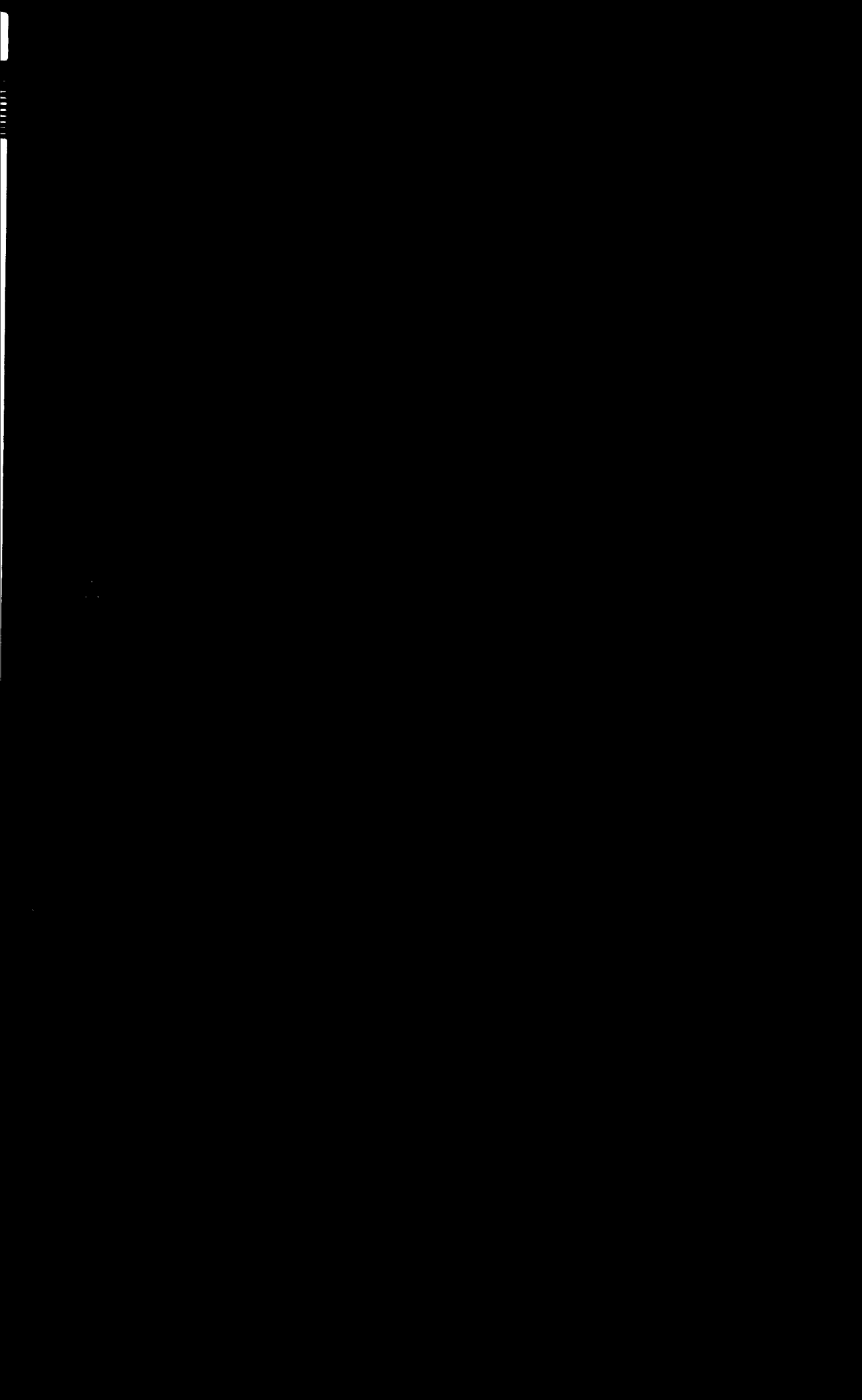
PLANNING OF NATIONAL INDUSTRIAL
RESEARCH ACTIVITIES

Document No.

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Preface

The term industrial research lends itself to several interpretations, but it is generally taken to mean the carrying out of practical experimental investigation at laboratory and pilot plant levels and the provision of technical advisory services for specific practical industrial objectives. In order to accomplish these objectives effectively, industrial research and development institutes are needed. To function properly, they must have:

- Good design, buildings, equipment and facilities
- Sound management and well-trained professional and technical support personnel
- Industrial information and documentation services
- Close working relationships with industrial enterprises and the rest of the business community

In order to build and develop such complex institutes in an orderly manner, the policy under which they operate, their field of activities, and the resources that are available to them must be defined, and care must be taken not to duplicate existing activities.

Since its inception in 1967, the United Nations Industrial Development Organization (UNIDO) has acquired considerable experience in assisting Governments to establish and operate new institutes in a number of developing countries, as well as in studying and recommending improvements in existing institutes.

This wide experience has shown that, while the part played by an industrial research institute varies somewhat from one developing country to another, many common features can be identified. It has also become clear that what is found to be appropriate in an industrialized country is not necessarily of direct application to a developing country, and that the nature and scope vary somewhat from one developing country to another depending on national targets, the stage of industrial development, the size and status of industrial companies and other local conditions.

INTRODUCTION

In industrialized countries, a number of members of the staff of the boards of directors. They frequently retain professional staff to supervise the analytical control of raw materials and the quality control of intermediate and finished products and, in addition, to investigate the possibility of improving processes and product quality, and to help develop new products and processes. It is common to find technologists on the boards of directors and management committees of such enterprises.

In developing countries, on the other hand, few industrial enterprises, even from the multi-national corporations, employ technologists to help in the running of the company. Many not only have no technologists but do not even appreciate the meaning of industrial research, or how it, or even its allied technical services, might help them. This is not to suggest that these companies are all at the stage where they require new products or processes; in most cases standardization of raw materials, processes and products are all that will be needed for some years to come. Therefore, if industrial research institutes in developing countries are to give immediate assistance to industry, they must be prepared - indeed eager - to offer help in standardization. Technologists in developing countries are trained to approximately the same level as those in industrialized countries, and many of them have had some training, especially in research, overseas. It is important that they should realize, however, that there may be little need in their country for sophisticated research. It requires a conscious change in attitude for them to adjust to the type of industrial research and service work that may be of immediate use in their own country.

It is reasonable to say that the term "industrial research institute", when applied to developing countries, is something of a misnomer. What these countries require is an institute for acquiring and applying technological knowledge, thereby making a direct and immediate contribution to industrial development in both the public and private sectors. (In one developing country, an industrial research institute was changed during the life of a UNIDO

project to an industrial research and consultancy corporation for this reason. The title is not important, however, provided it is accepted that research and consultancy is the purpose of the institute. Once this is accepted, the issue that the institute should do and how it should be done becomes an open question.

Since industrial companies in most developing countries rarely have any appreciation of the value of industrial research services, the staff of the industrial research institute must provide it. This means establishing mechanisms to show industry the value of industrial research and how it can be used to their advantage. Furthermore, as industry rarely has the capability of carrying out development work, economic studies or engineering design, such supporting services must be provided by the institute.

Another major factor that may affect the work of an industrial research institute in a developing country is the policy of the Government. It may be the policy to replace imports as far as possible by indigenous materials, even if they are not of as high a quality as the imported products, or to aim for maximum employment and capital costs (whereas in more industrialized countries the aim is usually to reduce manpower even at the expense of increased capital costs).

An industrial research institute should not exist in isolation, maintaining contact only with its clients; it must maintain a regular working relationship with such organizations as productivity centres, associations of manufacturers, trade associations, organizations for small-scale or cottage industries, and financial institutions. Such collaboration often results in ideas for technological work or research projects.

In general, industrial research institutes have been found to be most effective where they have been set up on a modest scale, providing only routine industrial services to clients at first. Where they have been set up too ambitiously and too far removed from the actual needs of the country, they have had little success. Some of these needs are discussed in Chapter 1.

1. CLIENTS' NEEDS

The major task of an industrial research institute in any country is to provide its clients - the Government, private and public industry and the organized business community - with practical technical and technical services. Whether an industry be privately or government-owned, the sole objective of the institute should be to produce results of commercial value. The institute's success should be judged largely by this criterion. Much of the work should consist of providing immediate assistance to the client, although it may often be advisable to carry out a proportion of in-house work initiated by the staff of the institute.

In some developing countries, the Government is the main client, particularly in countries where most industrial activity is managed by the Government, either directly or through its established public organizations. The number of private industrial enterprises requiring research services is increasing, however. In addition, various development banks are deriving increasing benefit from the work of industrial research institutes.

Industry

Generally speaking, industry in a developing country can be divided into indigenous firms and multinational companies. Indigenous firms are rarely large, sometimes of medium size, but frequently small or very small (e.g., cottage industries). If a large firm has begun its operations by purchasing know-how from overseas it will usually have made some arrangements for continuing technological support. Such firms could be placed, from the point of view of the industrial research institute, in the same category as the multinational companies.

1/ See Glass Building Materials: Industrialization in Africa: Report of the Workshop held in Tunis, 6-12 December 1970, including a Summary of Lectures Presented to the Workshop (United Nations publication, Sales No.71.II.B.24); and Guidelines for the Acquisition of Foreign Technology in Developing Countries with Special Reference to Technology License Agreements (United Nations publication, Sales No.73.II.B.1).

Many indigenous manufacturing companies, especially the small and very small ones, are craft-based. These crafts are quite old and the companies may not feel any need for technological support. Indeed, it may seem to them that old established processes are not capable of further improvement. A discussion with the owner or manager, however, will often reveal that difficulties are being experienced regarding which he had not supposed that the technologist might be helpful.

Very often the problems are relatively simple and the technologist can deal with them quickly and efficiently. They might include, for example, testing raw materials or products; selecting or calibrating a scientific instrument; repairing a broken instrument; designing some simple equipment; or providing information. Rapid and correct answers to such problems give a positive image to the industrial research institute, which previously might have been ignored or treated with suspicion. They also lead to requests for short-term investigations or for technological or economic trouble-shooting.

Medium-sized or large companies should be encouraged to employ at least one technologist. He should be a generalist rather than a specialist and one of his principal tasks would be to act as a liaison officer with the industrial research institute. He would identify company problems that might be submitted to the institute and also decide what use his company might make of the work of the institute. He should be able to deal with some of the company's smaller problems himself, perhaps in collaboration with the institute. In this way the company would increase its technological competence and efficiency.

Once a company, particularly a large one, realizes the value of technological help, it usually decides to establish a laboratory and to employ a number of technologists. One of the ways in which the industrial research institute can help is to offer advice on laboratory design, equipment and staffing. The company may wish to recruit its technologists direct from the

institute and, provided the number of personnel involved is not too large, should be encouraged to do so. If, in this way, the institute can serve the needs of technology throughout industry, it will have performed a most valuable service.

It may be thought that once a company establishes a laboratory of its own it will find no further use for the services of the industrial research institute, but experience shows that this is far from being the case. Technologists from individual companies are often glad to discuss problems with, and seek advice from, the institute. Furthermore, as private companies seldom have the wide range of equipment and experience that is at the disposal of the institute, they often require assistance in carrying out limited-term work of a specialized character. Such requests are more likely to come from a company employing technologists than from one which does not, since the company technologists are better able to identify the exact needs of the company and to appreciate the assistance that other technologists might provide.

In the same way, companies that have imported know-how, and even from time to time the multinational companies, may find the industrial research services provided locally to be of value. The industrial research institute can help by pointing out to the large enterprises the long-term benefits to themselves and to the country that might result from strengthening the over-all technological infrastructure of the country.

The Government can also stimulate research and development within industry by means of special tax concessions. This action would seem justifiable since research is not really a regular expense for one year's operation; it is more in the nature of an investment, the return on which is spread over many years.

The technological work generally required by industry falls into the following main categories:

Testing and analysing raw materials and intermediate products

Testing and analysis of finished products for standardization,
quality control and certification

Transferring scientific information on the industrial, technical and
techno-commercial fields

Carrying out instrument repair, maintenance and calibration

Designing equipment (e.g. simple ovens, kilns, miners and driers)

Trouble-shooting in plants

Investigating the possibility of improving the quality of finished
products and increasing process efficiency

Developing new processes for current or new products, at both the
laboratory and the pilot plant levels

Carrying out techno-economic studies

Undertaking engineering design work

As a country develops it may set up specialized agencies to deal with
some of these activities, such as testing and analysis of finished industrial
products for standardization, or quality control and certification. While it
may be advantageous under certain circumstances for a country to combine
national standards and industrial research activities in one institution, it
has been found preferable to keep the two separate, with the industrial
research institute acting as the technical arm of the national standards
body. Another activity which could become the work of a specialized centre
is the repair, maintenance and calibration of instruments. Any work requiring
advanced instrumental analysis (which is essential to a great deal of research)
is best left to the industrial research institute, however, because of the
high cost of purchasing and maintaining such instruments and the special
skills required in their operation.

It is important to the industry and Government of any country to know the quantity and quality of indigenous raw materials and to ensure the development of a comprehensive geological and agricultural survey for and by the physical and chemical examination of raw materials. In this regard, it is a responsibility of the institute to have a laboratory which is likely to be the main centre of analytical expertise in the country. In the case of raw materials that might be used as substitutes for imported materials, the institute can undertake performance and evaluation tests which may, in turn, result in additional research work being required.

Many of the activities discussed above can be of immediate value to industry. If they are carried out for an industrial concern without charge, the cost saved would amount to a subsidy to the concern and it will not be encouraged to set up a laboratory of its own. It has become generally accepted, therefore, that unless Government policy dictates otherwise, an institute's clients, particularly industrial companies, should bear the cost of work carried out specifically at their request. Charges can either be made on a full economic basis (including salaries, wages, consumable materials, services, travelling expenses, overheads and capital charges for buildings and equipment) or on the basis of direct out-of-pocket expenses (salaries, wages, consumable materials, services and travelling expenses) incurred while doing the job. While in industrialised countries the former is the normal method of charging, it is realised that in order to encourage the use of institute's service in developing countries the latter method may be preferred. It is also considered justifiable in a developing country for advice to be given free and only to charge for specific work involving experiments, design or feasibility studies. (Contract conditions and financial control are discussed further in chapter IX)

There may be a tendency for a country or an industry to adopt standards, e.g. for finished products, equivalent to those used in industrialized countries, but which are unnecessarily high for the country or industry concerned. Obviously, if a product is to be exported, it must satisfy the requirements of the customer country, but for home consumption care should be exercised that products are not made to a higher standard than is needed. For some products, several standards may be desirable at different prices, but customers should be informed of the situation and the products should clearly display the standards they satisfy.

Processes geared to low labour requirements or high material or power efficiency are not necessarily the most suitable for developing countries. Such processes often require capital expenditure which the country might not be in a position to afford; yet labour may be plentiful. Improvement in existing processes and equipment is often the most appropriate action to take. It may even be necessary to modify technology from industrialized countries to meet the requirements of small enterprises in developing countries.

On the other hand, there are instances of smaller developing countries which are without indigenous raw materials but which are anxious to promote exports. In such cases the country may well aim at high industrial production per capita and, as in industrialized countries, at low labour consumption.

A research activity that merits special attention is engineering design, an important factor in the process of innovation. It is concerned with the creation or modification of an individual article, and includes elements of research, development and testing. Engineering design entails the preparation of specifications, working drawings, pilot models and prototypes, and data and instructions for manufacture.^{2/} As a country develops it can cater for the

^{2/} See The Development of Engineering Design Capabilities in Developing Countries report of Expert Team Meeting, Vienna, 10-15 May 1970 (United Nations publication, Sales No. 72.II.3.2).

needs of industry in the present or setting up a separate research centre. It is desirable to limit the industrial activity nationalised, however, in order to draw funds from industry. In the initial stages of development, it should be considered one of the duties of the industrial research institute.

Government

The Governments of most developing countries are making great efforts to raise the living standards of their people. They recognise the important role of industrial development in achieving this objective. Certain industrial activities and aspects - e.g. the exploitation of indigenous raw materials and environmental matters - are subject to Government policy.

In framing its policies the Government usually needs the maximum amount of information on a wide variety of subjects, some of which are technological. While it is often possible, and even advisable, to seek advice from more advanced countries, local advice should be sought first. This approach helps to build up the confidence and expertise of indigenous staff, and the advice will be coming from experts who have a first-hand understanding of local conditions. The type of assistance that the industrial research institute might offer includes the provision of commercial and technological information, the carrying out of feasibility studies, and the provision of assistance in the negotiation of licensing agreements and patent matters. The institute may arrange for foreign advice to augment its own expertise when necessary.

Other important matters in which the institute might assist at the national level include product standardisation and adaptation, testing, quality certification, the drafting of standards for the national standards body, and the establishment of suitable arrangements for instrument calibration, repair and maintenance.

Clientele

An institute in a developing country may well have clients other than government or industry. Development banks often require technological information or ask the institute to carry out techno-economic studies. Consumer associations, associations of manufacturers and members of commerce also may need independent and objective information, studies or advice; or the client may be a university or a technical college. The institute may often be the only organization in the country that can provide such assistance.

II. SCOPE AND OF THE INDUSTRIAL RESEARCH INSTITUTES

The term "industrial research" covers many activities that are not usually thought of as "research" in academic circles. Some of these activities are concerned with service work and some link together the technical and economic aspects of a subject; the latter are usually referred to as techno-economic studies. Broadly, these types of activity may be considered as industrial, technological and economic services rather than research. Experience has shown that the balance of work in most industrial research institutes in developing countries is heavily weighted - and rightly so - on the side of those services that industry needs at first. Research activity is slow at the start, but increases in tempo with the passage of time.

The Governments of most developing countries, when they first set up industrial research programmes, do so in a multi-purpose organization designed to provide several types of assistance to a number of industrial sectors. Sometimes, usually at a later stage of industrial development, mono-purpose institutes are set up to cater for the needs of individual sectors. The establishment of such specialised institutes should be treated with the utmost caution in view of the limited financial and human resources available in most developing countries. At the outset, if it is to provide truly comprehensive technical assistance to industry, the institute should cover all aspects of industrialisation (except the carrying out of geological and agro-economic surveys, both of which often call for expertise generally not available in industrial research institutes). Later, if some of the functions can be satisfactorily undertaken by another agency, or if specialised agencies are set up to deal with them, the range of activities undertaken by the institute may be narrowed.

A multi-purpose institute has several advantages. The major ones include: the common use of specialized equipment and general services; lower overhead costs; and flexibility in the deployment of staff, e.g., by moving them on to programmes of the highest priority, irrespective of the terms of the initial contract. In the early days of industrial development in a country, therefore, it would seem advisable to set up a single multi-purpose institute and to consider establishing mono-purpose institutes only when special conditions apply.

The case for establishing a mono-purpose institute is most justifiable when:

(a) The work serves a well defined and well established industry that uses specific, specialised techniques. The institute can then become a centre of professional authority for the whole industry and help to raise its standards;

(b) The volume of work for the industry is considerable and likely to remain at a high level for many years;

(c) The industry is prepared to support the institute, not only with advice but with regular financial contributions other than contracts. (In this connexion it should be mentioned that there are examples in developing countries of mono-purpose institutes that are financed wholly or partly by industry.) This financing may be in the form of a levy on all firms in the industry, either legally imposed or encouraged by tax concessions;

(d) The institute can be located on a common site with, and use the same facilities as, other institutes.

Such conditions tend to apply only when a country has made considerable progress towards industrialisation.

Summary

It is clear that industrial research institutes in developing countries must be conceived of as an integral part of the national machinery for economic and social development, and therefore geared to the industrial, economic and other objectives of the country. It follows, therefore, that when they are firms

estimated that about 10 percent (in most instances) entirely by the Government. Although it may be expected that they will gradually acquire income from outside for their work, they will generally require strong financial support from the Government for many years.

Autonomy

Experience in various countries has shown that it can be a serious mistake to set up an industrial research institute as a government department or as part of a government department. By the nature of its work, an institute has to be both rigid and flexible. Traditional civil service rules and financial administration are too stultifying. It must be possible, for example, for the director of the institute, with the approval of the board of management, to hire staff temporarily and rapidly, to reward achievement, and even to discharge unsuitable staff.

Board of management

Without question the most satisfactory arrangement is an autonomous, State-financed body administered by a board of management. This board should be given full authority to establish policy guidelines, salary scales and other compensation schemes and to approve the annual work programme and budget of the institute. The director should be solely responsible to the board for all executive functions. As the board must represent a variety of interests, it should include competent persons representing relevant government departments (three), outstanding, university-trained technologists (two), representatives of private industry (two), and representatives of the business community, including industrial development banks or their equivalent, chambers of commerce, associations of manufacturers, and other public industrial or commercial organizations (four). The numbers quoted here are only by way of example and may well be varied depending on the importance attached to the

business section. It is also to show that a group of management engineers should have their number of members, ten to twelve, should be both a reasonable size and an effective number.

Director of the Institute

The qualities required in the director of an industrial research institute are manifold. At the time he is appointed he may not have had the opportunity to display his ability in all of the areas he must cover, but he should endeavour to develop the necessary qualities. He should be well qualified in either science or engineering and possess a sound record of achievement, preferably in industry. His interests should lie in the direction of applied research, to be of scientific and commercial exploitation. He should be a good judge of personnel and an able organizer with some business acumen. In addition, he should have a co-operative attitude towards people outside the organization and the ability to inspire his own staff to effective action. The institute director must be prepared to delegate responsibility as far down the line as possible and to hold his staff accountable for responsibility so delegated. He should also protect his staff from unjustified criticism but be prepared to take unpleasant decisions when they are necessary.

It is essential that the director be relieved, as far as possible, of routine administration duties in order that he may concentrate his attention on the technical work of the institute. There are several ways of arranging this, e.g. by appointing an administration manager or a personal assistant. The director remains, however, the chief executive of the institute and is solely responsible to the board of management for all technical and administrative actions taken by the institute.

Although the director is essentially a technologist he should be able to talk and write about technological matters in terms that are understandable to the layman. While he should not be expected to handle detailed public relations work he should give his personal attention to the more delicate and political aspects of public relations.

Evaluation

From time to time the activities, plans and performance of an industrial research institute should be evaluated in the light of changing national needs. In addition, every so often (say every five years), an independent assessment of the work of the institute should be made by a small team of industrial experts, preferably with foreign participation. This assessment should determine how effective the institute has been and identify areas in which it needs strengthening. It should cover structure, operation, finance and utilization of work.

Inter-institutional linkage

There is much support for the idea that an industrial research institute in a developing country should establish a linkage with a similar but more advanced one in an industrialized or in another developing country. Such a linkage could be of value to the less advanced institute in matters related to programme and project formulation and evaluation; organization and procedure; staff training; sharing of technical experience, technological information, research and development; and general institutional development. The linkage might even be part of a bilateral programme of assistance between two countries. (UNIDA and the World Association of Industrial and Technological Research Organizations (WAIIRO) could be instrumental in arranging such pairing schemes.)

Buildings and facilities

As the work of an industrial research institute varies considerably in nature from time to time, it is important that buildings and allied facilities be set up in such a way that they can easily be adapted to meet changing needs.

Technologists, engineers and service staff, as well as the architects, should be consulted at the planning stage. It is usually most expedient to nominate one member of the institute staff to co-ordinate all views. It is also advisable to arrange for an expert in the programming of industrial research buildings and facilities to act as an intermediary between the institute, the architect, and the builder's management and relevant staff, for the duration of the construction work.

The site selected for the institute will likely be in or near the capital or principal commercial city of a country, for convenience of travelling as well as for intellectual, social, economic and other reasons. The precise location will depend, however, on the results of an investigation into the capacity for expansion and the cleanliness of the local environment.

In the design and layout of the buildings, emphasis must be placed on adaptability, at any rate to the extent that changes can be expected. The building design and the construction materials should be selected taking into account features that are peculiar to laboratory work, such as the need to control temperature, humidity, vibration and noise; to provide suitable lighting and furniture; and to limit fires, fumes and other potential hazards. Materials should be used that are hard, easy to clean and easily repaired or replaced. As far as possible they should be indigenous rather than imported.

Particular attention should be paid to the arrangement and location of such services as water, gas, electricity and drains; they should be readily accessible for repair, maintenance, modification or extension. Consideration should also be given to the location of industrial information and documentation services; conference, office and catering facilities; and the movement of equipment and materials into and out of the building.

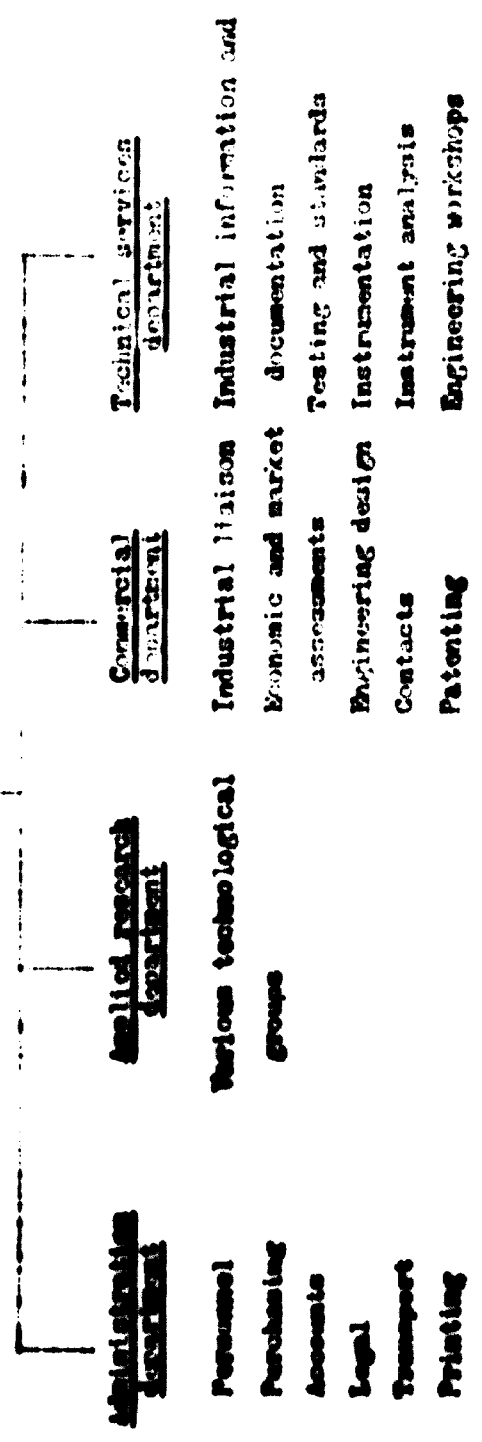
Internal structure

The internal structure of an industrial research institute can be classified under four divisions. They are not necessarily equal in size, but all are vital to the effective operation of the institute. For purposes of convenience they are described here as the applied research, development, technical services and administration departments (see organization chart); each one is dealt with at some length in the chapters that follow.

The departments are subdivided into sections and the person in charge of each section is referred to as the section head. (Depending on the size of a department, there may be need for a departmental manager.) The person in charge of each investigation is referred to as the project team leader. A wide variety of organizational arrangements are possible, but the chart shown here covers all the important functions.

It is essential for the smooth operation of an institute that the organizational structure be as simple as possible and the responsibilities of sections and individuals be clearly defined and understood. Problems must be handled speedily and efficiently if the institute is to attain a good reputation in industrial circles; a simple and well understood organization is essential in this respect. Experience has shown that an institute functions best if its research staff concentrate solely on scientific projects and are not distracted by commercial or administrative matters.

DIRECTOR



Organizational chart for an industrial research institute

III. CONCLUSION

The pattern of work and the structure of Industrial Research Institutes found appropriate in industrialized countries has to be modified in developing countries. Furthermore, the pattern which is most effective is likely to vary from one developing country to another depending upon national targets, the stage of industrial development, the size and status of the industrial enterprises in the country and other local conditions. The term "Industrial Research Institute" is often a misnomer since what developing countries need in the first instance is an institute for acquiring and applying technological knowledge in order to make a direct and immediate contribution to the country's industrial development. There is little need for sophisticated research, but a widespread need for technological assistance by way of industrial information, testing and analysis, quality control, instrumentation and engineering design. In addition there are techno-commercial matters such as economic and market surveys, feasibility studies, industrial cost accounting, trouble-shootings, advice on contracts, and patenting, on which the institute can make a positive contribution to the welfare of the country.

The clients of the Institute are likely to be not only industrial enterprises but also government departments and agencies, development banks, consumer associations, associations of manufacturers and chambers of commerce. In addition, the Institute should maintain close contact with many other bodies such as universities, technical colleges, productivity centres, bureaux of small-scale and cottage industries and so forth.

It is advisable for an Institute to be set up in the first instance on a modest scale, perhaps providing only routine services. As its contacts with the industrial community of the country develop, matters on which it could provide technical assistance would become clearer and its structure and organization could be strengthened accordingly. It might even be necessary to detach a department of the institute and develop it in a full

fledge organization entirely devoted to one specific area of the Institute's operations. The Institute needs, therefore, to be established on flexible lines as regards personnel, buildings, equipment and organization. Although it would almost certainly be entirely government financed at first, it has nevertheless been found best to establish it as an autonomous body, since traditional civil service rules and financial administration are too stultifying to enable an Industrial Research Institute to operate flexibly and with originality. Arrangements should, however, be made for periodic evaluation, say every five years, of the objectives, plans and performance of each Institute to identify what has been achieved and areas which need strengthening and to re-orient its programmes and operations towards the changing needs of the industrial community.

Contacts with potential industrial clients should be arranged on a systematic basis by visits made by the appropriate officers, say industrial liaison officers, of the Institute. A permanently manned enquiry service at the Institute through which all clients could obtain quick answers or leads towards obtaining answers to their questions is extremely useful. The Institute must have comprehensive, up-to-date industrial, technological and commercial information, and the capacity to readily retrieve and disseminate it to clients who might need such information.

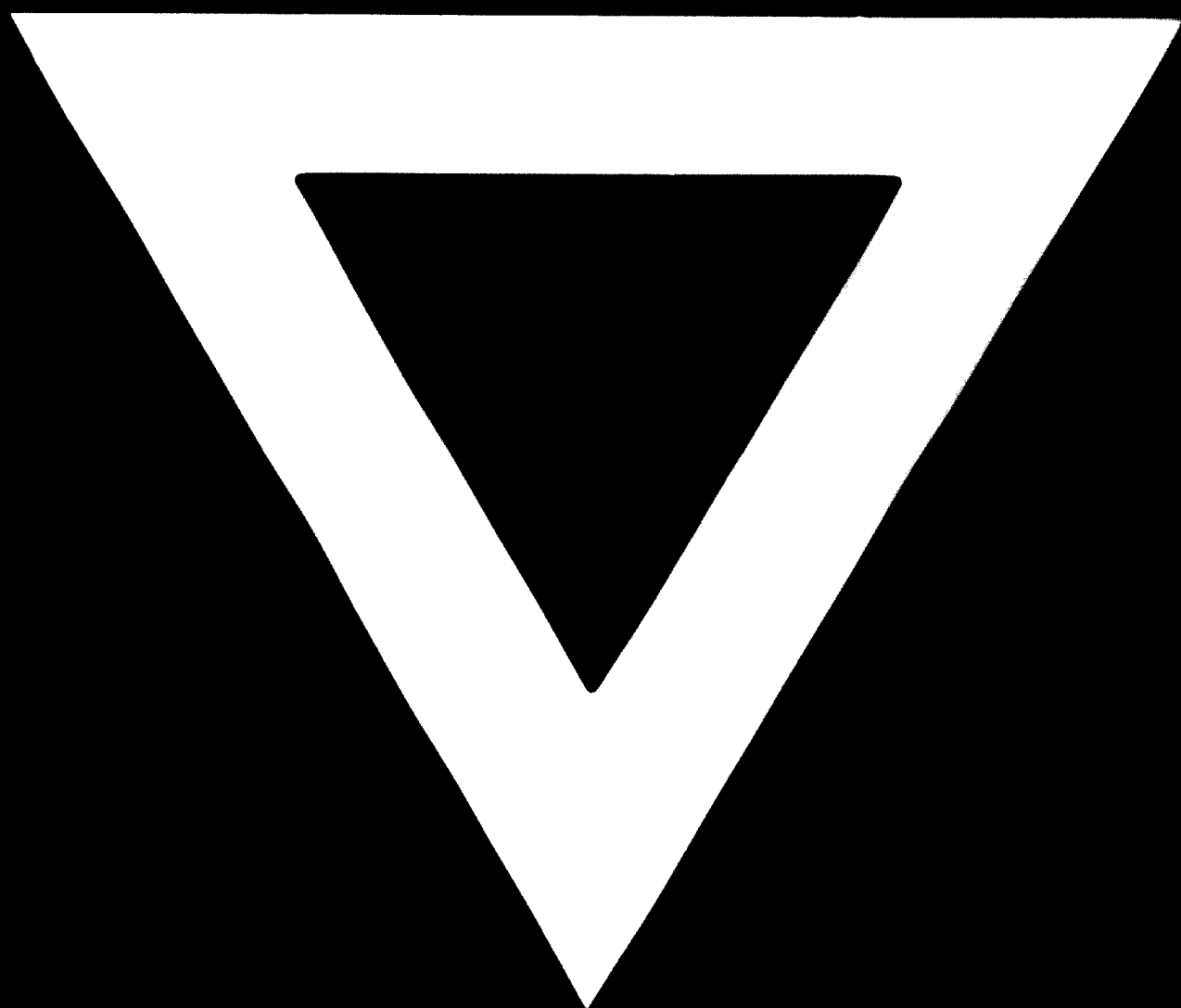
A capability which is essential in any Industrial Research Institute is that of analysing and testing raw materials and finished products. It should have the most comprehensive and suitable collection of a variety of equipment to enable it to act as the leading authority in this field in the country. In addition, the Institute should be able to standardise measurements of all kinds and calibrate instruments of various sorts. It may also be found necessary for it to undertake their repair and maintenance.

In addition to the engineering design necessary for modest industrial projects, the Institute should also be prepared to undertake the design, and perhaps the prototype production, of simple equipment required by small-scale industrial production. Some of this may involve only improvement in the design of traditional tools.

Research work should only be started when it is clear that, if technically successfully, there is likely to be a commercial case for the exploitation of the results. There should, therefore, be a careful paper study of a number of techno-commercial questions in advance of a programme being sanctioned and practical work started. Furthermore, as soon as possible, attempts should be made to interest a client, particularly from the industrial community, in "in-house" programmes which have been started. Pilot plant work is relatively expensive. Before undertaking such work much careful thought should be given to see if it is really necessary. Frequently data available in the published literature is adequate, while in other cases the required information could be obtained in large laboratory-scale equipment or in one section only of a pilot plant.

Over the years many mistakes and errors of judgement have been made in the industrialised and developing countries. With the experience now available and outlined in this document, it is hoped that both existing Institutes and those being planned would be able to benefit from this experience and achieve greater success.





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