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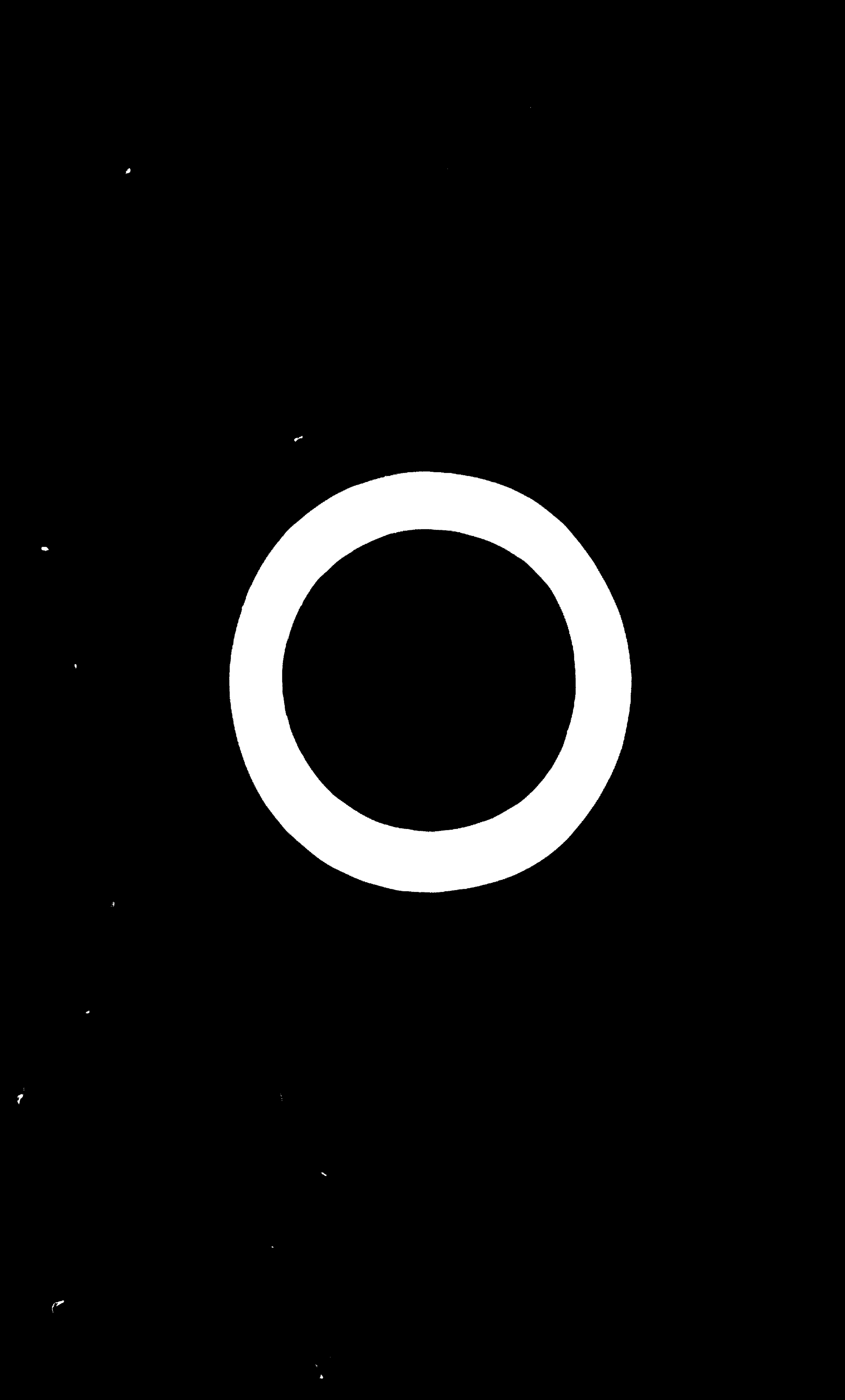
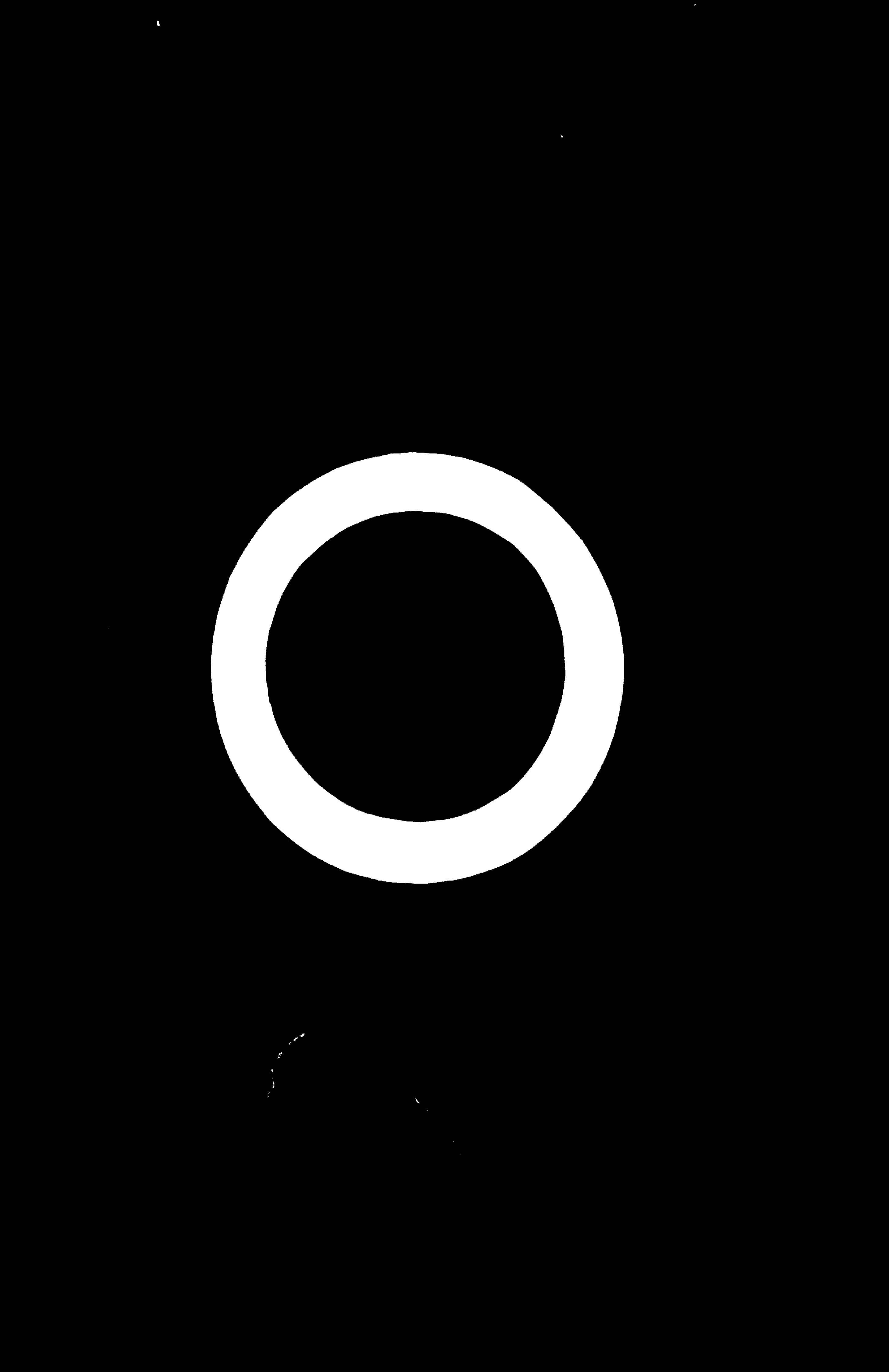
INDUSTRIAL RESEARCH INSTITUTES

I Project Selection and Evaluation
II Financial Administration

UNITED NATIONS





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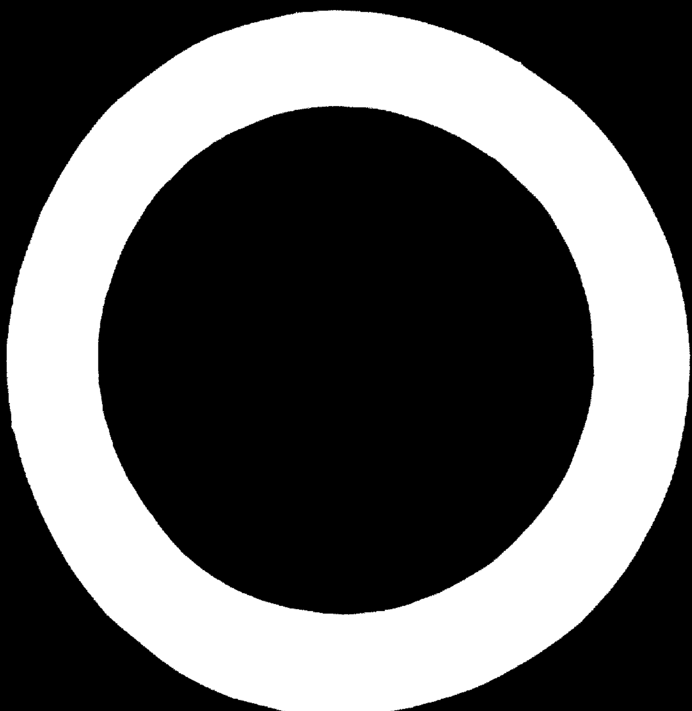

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
VIENNA

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Foreword

A United Nations Interregional Seminar on Industrial Research and Development Institutes in Developing Countries was held in Beirut, Lebanon, in December 1964, to seek ways and means of strengthening existing and future industrial research and development institutes in developing countries.

In the course of the deliberations, it became apparent that the problem of management was of paramount importance, since persons with the necessary experience were generally lacking in developing countries. As a result of these discussions, the Centre for Industrial Development - the predecessor of the United Nations Industrial Development Organization - published a *Manual on the Management of Industrial Research Institutes in Developing Countries*[1] to provide practical guidelines not only for managers and others working in these institutes but also for executives and policy-makers connected with the planning and conduct of industrial research in government departments and in private industrial enterprises.

Subsequently, UNIDO organized an Interregional Workshop of Managers of Industrial Research Institutes in Developing Countries, which was held in Athens in July 1967 and was attended by nineteen participants holding high managerial positions in industrial research institutes and by a panel of eight international experts. The discussion dealt with general principles which should govern the administration and functioning of research institutes: in illustration, typical institutes in developed and developing countries were discussed in case studies.

The discussions made clear the need for publications that could be of practical assistance to industrial research institutes in improving the quality of their work. The aim of this publication is to give such help in two important fields, namely:

The selection and evaluation of research projects;

Financial administration.

The wise selection of research projects and their proper evaluation at predetermined stages not only enhance the professional reputation of the institute but also have financial implications, since so much time is spent on projects and they constitute a major source of the institute's income. It was therefore impossible to avoid some duplication between the two parts without which the treatment of either subject would have been incomplete.

Background reports prepared on these subjects for the Athens workshop by Mr. Lawrence D. Bass and Mr. Robert Adams have served as the basis for the present publication.

[1] UN Publication Sales No. 66.II.B.3.

Part I consists of six chapters and covers the selection and evaluation of research projects.

Chapter 1 deals with the criteria for selecting projects. These criteria may be of a general nature, such as national development policy and general institute policy, having regard to its capabilities; or of a specific nature, such as the technical, engineering, marketing, economic or managerial feasibility of the project. *Chapter 2* contains a classification of the institute's short-term activities, such as information services, testing and quality control, technical services and standardization; of its small-scale activities, such as exploratory and applied research, product and process development, product evaluation and by-product and waste utilization; and of its intermediate-scale projects, such as engineering development and pilot plant. It also contains a classification of evaluation programmes into engineering and market evaluations, feasibility studies for new ventures and surveys of natural resources at a regional or national level. *Chapter 3* describes how to organize the institute's activities by means of a system of projects and illustrates this by an example of a research project proposal to develop natural tannins. *Chapter 4* details the mechanisms for project evaluation and shows the advantages of using special staff groups for this purpose and also of evaluating projects with clients. *Chapter 5* enumerates the major stages of evaluation and describes each of the steps in the evaluation and confirmation stages. *Chapter 6* explains how to organize a multi-discipline team to deal with projects and the advantages of the system. The principles are illustrated by an example of a multi-discipline team working on the project to develop natural tannins which gives estimates of the different categories of personnel required.

Part II, on Financial Administration, consists of four chapters. It is entirely devoted to financial questions related to the institute, from the early stages of feasibility studies to methods of drawing up contracts and their financial implications.

Chapter 7 deals with forecasting the institute's initial size and growth rate and with the financial aspects of initial and long-term planning. The sources of financing are discussed, including government subsidy, potential income from research and service contracts and the possibility of external assistance.

Chapter 8 discusses the details of capital and operating costs, including meeting the need for technical assistance either from international or bilateral aid programmes or by directly contracting for the services of an already established industrial research institute.

Chapter 9 describes all the elements of project accounting systems, including the allocation of staff time and overheads. *Chapter 10* deals with the financial side of the main work of the institute—the organization of research programmes for submission to clients, how to cost them and the provisions customarily included in contracts.

Three annexes following Part II illustrate points mentioned in the various chapters. **Annex 1** shows a specimen accounting system that a research institute can use. **Annexes 2** and **3** consist respectively of "An outline for a research project proposal", and "A form of agreement between an industrial research institute and a client firm sponsoring a research project".

An industrial research institute may be defined as a technical organization established to make direct contributions to industrial development in the private and public sectors. This definition distinguishes it from research institutions that conduct investigations to extend knowledge without having any responsibility for aiding directly in its practical applications.

When an industrial research institute is established in a developing country, the assumption is usually made that its services will be quickly utilized by industry and government agencies and that it will therefore soon become an important factor in stimulating industrial development. The history of industrial research institutes, however, does not bear out these assumptions, even in highly developed countries. A gestation period is necessary for the institute to determine and to supply the services required by the country's industrial complex and to acquire the necessary competence and recognition. It must inspire confidence among managers in its ability to render practical assistance so that all types of industrial groups will submit their problems. It will find that this confidence is best generated by disseminating information about successful projects it has carried out. It will inevitably find it difficult to reach smaller enterprises, which often do not know how to use technical help, and may indeed, be unaware of their need for it.

Only by selecting and completing practical projects that are then implemented by industry will the institute justify the original assumption of its value for industrial development. The director should have good judgement and be versatile and flexible. He must determine which activities will be of benefit to industry in his country. He must recruit competent personnel and lead them to employ their skills for useful objectives. He must establish procedures for selecting and managing projects that will attract and keep the interest of industry and government agencies. He must develop relationships with business organizations that will make it easier to translate new technical information into practical industrial progress.

Institutes in developing countries should select worth-while projects in order to employ their limited number of technical personnel to the best advantage. These projects should be managed so that they will have the optimum technological and economic impact. Otherwise, the resources and entrepreneurial spirit of the country will not be employed at the level most effective for socio-economic development.

Unfortunately, there are no good yardsticks to measure the efficiency of industrial research programmes, even those carried out by individual enterprises. In the case of an industrial research institute, however, one good criterion is whether industry and government agencies take an active interest in its services. This will be evident from the extent to which its services are being utilized i. e. from its income from private and public organizations. If the industrial community gains confidence in the institute's ability to solve practical problems and undertake successful assignments, the institute will receive more money to undertake specific investigations. An increasing income is the main test of success for any industrial research institute.

Realistic and consistent planning should be the keyword for the financial administration of a research institute from the date of its establishment. Most of the running costs will be for staff salaries. A close watch should be kept on this item through project accounting. Although it is inevitable that the institute should be heavily subsidized in its early years, it should attempt to earn an income from its activities as soon as possible. The only way in which it can do this is by making good use of its specialist staff.

PART I

Project selection and evaluation

PART II

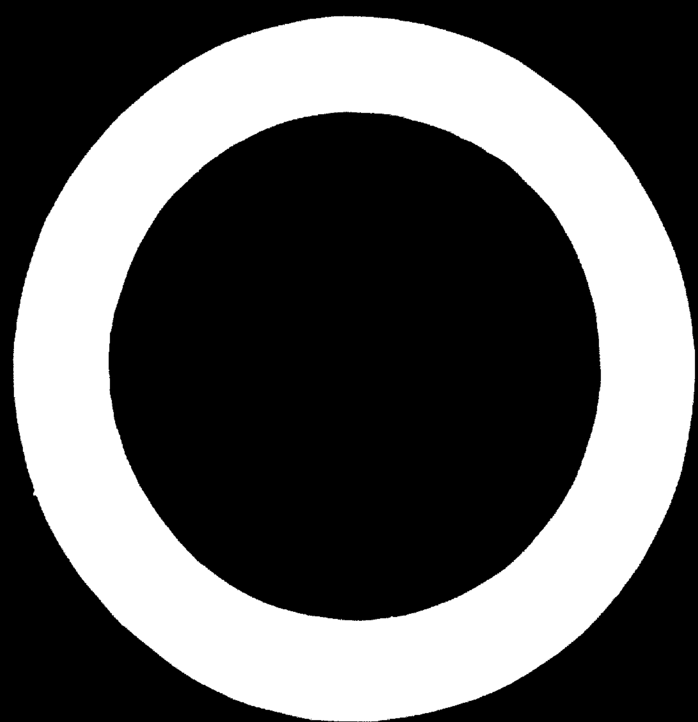
Financial administration

List of examples

Annexes

PART I

PROJECT
SELECTION AND EVALUATION



Chapter 1

CRITERIA FOR SELECTING AND EVALUATING PROJECTS

The management of an industrial research institute needs certain guidelines as to the type of projects it should handle bearing in mind its capacity to conduct them successfully and their industrial value. This is particularly true in the formative years when it has little experience to go by. The criteria discussed below are useful for selecting projects and for making interim evaluations of them.

ESSENTIAL STEPS IN EVALUATION

A project system (discussed in detail in a later section) has been found by most industrial research organizations to be an effective method for allocating the time of the technical staff to various activities. It is axiomatic that this allocation should reflect estimates of the relative importance of individual projects and different services.

A project should be organized by drawing up a written outline stating the objective, the technical and economic justification for the work, a summarized work programme, an estimate of the amount of man-hours required to reach the objective and a target date for completion.

Before such a project outline can be prepared, however, a preliminary study or exploration is necessary in order to estimate the potential value and the amount of work involved. Most organizations find it advisable to limit the effort devoted to preliminary work on a given subject. This can be done by establishing a rule about the maximum number of man-hours to be expended before a project outline is submitted. Experience in many organizations indicates that two to four man-weeks is a reasonable limit, with provision for an extension in promising cases. Between 10 and 15 per cent of the total time of the entire organization may be devoted at first to exploratory activities, although subsequently this may prove to be too much. As the staff becomes more skilled in the techniques required for preliminary evaluation, the average time spent on exploratory work for an individual project will be reduced.

The reason for setting a limit on the amount of exploratory work on a given concept is that such investigations tend to become diffused. People always think of new ideas that are attractive from the scientific or technical point of view; unless an objective has been defined, so that the work can be considered in terms of a practical goal, the researchers' interest may be diverted to other aspects that are not pertinent to the immediate subject. The fact that a project outline has to be prepared as soon as possible helps to focus attention on the major points that have to be settled to justify further work.

Experience also shows the wisdom of dividing a major undertaking into successive phases or stages, each of which is the subject of a separate project outline. Such subdivision improves the reliability of estimates of the usefulness of the work and the man-hours required before a new stage is begun. The stages serve as good checkpoints at which the project may be comprehensively re-evaluated to determine its validity before additional work is authorized. It then becomes possible at later stages to make more accurate evaluations, which require careful analysis because they involve greater technical effort and expense than earlier, smaller-scale phases.

To administer a project system, an analysis is required of the total amount of time spent on different lines of work by all members of the technical staff. The usual practice is for each staff member to submit a time card on a regular basis, for example, at weeckly intervals, showing the number of working hours he has spent on individual projects and other activities (for further details, see chapter 3 under "Control of short-term activities" and "Control of overhead activities"). The expenditure of time is often converted into financial equivalents for convenience of budgetary control. The cost of professional time normally includes part or all the overhead charges on a *pro rata* basis.

At longer intervals, for example, monthly, or quarterly for longer-term projects, the technical progress made should be reviewed in relation to the target data for completion and the budget for professional time. Such reviews should include a written summary of results achieved to date and of plans for future work to attain the objective.

Admittedly, it is difficult to estimate how much technical effort will be required to complete an investigation. Hence the administration of project costs must be understanding and sympathetic, or the morale of the organization will suffer. Progress reviews must take into account the uncertainties inherent in the original estimates and should provide for adjustment of budgets, time schedules and costs. Adjustments are usually not so seriously questioned in the case of in-house projects, because additional work and expense can be compensated by curtailing the time available for other internal activities. When it comes to sponsored projects, however, faulty estimates make it difficult to recover the full costs from clients. It is usually not considered good practice to return to them for higher fees or extensions of target dates: the institute is therefore obliged to absorb the over-run in expense and to increase the allocation of man-hours in order to maintain the schedule, to the detriment of in-house activities. The situation is often due to a broadening of the scope of the work, which should have been covered by earlier discussion with the client to obtain his agreement to the revision of the budget or time schedule.

In general, technical personnel resist the introduction of a system for keeping track of how they use their time. The plea is usually made that the estimates of time required to reach a defined objective are meaningless because it is not possible to foresee in advance the course which the investigation will have to take. This may be true of basic research, but practice in estimating time requirements for applied research projects makes the forecasts more realistic as the organization acquires skill in outlining the steps and amount of work required to reach a definite goal. The system must, however, be operated with flexibility.

In spite of the difficulties of making estimates of the man-hours required to complete a project, this scheme is a practical device for controlling the deployment of skills of the organization in terms of its over-all objectives. As such, it has become very widely used. Few, if any, of the industrial research institutes that have adopted it, have found it not suited to their managerial requirements.

General criteria for evaluation

National development policies

Many countries have already adopted or are formulating general plans for industrial development. These plans usually include the general objectives of expanding the domestic demand by increasing national and *per capita* income, of creating employment opportunities, of increasing the utilization of national resources and developing new raw materials and of improving the foreign exchange position both by reducing imports through substitution and by promoting exports.

Subsequently, more detailed criteria and legal norms for evaluating new undertakings come into force. In some countries, the government favours a strong central control over the type of new industrial enterprise which it is prepared to authorize and requires extensive justification before it will give approval. In others, the Government concerns itself chiefly with the infrastructure and certain sectors of industry that are important to the national welfare or require capital outlays beyond the ability of private sources to provide. Under this method of operation, the Government may leave to private entrepreneurs the initiative for establishing other new undertakings. It may provide incentives such as tax concessions, special terms for financing, protective tariffs, or favourable regulations for importing equipment or raw materials in order to encourage investment in preferred sectors of industry. In such cases lists are often prepared of industries favoured by the Government, classifying them, for example, into those of high and secondary priority.

The generally applied criteria may not be sufficient to assess the full impact on the economy of certain proposals. For example, a large investment is required for heavy industrial installations, such as iron and steel or petrochemicals, that do not directly create many jobs in comparison with the labour-intensive industries. On the other hand, the products of such enterprises may be essential to the expansion of secondary industries that offer employment to large numbers of workers.

An orderly plan for national development, even though it may be formulated in general terms, is therefore of help in establishing priorities for research projects. The industrial research institute can encourage the working out of development policy by requesting more detailed guidance from the national planning agency to assist it in evaluating the importance of both in-house and sponsored projects. If it frames these requests in terms of techno-economic criteria, it can create patterns of analysis that help to clarify the Government's objectives.

Institute policy

National policies become meaningful as criteria when they have been shaped by a study of specific test cases; in the same way, the growth plans of an industrial research institute reflect the experience of the organization in identifying promising areas for industrial development.

When an institute is first founded, it has the broad general policy of encouraging economic development by offering technical assistance to industrial and government enterprises. After operations begin, the practical problem arises of how to carry out this mission. For example, which sectors of industry does the Government wish to encourage? In which of these sectors will the private and public enterprises be most likely to recognize the need for technological improvement? In general, the science-based industries (for example, chemicals, electronics and pharmaceuticals) are more inclined to be receptive than those relying heavily on traditional know-how and experience.

The institute's policy must be shaped through experience in dealing with private and public organizations. The Board of Directors sometimes takes an active part in drawing up the work programme, but it often relies on the director and his staff to provide information on which it can base decisions as to the general lines of activity that will be effective in assisting industrial development.

The data required to formulate policy can be obtained by making a systematic market research to determine those sectors of industry that are not only likely to grow but that also need, and have a receptive climate for, new technology. Various methods of establishing contacts with managements have to be tried. Studies must be made of the services that will be most useful to the largest number of clients.

Institute capabilities

The reputation of an industrial research institute depends upon its ability to carry out successful projects; an important criterion for the acceptance of new assignments is, therefore, an objective assessment of the competence of the institute to handle them. Unfortunately, the news of failures is likely to travel faster than reports of successes. When sponsored projects show unfavourable trends, it is recommended practice to cancel them at an early date, if necessary, to refund the fees paid rather than to leave dissatisfied clients.

The institute should refrain from making over-optimistic forecasts about results. It should not accept assignments unless it is confident that its staff is competent to conduct and evaluate the investigations and that it has the equipment necessary to carry out the work; it may be able to supplement its own skills by establishing co-operative arrangements with other more specialized or experienced research organizations. Its estimates of expense and target dates should be realistic. If it cannot undertake the more advanced stages of a project that are necessary for its commercial application, the institute should inform the client to this effect. It should not make managerial decisions for the client except in the rare cases when it also has responsibility for implementing the decisions.

SPECIFIC CRITERIA FOR EVALUATION

The feasibility of an industrial research project has to be judged from several points of view: technical, engineering, marketing, economic and managerial. Before a project is accepted from a sponsor or authorized for in-house work, it should be given preliminary scrutiny from these five aspects. The institute's technical staff are usually competent to decide on technical feasibility. They may and often do have the qualifications to make judgements on engineering, marketing and economic feasibility; but, if possible, they should get the client's personnel to agree with their evaluations. Decisions as to managerial feasibility must rest with the client, who can alone determine whether he intends to implement a project on a commercial scale or use his resources in some other way. He should be made aware of the risks involved and skills required.

Technical feasibility

Technical evaluation is concerned with the suitability of processes and products. It involves such points as availability and cost of raw materials, feasibility of manufacturing steps and equipment and product characteristics within the range felt to be suitable for the market. This type of evaluation is usually made by an experienced technologist familiar with the industry to which the project relates.

Engineering feasibility

Engineering feasibility studies are made by engineers, often called process engineers, who consider such matters as types and availability of equipment, flow of materials through the operation, process control procedures, wastes, by-products and hazards. They make estimates of the cost of purchasing and operating plant and equipment including overheads. They prepare drawings of plant layout and specifications for equipment, materials-handling devices, construction materials and instrumentation for process control. They estimate minimum economic plant size when this is a pertinent consideration. They prepare drafts of manuals dealing with plant operation and process control.

Marketing feasibility

Marketing feasibility is usually called market research. "Marketing" is used here in the broad sense of consumption capacity and would include, for example, a survey to estimate the demand for fertilizers in order to meet a national target of greater agricultural production. A market study deals with the volume of demand, suitable price structure and requirements of distribution channels, including packaging. It also includes an evaluation of present and potential competition and should provide estimates of marketing costs such as expenses for direct sales, advertising and promotion.

Comprehensive economic feasibility review

After the process engineers and market research specialists have prepared their estimates, it is necessary to make an economic analysis of the whole project in order to prepare the data for entrepreneurial decision. Such an analysis may be carried out by joint efforts of the process engineering and market research groups, or it may be done by a separate group working closely with them. In either case, a sum for working capital is included in the estimate of the total investment required for the project. The rate of return on sales and investment and the cash flow are projected. The study may include the method of financing and the effect on the national economy. The report thus constitutes a summary of the financial results that may be expected from the commercial application of the project.

Managerial feasibility

As was stated earlier, the management of the private or public enterprise sponsoring the project must make the final decision regarding its commercial application. On the basis of the information provided on technical engineering, marketing and economic feasibility, the advantages of a commercial operation must be weighed against alternative uses of resources. For, even if it is assumed that the feasibility studies are all favourable, there still remain questions that can be answered only by the management of an enterprise or a government agency. Is the undertaking in line with existing policy and plans for future growth? If it is not, is it still so attractive that it warrants revision of these general objectives? If so, the particular project should then be compared with other possibilities that can be considered if the criteria are revised. Does the organization possess adequate managerial talent to launch the new venture successfully? If it should later expand in scope, would it force the enterprise into new raw material commitments, types of processing or marketing areas beyond its capacity? If the management has already worked out systematic criteria on which to base policy decisions, these questions should have been raised at earlier stages so that work on doubtful projects can be cut short. It is advisable that the institute's contract with the client make provision for such re-evaluation at major stages of the project. Nevertheless, before the final decision is reached, the proposed commercial application should be reviewed once more in its entirety to make sure that it conforms to the enterprise's broad objectives for expansion and growth.

Chapter 2

CLASSIFICATION OF ACTIVITIES

Typical pattern of development

Initially, industrial research institutes are usually staffed to handle only a limited range of problems and services, chiefly in technology. Some institutes are concerned with the science of management, but they are not generally called "industrial research institutes". Instead they are more likely to be described as "management development" organizations. However, research institutes may establish divisions to handle problems of economics and management as the need for these services becomes apparent.

In developing countries, the general pattern followed in establishing industrial research institutes is to assemble a staff of individuals whose academic training usually includes chemistry and other branches of physical and applied sciences and engineering. Some of the personnel will have had experience in certain branches of technology, and other staff members may be given the opportunity to take advanced training in various industrial fields in more highly developed countries. The assumption is that the projects will, in general, be of longer-range character, and personnel are selected largely on the basis of their training for this type of work. In addition, the institute assembles a library with a small staff to provide an information service and sets up an analytical and testing section to assist research projects, act as a quality control service and carry out special assignments from government agencies and private enterprises.

As the institute grows, it is likely to expand its range of activities. Usually one of the first additions is an engineering group to carry laboratory work to a pilot-plant scale and conduct engineering analyses to determine the feasibility of large-scale manufacture. Such groups are often in great demand to conduct projects for industrial enterprises and government agencies.

The institute then begins to receive requests for comprehensive economic evaluations and may need to carry out market research. Groups making economic evaluations consist principally of economists, development engineers and "process engineers", who are likely to have received more training in business economics than those whose education has been chiefly scientific.

About the same time, there is likely to be a demand for advisory services to assist industry or government establishments on short-range applied problems. The more experienced staff members often do this in their respective areas of competence on a part-time basis. Their activities may be supplemented by expatriate technologists who provide constructive help and enjoy considerable prestige because of their extensive experience. They can give valuable practical training to their local counterparts, if they work closely with them. Inclination towards short-range technical service is a matter of personal preference. Many science-oriented individuals do not like such assignments and prefer to stay in longer-range projects; others, with a more practical bent, prefer direct contacts with industry. The United Nations Industrial Development Organization (UNIDO) has provided international experts to assist a number of industrial research institutes in developing countries with programmes to provide technical services.

Such additional technical activities often grow very rapidly. This is particularly true if the institute wishes to obtain at least some of its income from sponsored projects; in developing countries, clients are more likely to be interested in projects that lead to rapid commercial applications than in the classical type of product and process development for which the institute was often founded in the first place. The reason for this is that time is saved by acquiring existing technology and know-how from some source, rather than by obtaining it through research and development.

Speedy industrial growth seems particularly desirable in developing countries. Hence, if a new operation can be put into effect by using foreign technology, this course is likely to be adopted. The important point that the country will need improved technology in the future or technology better adapted to its requirements is often overlooked. When an up-to-date plant has been installed and the local operating personnel have been trained, it is often assumed that the technology will remain static for the life of the plant. Sooner or later, however, improved technology will have to be discovered to handle different raw materials, to satisfy changing patterns of consumption, or to meet altered economic patterns. This new technology to meet local conditions cannot be easily and rapidly obtained. The enterprise must provide it through its own staff, outside consultants or turn to the institute with its pool of diversified talents.

Various categories of activities are discussed in the following pages:

Short-term activities

Information service

Digests of technical information are of value to industrial managers. Institutes regularly publish technical summaries or abstracts of important papers. This activity has the advantage of creating goodwill and contacts among those on the distribution lists and is a way of drawing attention to the work of the institute. To reach smaller companies most effectively, special publications are needed, relating to particular fields and written from a very practical point of view; some industrial associations may be willing to share the cost of such publications.

In addition, the institute usually offers to provide information on specific problems from its library or its specialized personnel. The information service is normally an overhead expense of the institute. It is a valuable promotional activity that often leads to sponsored projects. Occasionally an assignment is received that requires an extensive study; a charge may then be made to recover part of the expense.

Analysis, testing and quality control

The testing section of an institute is a valuable service to local manufacturing establishments, a great many of which cannot carry out such work themselves. Part or all of the costs may be recovered by appropriate fees; charges for the service are a wise safeguard against requests for analyses that are not justified. Where possible, the institute should encourage clients to submit samples in a form suitable for standard testing; otherwise, the laboratory staff will have to work out a special procedure to meet the case, and it may be difficult for the institute to charge for the extra time involved.

It is sometimes possible to establish a regular system of quality control for purchases by the Government, industrial associations or individual establishments. The volume of such work obviously justifies making a charge for the service. Regular standard tests of this sort that make efficient use of staff and equipment reduce the average cost of analyses.

Analysis and quality control in the past did not enjoy high professional prestige because the work was routine and was performed chiefly by non-professional personnel. As more advanced techniques have been developed, using sophisticated instrumentation and interpretation, this work has become much more attractive to well-trained scientists.

Technical services

Often called "troubleshooting", technical services deal with a wide range of practical problems encountered in manufacturing. They may involve recommendations on selecting or handling raw materials, controlling operations, adjusting equipment, training and supervising operatives, storing and packaging products, or dealing with complaints or inquiries from customers.

It is difficult to develop a system of charges that will cover the expense, although, when the problem requires several days to solve, a charge on a cost-incurred basis may be made. Troubleshooting is, however, a very valuable service to industry and one that broadens the experience of the staff. It is the policy of many institutes to devote a fair percentage of their domestic budgets to this activity. Technical services create goodwill and help to reveal more important problems, which may ripen into sponsored or in-house projects.

Standardization

Standardization is a valuable service carried out by some industrial research institutes either by checking samples against specifications, working out technical procedures for such checks, or even conducting the entire procedure of selecting, establishing and publishing specifications and assisting industry to attain them.

It is often subsidized by government agencies or industrial associations, and the cost of evaluating individual samples may be charged to those submitting them.

Standardization is important for government purchasing operations, for upgrading the technical quality of an industry and for producing goods of acceptable export quality. In a number of countries standardization is the responsibility of an independent organization. In such cases, staff members of the institute serve on the technical committees set up to formulate national standards, and the institute can undertake many technical investigations for the National Standardization Institution.

Medium-term activities

Exploratory researches

Exploratory researches are often required to determine the technical parameters of a concept for a new product, process, or use for a raw material. They provide information upon which it is possible to base an ordered plan for a project to reach a defined objective. To make the best use of technical skills, the project outlined should be drawn up as soon as sufficient information is available; otherwise, man-hours may be wasted. As stated in chapter 1, many industrial research institutes find it advantageous to set a limit on the amount of time expended on a given idea before a project outline is prepared.

Long-term activities

Product evaluation

Product evaluation is usually conducted by specialists, often from the analytical section, who are skilled in the development and application of test procedures, including those of the analytical type but also some which simulate performance under conditions of use. The work involves systematic study of the proposed product and critical comparison with competitive products, including price.

In addition, field tests need to be carried out. For industrial products, these are usually small-scale tests in the plants of potential industrial customers. For products sold to the general public, consumer-testing procedures are used. These investigations will either confirm the preliminary product specifications or show that modification is required.

Applied research

Applied research projects are carried out to provide a preliminary definition of a product or process. On the basis of the information obtained from exploratory work, the investigation is undertaken to confirm that known raw materials can be converted by laboratory techniques into specimen products that could be readily utilized. This work may be carried out by scientists or technologists; in larger organizations, it is often assigned to an applied research section.

Product development

Product development, carried out by technologists who have specialized in the products manufactured or used by a particular sector of industry, is required to refine the definition of useful products reached through applied research, to explore systematically the merits of various modifications or formulations and select the most promising, to develop methods of testing their relative efficiency, to set preliminary product specifications, to confirm the preferred forms of available raw materials, and to demonstrate the proposed method of production.

Process development

Process development, which may partly overlap the product development project, is conducted to evaluate the proposed sequence of operations in terms of manufacturing practicability. It is best carried out by technologists with experience in the type of manufacture concerned. Its object is to prepare a preliminary process definition in which raw material specifications are set, equipment and optimum operating conditions for each major step are described, process and quality control procedures are proposed and preliminary estimates of plant investment are prepared. The scheme of operations is usually shown in a process flow diagram. Finally, the preferred process is carried out on a large laboratory or pre-pilot scale to produce sufficient quantities of the product for critical evaluation.

By-product and waste utilization

Studies on by-product and waste utilization may be carried out to make manufacturing operations more economical or to abate nuisances. The investigations may require the entire sequence of stages described previously in this section or they may begin with product and process development. Special attention should be paid to the future volume and composition of the waste or by-product in the light of possible changes in raw material or process.

Engineering development

Studies on engineering development are carried out to verify the results of process development work. They require rigorous analysis of the suitability of the process for scaling up to a commercial operation. They involve complete process design, final specifications for equipment and auxiliaries, and firm estimates of operating costs and plant investment. Frequently they also include the preparation of drafts of operating manuals. They may require establishment of criteria for selecting new plant sites and specifications for new buildings.

They provide data on operating costs for managerial decisions. Engineering assistance of this type may be required throughout the design, erection and initial operation of commercial plants.

Pilot plants

Pilot plants are semi-commercial scale prototypes of large plants. Although they are expensive to install, they should be used, if necessary, to confirm the information from process development studies. Where feasible, however, only part of the entire process should be piloted as an economy measure. Pilot plants are nearly always below minimum economic size and are therefore also expensive to operate as small production units unless the products can initially command premium prices. In developing countries, pilot plants often provide an effective means of training operatives from individual establishments in new or improved techniques.

EVALUATION PROGRAMMES

Engineering/economic evaluations

Engineering/economic evaluations are similar to the engineering development work described previously as one of the stages in developing products and processes. It is listed again in this section because industrial research institutes are sometimes asked to carry it out for clients. In such cases, the information available may not be as complete as it would have been if it had been collected systematically within the institute. Such evaluations, therefore, call for careful scrutiny to determine whether the basic facts are available on which to base a judgement. Some gaps may be filled by interpolation from other data. On the other hand, there may be deficiencies that can be supplied only by experimental work.

Market evaluations

Market evaluations may be requested by clients when an industrial research institute is competent to undertake them. They may be conducted by surveys of potential customers through questionnaires and personal interviews or they may require submission of samples to industrial users or carefully selected consumer groups. They provide the information management needs for deciding on marketing feasibility. This service includes such activities as statistical analyses and opinion surveys.

Feasibility studies

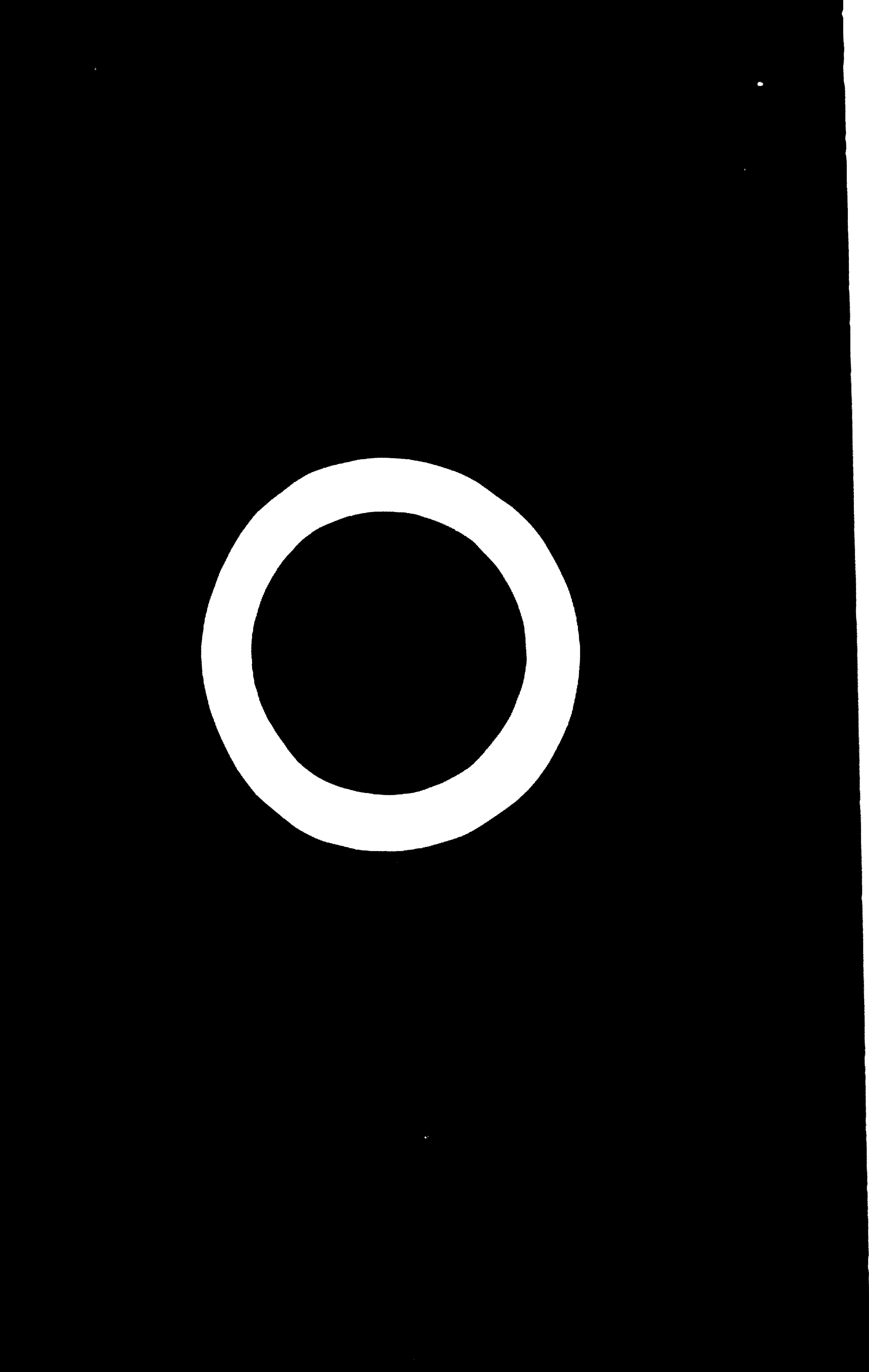
Comprehensive studies incorporating market analysis, selection of appropriate technology, engineering and economic appraisal of proposed ventures are often referred to as "feasibility studies". If an industrial research institute is to carry them out successfully, it should have personnel adequately qualified in all these subjects. Such investigations are best conducted as a team effort because the skills from different disciplines benefit from cross fertilization.

Surveys of natural resources

Surveys of natural resources, including raw material surveys, are of importance to economic development in countries lacking accurate information on the extent and quality of their resources. Industrial research institutes may be asked to conduct such studies, which require breadth of experience in technology and economics on the part of the staff.

Regional and national development studies

Regional and national development studies are comprehensive reviews to determine how well the natural and human resources are suited to various new industrial operations. Industrial research institutes have often carried out surveys of this type.



Chapter 3

PROJECT SYSTEMS

Advantages of administration by project

Many industrial research organizations in developed countries, both institutional and those in individual enterprises, have adopted the managerial device of subdividing their operations into projects for the purpose of defining objectives and allocating staff to individual lines of work. Projects provide a framework for analysing the programme in terms of general plans and objectives. Although some organizations operate successfully without the formal procedures discussed in this section, the management must in any case use these principles in assigning work to the staff.

This system of administration may suffer from two weaknesses. First, projects may be selected chiefly from the viewpoint of technical interest and feasibility, without an adequate evaluation of their engineering, marketing, economic and entrepreneurial justification. Second, even though estimates of the man-hours and the timetable are included in the project outline, the rate of progress may not be adequately reviewed by the management in relation to the cost; hence the work may be allowed to continue without careful re-examination in terms of its ultimate value as against the total man-hours required.

For efficient administration, some form of accounting for expenditure of time, preferably on an hourly basis, is essential. This will not show time spent on activities other than formal projects unless the staff's time cards mention these other categories. The management of projects may be excellent, but the total amount of effort available for them may be reduced by laxness in examining the other ways in which the staff spend their time. In many organizations, therefore, account numbers are set up for time charges for miscellaneous technical activities and overhead activities. For practical reasons, the number of such accounts, which are discussed in more detail in chapter 9, should be kept to a minimum. A specimen staff time card is given in example 6.

The underlying purpose of accounting for time in professional organizations should be clearly understood. It is a managerial system to enable the executive staff to direct the institute's effort into the most constructive channels. It is a procedure that should be accepted by staff members as helpful in increasing their efficiency, and it should never be regarded as a disciplinary measure for controlling attendance during stipulated working hours. Attendance records should be kept by some other appropriate means, and the two should be handled separately. Second, if the system is to be recognized as a managerial tool, it must be applied as such and used to compare expenditure of effort against projected value of results.

Finally, a project system has great value as an on-the-job training in managerial principles for all staff members. It has been pointed out that the essence of successful administration is to train the other members of the organization to be good managers in their own functions. Certainly a project system can be a useful means of training in logical methods of defining objectives and their importance, of outlining procedures to reach them, of examining the progress made at intermediate stages during the investigation, and of evaluating the results in terms of the goal.

Research project proposals

In describing a research project, it is essential to justify it and define its objectives and requirements. The following headings are very frequently used in project proposals by industrial research institutes and by the technical departments of private or public enterprises:

Subject

A short descriptive title is a very useful way of referring to a specific project. The routine use of titles instead of numbers is recommended because the latter do not have significance except for those intimately identified with the work and have to be explained in discussions with individuals outside this limited group.

Objectives

The objective of the work should be stated in concise form, for example, "the development of (a certain type of product) for use (in a defined application) to permit (greather efficiency, better quality, lower cost, or utilization of an available raw material)". A short statement of purpose helps to keep the attention of the research team focused on a definite goal.

Justification

If the activities of an industrial research institute are to be concentrated on projects that have practical application, the assumptions about their utility should be carefully examined. The analysis must necessarily be less rigorous for work in the earlier stages of research and development. Nevertheless, it is recommended as general practice that each project proposal include a statement explaining why it is considered useful; the project should be justified in terms of technical, engineering, marketing, economic and managerial feasibility. For in-house projects, special thought should be given to the type of enterprise or agency that might make use of the results, preferably with mention by name of one or more entrepreneurs with whom the concept has already been discussed or will be discussed as soon as enough information has been obtained.

In addition, the project's potential value to the economy in terms of the Government's industrial development policy must be estimated.

Proposed programme

A summary of the plan for attacking the problem should be given. The need for information or assistance from other groups or organizations should be foreseen and planned from the inception of the project.

Personnel requirements

An estimate should be made of the number and categories of individual staff members needed to carry out the investigation and the man-hours involved.

Cost of project

The total cost of professional time and other major items of expense, including new equipment, should be estimated.

Future extension of the work

The project proposal should cover the major stages of the work, and the additional stages required to make it suitable for commercial application should be stated. The advice of other sections of the institute responsible for the later stages should be obtained on this subject as early as possible.

Assignment of responsibility

The name of the staff member responsible for directing the project should be stated together with the names of those who will assist him or work under him.

Outline of a specimen research project proposal

Annex 2 to this publication gives a form of research project proposal, useful for accounting purposes and for submission to clients.

Example 1 illustrates a combined process and product development stage to provide a commercial source of tanning agents from local raw materials. Preliminary investigations have revealed that suitable raw materials are available, that existing technology can be adapted; there is believed to be adequate justification from the viewpoint of economic and managerial feasibility, and the project is in line with the national development policy.

The statements may appear to be more positive than would be possible for many in-house projects of industrial research institutes. If such institutes are to

Example 1

RESEARCH PROJECT PROPOSAL

Subject — Natural tannins.

Object — To develop a commercial method for extracting natural tannins from two local sources of bark to supply a major part of the domestic market.

Justification

Technical — Bark from two species of trees (.......... and ....) existing in large numbers has been found to contain considerable quantities of tannins which preliminary tests show to be similar in properties to imported materials.

Engineering — The extraction and purification processes would follow known technology and would require equipment which can be made locally.

Marketing — Present total domestic consumption of imported tannins of similar type is ....kg per year, selling at $.......... per kg, total value $.......... If 50 per cent of this market could be supplied by local manufacturers at 80 per cent of the present price, total sales would be $.......... A marketing organization already exists in ABC company which sells imported tannins.

Economics — Preliminary estimates of direct manufacturing cost, assuming bark delivered to the plant at $.......... per ton, is $.......... per kg of tannins. Estimate of plant investment to produce ....kg per year is $.........., including purchase of land, erection of buildings, and auxiliary facilities.
With 5-year amortization and appropriate allowances for sales costs and overheads, total profit is estimated at $.......... per year for a 5-year period, which would pay out the investment in .... years. (These are recognized to be rough, or "order of magnitude", estimates which will require careful revision when this phase of the investigation has yielded more exact information.)

Managerial — ABC company would be willing to undertake commercialization, and would pay the institute one third of product and process development cost on acceptance of the results and would meet the entire costs of later development stages. (This is a special arrangement for this case.)

Programme — Fifty representative samples of bark will be collected in the field for analysis and used as raw material in the investigation. The extraction process described in (reference) will be carried out on 6 large composite samples in glass equipment. The tannins will be isolated and purified by the procedure used by (reference). The products will be evaluated by the leather section of the institute. If evaluation is satisfactory, a quantity of ....kg will be prepared for small tests in 3 commercial tanneries in comparison with imported material now being used.

Personnel requirements — The total number of man-hours to complete the project is estimated as follows:

	Manhours	Completion date
Sample collection		
Analysis		
Extraction procedure		
Purification procedure		
Evaluation of product		
Preparation of large samples for field tests		

Costs

	dollars
Technical manpower	
Supplies, travel etc.	
New analytical instruments	
Total	

Future work

Estimate of costs and schedule of work to be supported by client:

	Manpower	Other expenses (dollars)	Completion date
Pilot plant			
Market test			
Design of plant			
Supervision of construction			

Reporting

Monthly reports to: ______________________

Project leader (Name): ______________ ______________ Date: __________
(Signature)

Authorization (Director): ______________ Date:
(Signature)

make the practical contributions to industrial development that are expected of them, however, the directors would do well to insist that all concepts proposed for research be subjected to this type of scrutiny.

This project proposal is for internal administration. The information on which it is based would be used to prepare the terms of the contract or agreement with the client. Further information about costing a project will be found in Part II, chapter 10.

Control of short-term activities by collective project

The management of an industrial research institute often does not realize how much of the technical staff's time is expended on miscellaneous activities made up of numerous short assignments. These include analysis and testing, technical services, exploratory work and the like. Though they help in improving industrial operations in the country, a fact which is recognized by the institute's policy, they may consume much more professional time than was assigned to them in the programme unless they are subjected to some kind of managerial control.

Analysis and testing

For the purpose of managerial control, analysis and testing are assumed to cover all the work done in the testing and analytical section; their share of the total programme is determined by the number of individuals in the section and the costs associated with their work. But this does not show the cost of the work done for other sections on their projects or for clients who pay a charge covering a part or the whole of the cost, or for work done as a free public service at the request of enterprises and agencies. When analyses are carried out for other sections, the cost is really part of the project costs and should be charged to them. Assessment of costs against projects or clients can be much simplified by establishing a schedule of charges for standard types of analyses.

A control study can be given the title "Analysis and testing" and the objective may be stated as: to accumulate figures on the total amount of analysis and testing, with details on how it is being distributed among those requesting the services.

Mere collection of figures becomes a useless chore for everybody unless the data are put to use in a constructive way. A control chart tabulating the internal or external requests would help answer questions such as the following:

(*a*) Is the work done for other sections continuing at a reasonable level? Has it been increasing or decreasing? Do some sections appear to be using the service too much, while others are not using it all?

(*b*) Is any trend discernible in the volume of work done for clients? Do the fees collected bear a reasonable relationship to actual cost? Are there trends in the type of work that indicate the need for different personnel or facilities?

(c) Is the volume of requests reasonable for work done as a free public service? Should an attempt be made to charge for some of it? Are there discernible trends in type of work and source of requests?

From a still broader point of view:

(a) Are the paying clients or recipients of public services being studied as possible sources of other types of projects in order to take advantage of goodwill created?

(b) What is the total number of analyses classified by type and branch of industry? Does this number appear to be reasonable in relation to the total man-hours available in the section?

(c) How does the cost per analysis compare with figures that may be available from other organizations?

(d) Does the work-load show fluctuations that might be smoothed out, or could part-time temporary assignments to or from other sections accommodate the trend?

Such information would be very useful to the management in planning the over-all strategy and requirements of the testing department.

Technical services

These activities may similarly be collected under a master project, by using a control chart of the same general type. The objective might be given as: to collect data on the amount of work devoted to identifying specific short-term problems, interpreting tests and data, and proposing solutions. The control chart should tabulate the source of each inquiry, the type of problem, the staff member who handled it, the total time spent and the cost (preferably including costs for work by other groups, such as the analytical section), other expenses, such as for travel, and the fee charged.

Control of overhead activities

Overhead activities consume a considerable part of the staff's time. A good manager will supervise the time spent in this way, decide how necessary or valuable any activity may be in relation to the objectives of the institute, establish a policy concerning overhead activities and procedures for regulating them and finally, exercise control in accordance with these rules.

A few comprehensive studies should be undertaken to obtain an analysis of these activities. If, however, the staff member's time card lists too many categories, it will take a long time to fill in and will be difficult to analyse constructively because temporary situations may cause wide fluctuations in the individual accounts. If it appears desirable to make a detailed analysis of certain categories, this should be done by an *ad hoc* survey rather than by adding a new category with its account, which will probably continue through inertia after its managerial importance has lapsed. Responsibility for supervising each category of overhead-time expenditure is retained by the director or allocated to a particular member of his senior staff. Each category should be defined concisely in an explanatory manual in such a way that each staff member will have little difficulty in allocating his time to the different accounts. (See also chapter 9 and example 6.)

The various categories into which overhead activities should be subdivided depend upon the local situation and the judgement of the director. The following are suggested as those that many organizations have found useful:

Administration

Time charges usually limited to senior members of the organization.

Professional development

Time spent on training courses, attendance at technical meetings, library work and study of literature to keep informed about technical and professional developments.

Public relations

Hours devoted to meeting visitors, meetings with potential clients to discuss assignments or preliminary analysis of problems that might be submitted and preparation and presentation of technical papers. (Some organizations find it desirable to set up an account for "project development" or "business development" to keep track of the time spent on discussions with potential clients about possible work assignments.)

Illness and holidays

Records of working days lost for these purposes are needed to give the management a complete record of how the staff have spent their time. Some industrial research organizations use statistical records of such absences for managerial control to prevent abuse of privileges and also to compensate, if need be, for unused annual leave and for overtime work by the secretarial staff and the manual workers.

Chapter 4

MECHANISMS FOR PROJECT EVALUATION

An axiom of good management is that an objective and systematic assessment of performance should be constantly maintained. The individuals engaged in a line of work are likely to be biased because of their direct involvement. Although they are the ones most familiar with the details of the progress made in the investigation, they cannot, in the case of a research activity, divorce themselves from their personal inclinations and enthusiasm.

An industrial research institute needs to analyse the results of its work from a particularly broad perspective. In earlier chapters, it has been pointed out that to evaluate a project, it must be examined from the viewpoint of technical, engineering, marketing, economic and managerial feasibility. To be effective, such an examination must be made by experienced individuals with a specialized background and professional qualifications. Though a technologist may be competent to handle problems in some sectors of industry, it is questionable that he will apply impartially rigorous criteria in appraising the advantages and disadvantages of his own findings, even if he thinks he is being reasonably objective. It is a sign of professional maturity when he recognizes his limitations and seeks the advice of the specialists in areas about which he knows little.

Drawbacks of evaluations by senior staff

Evaluation procedures in most industrial research institutes are therefore usually referred up the hierarchy of the division concerned. It is assumed that each successively more senior supervisor will have a broader basis for judgement, but this is by no means necessarily true. The supervisor may have higher rank and often be more mature, but his opinion may have less validity in a given case than that of the project worker who is steeped in the technology of a particular sector of industry. In fact, if the project worker makes out a good case for his views on a subject with which his supervisor is less familiar, his recommendations are likely to be accepted without reservations.

As the evaluation proceeds to higher levels in the organization, either through meetings or reports, the same thing is likely to happen. Successively, the individuals concerned are presumably more experienced and have greater maturity, but in an organization such as an industrial research institute, they are normally better qualified in technology than in engineering, marketing, economics or in understanding the factors on which an entrepreneur is likely to base his decisions.

It is probable therefore that the individuals concerned will have had less and less contact with that sector of industry for which the project has been developed.

At some stage, engineers, market researchers, or economic analysts from other parts of the organization may be called in. This is not likely to occur until a large amount of work has been done and the project has reached a critical stage. In a large institute, these experts may not even have been aware that the project was in existence. When their opinions are requested, they may have to base them on limited examination or they may be requested to make an exhaustive evaluation. They may reach the conclusion that the information available is inadequate for their purposes or even that a good deal of work needs to be done in other directions.

Advantage of using staff groups for evaluations

Unfortunate experiences of this sort have led some directors of industrial research institutes to establish staff groups to undertake interim evaluations of the engineering, marketing and economic aspects of technological investigations. They are used as "devil's advocates" to review projects periodically so that their findings and recommendations can be acted upon at an early stage of the research project.

These groups need not be large if they are made up of individuals with broad experience. For example, a senior engineer with one or two junior assistants can handle engineering evaluations for a fairly large organization. One or two individuals experienced in market investigations can take care of these aspects. Economic evaluations can be made by the group as a whole, working as a team. When it is considered desirable to add one or two economic evaluators, these are often individuals with an engineering background who have become qualified in industrial economics.

The cost of these evaluators' time is rightly charged to the project because they make a real contribution to its success. In organizations using this form of accounting, the project budget should include funds for such evaluations.

The services of evaluation groups are valued by clients, particularly in developing countries. Many industrial or government agencies feel that they need outside help in the form of independent and technically qualified opinion in order to determine the feasibility of major undertakings. Not infrequently, industrial research institutes find that such activities are among the most rapidly growing sectors of their operations.

Evaluating in-house projects by the test of sponsorship

The use of staff evaluation groups can help the institute management in selecting and implementing projects supported by its own funds. If their preliminary opinions are obtained at the end of the exploratory period, when the project proposal for applied research or product development is being drawn up, the objectives and criteria will be more realistic. If they make more detailed analyses at subsequent stages, the likelihood that the project will have practical value is increased.

In one important respect, however, internal evaluations by the institute staff cannot be considered adequate to justify further work. No matter how attractive the project appears from all other aspects, if no private enterprise or government agency takes entrepreneurial interest in financing further activity and applying the results commercially, continuation of the project is likely to be unproductive. It is sound practice, therefore, for the institute management to seek a sponsor as soon as results show that the project has serious commercial possibilities. An entrepreneurial group may not be willing to participate in the expense until further work has been done. However, the discussions will reveal what further information the entrepreneurs think should be collected. Even after this has been done, they may finally decline to go ahead with the project; but with the additional results, if the economic climate for the venture is favourable, the institute will be in a better position to seek another sponsor. If this search for entrepreneurial interest is still unsuccessful, the project should remain dormant until more favourable conditions for commercialization arise, but a report containing the essential facts and findings should be prepared.

The question naturally arises as to how far the work should be carried before attempts are made to find a sponsor. A logical answer is: the sooner a sponsor is found, the better. There is, however, a particularly good dividing line between the evaluation stages and confirmation stages that are discussed in detail in the next chapter.

It therefore appears that a reasonable cut-off stage for unsponsored in-house projects is at the conclusion of the evaluation stages. At this point the product or products have been defined and samples of preferred composition or formulation are available for inspection. A preliminary estimate of operating costs and plant investment has been made. Projection of market volume and price range has been based on internal evaluation and confirmed through field tests. From these data, a forecast of economic feasibility can be made that should be sufficiently accurate for initial entrepreneurial decision. This should be the basis for an agreement whereby an entrepreneur meets the whole or part of the cost of larger-scale work, or at least undertakes to do so if any additional information he may request is still favourable to the project.

Advisability of evaluating projects jointly with clients

Discussing a project's progress with the client concerned is a useful way of speeding up its commercial application. Some organizations have established a policy of frequent contacts. Even in the case of long-range projects it is often advantageous to be in touch with the client at least once a month by personal meeting, report, letter, or telephone call, if only to let him know that the work is going ahead on schedule. It should be borne in mind, however, that the institute reserves the right to make the final decision about the research it has undertaken. Contacts with the client, therefore, are only for the purpose of determining how the results can best be utilized by his organization, and he should not be permitted to assume direction of the work.

In the case of larger industrial organizations, it is often valuable to have contacts at two levels, one between the chief executive and an institute executive, the other at the working level between project personnel and the employees in the client's firm who will be responsible for the commercial application. Research and service contracts often mention by name the official representative of the firm and the representative of the institute, who is generally the person who keeps in touch with the progress of the work.

The importance of client contacts increases in the later stages of the project. In the earlier phases, information is being collected, but the steps needed to apply it have not yet been defined. As soon as it is possible to programme the manufacturing processes involved, however, there is merit in discussing how they will actually be carried out.

Manufacturing processes have to be adapted to the client's resources of personnel, either those already in the organization or those who will be engaged to take care of the new venture. The design of plant, operating directions and training of personnel need to be worked out so as to fit in with the factory conditions. The resources required for successful marketing have to be agreed upon with those who will be responsible for the sales programme. If such discussions are not held, there may be a wide gap between what the institute personnel consider necessary and what the client is actually prepared to do; the result will dissatisfy the client and harm the reputation of the institute.

Chapter 5

EVALUATION AT SUCCESSIVE STAGES

The progress of a project from concept to commercialization is a continuous process into which the contributions made by various disciplines are integrated. Nevertheless, for a proper administrative control, progress must be reviewed periodically in relation to the ultimate objective.

There are a number of major stages in product and process development. These mark a change in scale or type of activity. The main responsibility for the project usually passes from one category of specialists to another at such junctures, which may therefore be regarded as logical checkpoints at which to evaluate feasibility before additional work is undertaken.

A development project generally includes certain major stages, which are discussed below. These stages are similar, whatever the subject of the project. In each case, the criteria for analysing feasibility will be given.

Evaluation stages

(a) Exploratory work

(b) Applied research

(c) Product development

(d) Process development

(e) Internal evaluation and field tests

Confirmation stages

(a) Process confirmation

(b) Market confirmation

(c) Comprehensive review

It is appropriate to include the final stages preparatory to commercialization because industrial research institutes are called upon in developing countries to undertake them. They correspond to the feasibility studies made by foreign experts in connexion with projects using imported technology and the installation of fully equipped operational plants.

In discussing each stage, it is assumed that its evaluation has been favourable and that a recommendation to undertake the subsequent stage is justified.

EVALUATION STAGES

The evaluation stages are carried out within the industrial research institute, except for field evaluation, which involves submitting samples to potential customers for use testing. The scale of work is small to intermediate, not exceeding large-laboratory or pre-pilot size.

Projects that do not entail much innovation, such as the manufacture of products similar to ones already being marketed or the modification of processes currently being used, may omit intermediate stages, even to the extent of proceeding directly from laboratory scale to commercial production. In such cases, the risk involved in speedy commercialization is relatively small and may be justified by the saving of time and money a stage-by-stage evaluation would require. The questions considered in a feasibility analysis at intermediate stages will, however, provide a useful checklist of the factors that must be favourable if operation on a large scale is to be successful.

All the evaluation stages should be carried out for entirely new projects because failure to consider all the criteria may result in much wasted effort. It takes far less time to make a careful evaluation than to retrace steps because important factors were overlooked earlier.

Exploratory work

Exploratory work provides the general justification for an applied research project. The percentage of ideas for new products or processes rejected during this stage is quite high in many organizations, even though the criteria cannot be applied rigorously because the available information is not sufficient. The reason for rejection is often lack of market potential. Approved concepts should meet the following requirements:

- *(a)* One or more products can be prepared that appear to have useful applications;
- *(b)* The process should not present great difficulty or unwarranted expense on a commercial scale;
- *(c)* Suitable raw materials are believed to be available;
- *(d)* Products are in the client's line of business, or, for in-house projects, conform with general national or institute objectives.

Applied research

Applied research leads to a fairly definite concept of product characteristics, which permits a more reliable estimate of marketability. At the completion of this stage, progress should be such that the following conclusions are justified:

- *(a)* Products should find a market of acceptable size and price range;
- *(b)* Process continues to appear practical and gives satisfactory yields;
- *(c)* Selected raw materials have been used, but commercial grades of suitable specifications are available and usable;
- *(d)* Preliminary research of patent literature and restrictive regulations does not reveal obstacles to marketing (may not apply in many developing countries);
- *(e)* Client interest or institute policy confirms desirability of continuation.

Product development

Product development results in preliminary specifications for the preferred composition or formulation which in its turn makes it possible to examine the commercial potential more rigorously. Satisfactory completion of this stage implies that:

(a) From a study of the possible products, a selected list has been prepared of those that appear, in the opinion of the institute's market research group, to have satisfactory marketing characteristics;

(b) The preferred process has been defined and is judged to be generally suited to commercial operation;

(c) Raw materials of commercial grade give products of satisfactory quality in acceptable yield;

(d) Preliminary estimates of cost and sales forecasts made by the institute's economic group are acceptable;

(e) Patent study on the basis of better definition of product and process reveals no impediment; this may not apply in developing countries;

(f) Client interest, or probability of client support for an in-house project, warrants continuation.

Process development

Process development confirms, by large-laboratory or pre-pilot scale investigation, the feasibility of the proposed method of operation. If the product development work is successful in providing tentative specifications before all the work at this stage is completed, process development may be started before the final report is submitted. Completion of this stage shows that:

(a) A preliminary flow diagram illustrates the practicability of projection to commercial scale;

(b) Products can be prepared from commercial raw materials in satisfactory yield, and with some minor adjustments in specifications, the finished products are acceptable to the market research section;

(c) The projected plant is not below minimum economic size; this may not be critical in developing countries;

(d) Revised estimates of operating costs and plant investment prepared by the engineering section confirm satisfactory production costs;

(e) A packaging concept has been approved;

(f) A process control concept has been prepared;

(g) Process has been proved by preparing samples of acceptable quality for internal evaluation and field tests.

Internal evaluation and field tests

The final small-scale stage to define market potential, the stage of internal evaluation and field tests, consists of two parts: the first, carried out by an evaluation group often working in conjunction with the analytical section, is a comprehensive review of the performance of the products; the second consists of tests by potential consumers.

Considerable analytical work and some use testing was carried out in earlier stages. The results cannot be considered conclusive until the product is available in its final form, i. e. meeting firm specifications and utilizing raw materials of commercial quality that have been selected as a result of the process development work. The investigation covers not only the product's quality and performance in tests simulating actual use, but also an assessment of its advantages and disadvantages compared with any similar existing products sold at a competitive price.

Conclusions drawn from internal evaluation may be influenced by inadequate criteria of performance and by the personal bias of institute personnel; they should, therefore, be confirmed by the independent verdict of potential consumers. For industrial products, samples are submitted to a selected group of industrial enterprises to be tested by their own methods and preferably by practical trials in small-scale operations. For consumer products, panels representative of the general public are used as judges; satisfactory methods of selecting them have been worked out. Some projects may involve only taking an opinion poll by questionnaire.

The samples used in systematic industrial field tests or consumer tests should conform to the specifications proposed for commercial operation to ensure that the conclusions are valid. It is often necessary to use prototypes for the preliminary evaluation, but for the final tests, on which recommendations for future action are to be based, customers should be asked to judge a sample of the product exactly as it will be manufactured. The results of the tests may show that the specifications should be changed in some way. If the changes are considered of sufficient importance to affect acceptance, additional field tests should be carried out.

The evaluation at the end of this stage is critical. Unless all the factors are favourable, the risks involved in continuing a project are high. The evaluation should cover the points listed below, because the conclusions will form the basis for deciding whether to continue the investigation on a larger and more expensive scale.

- *(a)* Semi-final specifications have been prepared and will produce the type of products commonly used by the consumer.
- *(b)* Comparison in internal evaluation with any similar products on the market shows that the new products are satisfactory as regards utility and price.
- *(c)* Samples submitted to representative customers for independent tests confirm internal conclusions as to quality, suitability for use, and competitive cost.
- *(d)* A preliminary marketing plan, including price structure and distribution channels, has been prepared.
- *(e)* Estimates of marketing expenses give acceptable costs.
- *(f)* Review of total economic projection, including costs of production, marketing, and overheads, shows a satisfactory financial return.

Marketing personnel from the client's organization should participate in planning, executing and evaluating the field tests because they will later have responsibility for the sales programme. If they do not have first-hand experience of the conditions that new products will face when launched commercially, they may not be prepared to develop and use the marketing techniques necessary for success.

Confirmation stages

For completely new products, the evaluation stages do not provide definitive answers that ensure a sound basis for a commercial venture. Additional information is needed from larger-scale studies of production and marketing problems. An industrial research institute must recommend such further work to its clients in order to avoid being associated with a commercial venture that fails because it was launched with too much haste.

It may be possible to conduct engineering analysis of sufficient depth without resorting to a pilot-plant operation. Elimination of market evaluation by test sales is more hazardous, because, in spite of favourable results from field evaluations, consumer demand may fall below expectations when the product is offered commercially.

The stages described below are discussed in terms of a pilot-plant operation and test marketing when the client decides that such steps are necessary to provide additional confirmatory information before undertaking a commercial venture.

Process confirmation

Process confirmation consists of final process design, preparation of engineering specifications for the commercial plant and final estimates of operating costs and plant investment, and, when necessary, pilot confirmation of the process.

Confirmation of process design requires a thorough review of the flow sheet prepared by the process development group. Detailed estimates are needed of the size of the commercial plant under consideration. The handling of materials from storage, the flow and scheduling of work in process, utility requirements, control procedures, and the handling of finished product should all be subjected to re-examination. Specifications have to be drawn up for special facilities, such as control laboratory, maintenance shop, sub-stations for utilities, and shipping requirements. Estimates have to be made of the labour force required, including operatives, supervisors, control personnel, maintenance staff, and office and warehouse staff. Drafts of operating and control manuals have to be prepared and possibly translated. A plan for training workers is required so that they are available when commercial manufacture is scheduled to begin.

Concurrently, working drawings for the plant should be prepared. These are not the final, detailed designs, which are not required until it has been decided to install the plant. Working designs include the size and specification of buildings, layout for equipment and auxiliaries, special foundations where required, type and location of instruments, sizing and specifications of all major items of equipment and their ancillary parts, raw material storage and warehousing facilities and other auxiliary facilities, such as control laboratories and offices, roadways and parking space.

From the working drawings, a final estimate of the cost of the plant can be calculated. From the process flow diagram, raw material costs, personnel requirements, and other data on items of expense, a final estimate of the operating costs can be prepared; it should include an allowance for depreciation and working capital. This estimate is used to calculate the unit production costs and is incorporated with the marketing and overhead costs in the final economic feasibility study.

Market confirmation

It is desirable to negotiate advance purchase commitments from customers to cover a substantial proportion of the initial production. To stimulate this demand, it may be necessary to supply fairly large quantities of the product before the commercial plant is in operation. If this is done by pilot-plant production, the cost is likely to be high. Nevertheless, the client may feel that the extra cost is worth while to get the assurance of a firm market.

In developing countries, the record of past sales of similar imported products may help in evaluating the market. If no such products are available locally, it may be possible to import sufficient quantities to carry out market confirmation studies; even if import duties have to be absorbed as a special expense, the net cost may be less than that of installing a pilot plant and producing the necessary quantities for exploratory sales.

Purchase contracts are legally binding on the producer; the client himself must therefore be the negotiating party. The industrial research institute personnel may be of assistance in the negotiations, but unless they have been put in charge of the entire operation—a very rare case—they are not in a position to make commitments for supply.

Comprehensive review

A comprehensive review of all projects should be conducted before the final decision is reached to proceed with commercialization. Failure to do this can mean the failure of the venture.

This review should be co-ordinated by the client's senior executive responsible for the project. All groups that have participated in the project, including industrial research institute personnel, should be asked to reassess their judgement that the venture is soundly based and that no fresh facts or change in the situation would lead them to doubt their earlier conclusions. The technology is sound, the product has satisfactory characteristics, the plant specifications and operating procedures are acceptable, the marketing plans and price structure are approved, and economic analysis is favourable. If the opinions are not unanimously favourable, the doubtful aspects should be re-examined.

When the entrepreneur decides to go into commercial operation, activities should be co-ordinated so that the project can proceed on schedule. Work on the detailed design of plant and arrangements for installation should begin. The training of operatives should be properly timed. Sales promotion should start to build up the market. Technical programmes such as quality control and servicing for manufacture and sales should be drawn up. If the steps leading to commercialization have been well managed, the venture can proceed as an integrated whole.

Chapter 6

MULTI-DISCIPLINE PROJECT TEAMS

It has already been mentioned that information and opinions on the different technical aspects must be co-ordinated in order to obtain well-balanced answers to problems. Only in this way can the necessary technological, engineering, marketing and economic viewpoints be brought into focus. A feasibility analysis of all these aspects is required to determine the chances of success of a proposed new industrial development.

The usual way of obtaining a co-ordinated evaluation is to assign analysis of the various aspects to different administrative groups in what is felt to be a logical sequence. There is sometimes a certain amount of formal or informal discussion among individuals in these groups at the working level, but each group feels free to carry out its assignment in its own way unless a supervisor is made responsible for co-ordinating the various opinions.

SHORTCOMINGS OF CONVENTIONAL ADMINISTRATION THROUGH FORMAL ORGANIZATION

To illustrate the usual course of events, the history of a specific project may be traced, such as the production of natural tannins to supply the local market in a developing country, already used as an example in the research project proposal given in chapter 5. It is doubtful whether the justification before authorization of the product development stage would be even as comprehensive as the one given there. If the industrial research institute has a staff evaluation group, however, such an analysis of a project's commercial potentiality would probably be made.

Once the project has been authorized, the project leader in the product development group launches the investigation in the direction he considers proper, subject only to guidance from his supervisor, who is also a specialist in product development. The research is completed on the process for producing the tannins on a small scale, and a report is written to summarize the information for the next phase of engineering development.

The engineering group, after studying the report, concludes that there are several things wrong with the process as described. The extraction was carried out on finely ground material instead of chips, so that either a new comminuting step has to be introduced or the extraction process has to be restudied on coarse material. Further, the extractants used were of reagent quality, and one component is very corrosive; the work must therefore be repeated with commercially available extractants and the heavy corrosion reduced. Clarification of the extract seemed simple in the laboratory, but on a large scale it would require an additive and a settling tank, plus a very low through-put on the filtering equipment. Precipitation of the tannins by the laboratory procedure gives a flock that, on a larger scale, is very difficult to handle, and therefore this operation must be improved. Either the process is referred back to the laboratory for reworking or else the engineering group starts all over again.

It may be assumed that the process has been successfully readjusted and samples of the final product are ready for internal evaluation and field tests. The specifications for commercial quality that were used by the product development group turn out to have been several years old and to have been superseded by improved, competitive products. It will therefore be necessary to rework the process again to obtain a better product, and the product development group is requested to do this; finally, the engineering group has to re-check the modified process, and at last new samples prove to be satisfactory for field tests, which turn out to be favourable.

The preliminary estimates of production costs and plant investment were made at the time the project for product development was being considered. The estimates are now revised on the basis of the improved process, with additional steps and new items of equipment. These calculations show that the increased costs render the undertaking marginal in attractiveness, whereas it appeared as very encouraging earlier.

This is not an exaggerated case. The records of any industrial research organization will reveal many instances in which much extra work has been needed because co-ordination of the different disciplines was inadequate.

Principles of multi-discipline team organization

The latest way to organize research is to have a working group that includes representatives of the disciplines needed to provide a balanced approach to the problem. Schemes of this kind have been used successfully for many years by a few organizations, and they are now being adopted increasingly by others. Incidentally, they resemble the group co-ordination that has been widely used by engineering consulting firms.

In the multi-discipline approach, responsibility for a given stage of a project is entrusted to a senior member of the professional staff who is selected for his technical and managerial capability rather than for his administrative rank in the organizational hierarchy. He is chosen as soon as the problem has been defined, and he prepares the research project proposal, under the general supervision of the institute management. He decides which disciplines should be involved and arranges for the estimated time required from various individual specialists. They are assembled from different administrative groups in the organization with the concurrence of their respective supervisors. They serve on the project on a part-time basis at the discretion of the project leader, the remainder of their

Example 2

MAN-HOUR ESTIMATES FOR PROPOSED TANNINS PROJECT

Staff member	Administrative group	Functions	Exploratory period	Project period: Jan	Feb	Mar	Apr	May	June	Total
Project leader	Product development	Co-ordination of all activities. Supervision of product development	40	60	40	30	30	60	60	280
Junior technologist	Product development	Collection of raw materials. Product development work. Preparation of sample	20	20	100	100	100	100	40	460
Analyst (chemist)	Product development	Detailed analytical work	40	20	60	60	60	20	0	220
Leather technologist	Technical service	Advice on evaluations	10	10	10	5	10	10	10	55
Colloid chemist	Applied research	Participation in process development	0	20	10	10	20	10	10	80
Organic chemist	Applied research	Advice on purification procedure	0	10	0	10	10	0	0	30
Product evaluator	Analytical	Selection of procedures. Evaluation of products	20	10	20	40	60	80	20	230
Senior engineer	Engineering	Engineering advice on process. Calculation of production costs	10	0	10	10	20	20	30	90
Junior engineer	Engineering	Engineering advice on process. Calculation of production costs	0	0	20	40	60	60	10	190
Market researcher	Market research	Advice on marketing and competitive products	20	5	10	20	30	40	20	125
Economist	Economics	Initial and final economic estimates	10	0	5	20	20	20	20	85

time being allocated to other activities. The project leader plans the work of the entire programme, makes individual assignments to the team members and supervises their performance and arranges for the co-ordination of information and opinions through reports and group meetings. He does not have general administrative responsibility over all or most of these specialists, who report to other supervisors for strictly administrative matters, but he is responsible for the technical direction of this particular assignment.

A SPECIMEN MULTI-DISCIPLINE TEAM OPERATION

The method of operation can be most easily illustrated by a specific example for which the preparation of natural tannins will again be used. Example 2 below shows the specialism of staff members assigned to the team, the administrative groups to which they belong, their functions on the project and the estimated time each staff member will devote to his work, which reflects how his particular activities are phased in as the project progresses. The time spent on exploratory work was 170 hours (about one man-month), but this expenditure of effort was judged necessary to obtain enough information to interest potential clients. Total man-hours were estimated at 2,000 for the purpose of project cost calculations, but the actual total was 1,835. Such a figure may seem excessive; this is because an unusually large team has been selected to illustrate the principles.

The project leader has responsibiblity for co-ordinating the activities of the other members of the team, but for the most part he is not in a position to give them detailed directions even if he wished to, since they are specialists in their respective fields. His function is to outline the objectives, discuss how the proposed programmes relate to these objectives, and to see that each member is kept aware of the views and problems of the rest of the team. For this purpose, the project leader organizes discussions among the key members, arranges for advance distribution of reports to prepare them for the meeting and sees to it that action is taken in accordance with the recommendations agreed upon. In case of any disagreement about the findings or their interpretation, he has to find means of reconciling the divergent opinions and decide what is to be done. He has to maintain an efficient schedule for the different types of work so that the project moves forward and its component parts are properly timed. In short, he acts as a leader, not as a director.

The individual members gain much from team membership. They inspire each other, and they have the feeling that it is their project because each is responsible for one part that will be integrated into the final report. They get a broader outlook because they are intimately exposed to the methodology of other disciplines; they learn to appreciate the value of other criteria in determining feasibility without having to undertake work they are not qualified to do. They have confidence in the validity of their conclusions about the soundness of the project because they have been evaluated constantly from multiple points of view.

ADVANTAGES AND DIFFICULTIES OF ESTABLISHING A TEAM SYSTEM

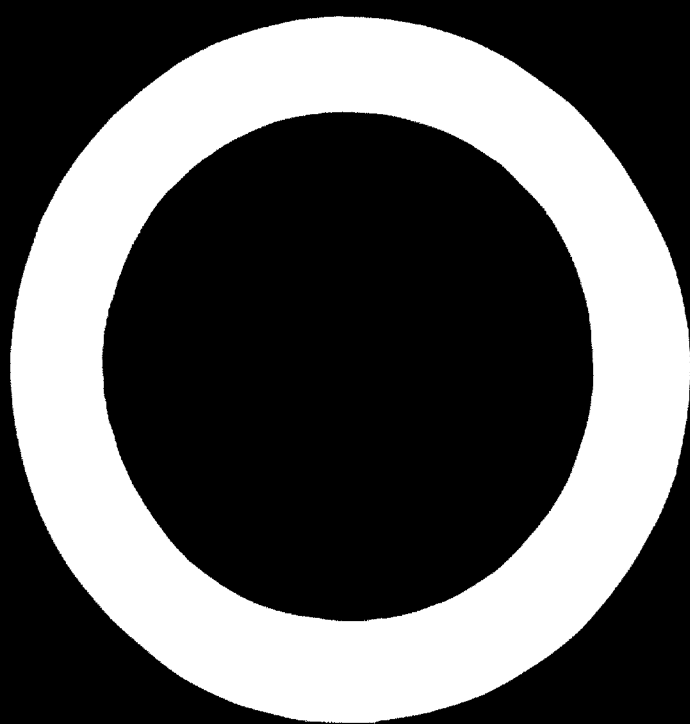
A team system of operation has many advantages. The project objectives are reached more rapidly than when individual lines of investigation are pursued independently and sequentially; major problems are brought to light earlier so that they can be faced and solved without the necessity of going back over the work at a later date; the reports are more reliable as guides to future action because they reflect a spectrum of criteria; it is easier to pass on information about the project at the major stages because the new project leaders—for example, the development engineer or the market researcher—are normally chosen from among the specialists who participated in the earlier stages. Similarly, when further research project proposals are prepared for the later stages, key individuals from the preceding team are asked to continue their participation.

An important feature is that the industrial research institute benefits through more effective use of the skills of the staff. Tendencies to "empire building" in the various sections are diminished because the section heads who might wish to enlarge the range of disciplines under their jurisdiction learn that these additional skills are available from other sections. Communications among the disciplines are markedly improved.

It takes time and experience before the multi-discipline team system is generally accepted in an institute. The main difficulty is getting the members of the staff to understand the difference between administrative channels and working channels. Supervisors do not take readily to the idea that individuals under their jurisdiction will serve on project teams for which they themselves do not have technical responsibility. It also takes time for the individuals at the working level to realize that they must look for leadership on the projects in which they are concerned to the project leader and not to their administrative superior.

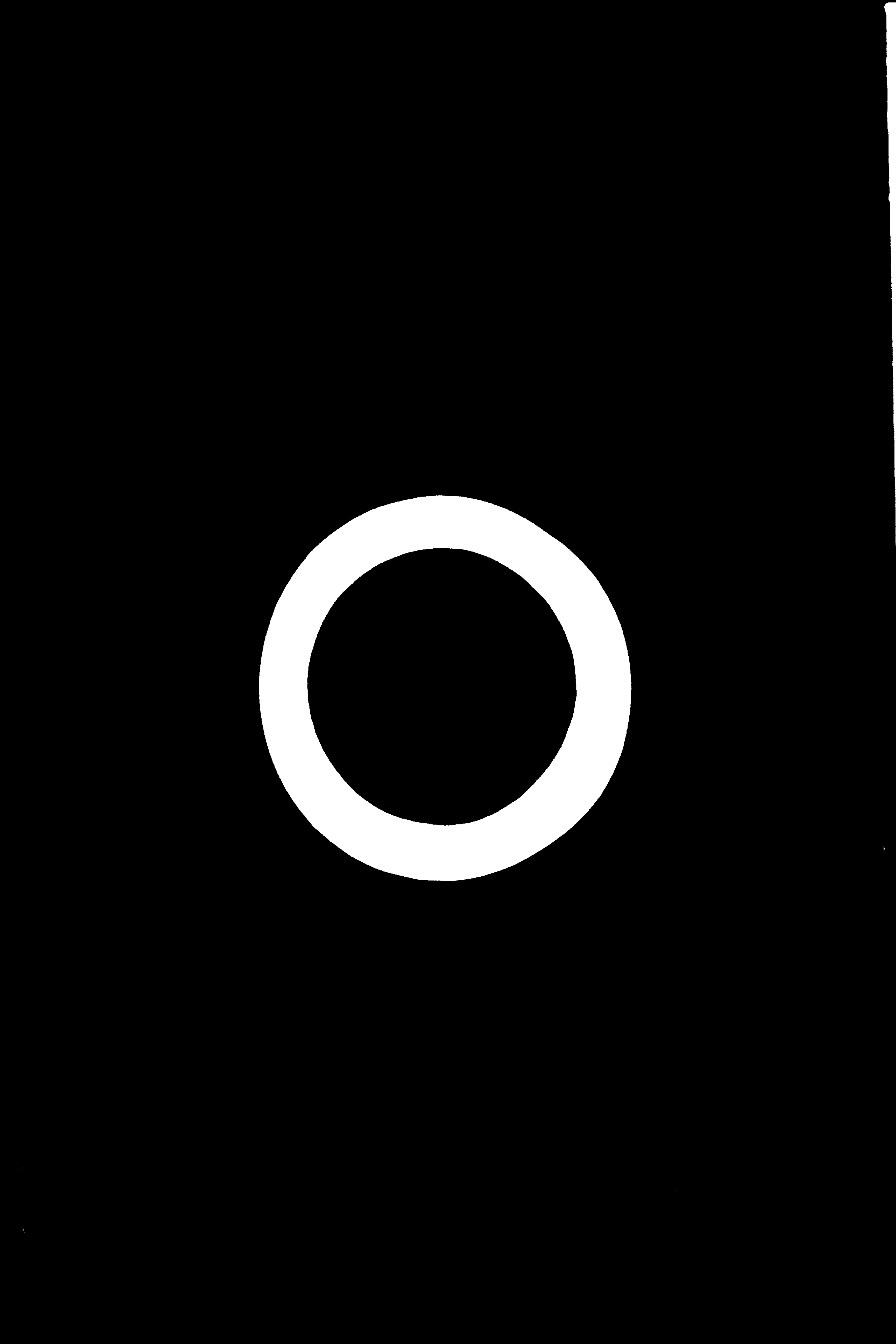
The scheme can best be introduced gradually by using it for one or two selected projects obviously requiring cross fertilization between several disciplines. The members of the team will become experienced in their interrelationships, and their favourable reaction to the new system will be gradually imparted to their associates.

The advantages of the multi-discipline team system by far outweigh its disadvantages, and it is recommended that the institute adopt this system as soon as practicable.



PART II

FINANCIAL ADMINISTRATION



Chapter 7

PLANNING THE INSTITUTE

Industrial research might be defined as an attempt to develop the most suitable method of achieving a desired end within a framework of technological and economic constraints. Designing a system of financial administration for an industrial research institute is, in itself, an exercise in research. In this case, the constraints may be *inter alia* political, legal, economic and sociological. These constraints, as well as the purpose, structure, size and scope of the organization, will vary for each research institute; the optimum system for the financial administration will therefore vary. Experience shows, however, that certain basic principles of financial administration are common to nearly every industrial research institute. These basic principles will be reviewed and, where practical, some of the detailed modifications discussed that may be dictated by local conditions.

The decision to establish an industrial research institute should be taken only after careful consideration. Such an institute may properly be considered an important national resource; its potential value, however, unlike that of most natural resources, may be expected to increase with use rather than diminish. At the same time, in common with most natural resources, its development does involve a long-term capital investment. For this reason, although the character of the proposed institute may be dictated primarily by technical or economic considerations, as well as by development needs, the problems of the long-term financial administration must receive consideration from the very beginning.

Definition of scope of the institute's activities

The first step in formulating a preliminary initial budget is usually to define the institute's scope. This is normally determined to a large extent by the current status of industrial development in the country and by the potential resources of raw materials, money and manpower.

If little or no major industrial base exists, initial institute activity might concentrate on technical-economic feasibility studies to establish the potentials for industrial development, on guidance to government agencies on technical and industrial questions, and on general technical and managerial assistance to existing small and medium industry. Such a range of activities would initially require some office space and only a minimum of technical facilities; for example, a laboratory for analytical chemistry and a section for mechanical testing might be included as a service to industry and to the Government. There might also be a small machine shop.

On the other hand, if there is a developing industrial base or if there are known major natural resources (such as ores, petroleum, forest products, or agricultural potential) available for development, more extensive laboratory facilities may be desired from the start in order to carry out the research necessary to demonstrate the technical feasibility of developing these resources and to adapt known industrial processes to the specific raw materials, local conditions and markets. The particular laboratory facilities and equipment would be defined by the resources potentially available and the fields in which the industrial base had developed.

Initial size and growth rate

Once the institute's character or its initial scope has been defined, consideration must be given to the optimum size of the initial staff and to the projected growth rate. This is a matter of judgement; there is no set rule or precise method of calculation. The institute's initial scope generally defines a minimum figure; the scarcity of properly trained personnel may set a maximum limitation, so that it is often desirable to ensure that managerial and technical guidance from an established industrial research institute or a group of international experts is available. Under such an arrangement, a team is provided to supplement the local staff and to conduct, in effect, an on-the-job training programme. This type of assistance usually constitutes a major expense item in the initial budget, which is generally borne by international organizations or bilateral aid programmes. The character of the local industry and the willingness of its management to seek, accept and utilize the services of the institute also need to be given careful consideration when its initial size and projected growth rate are estimated.

Financial aspects of initial planning

Assuring a sound financial basis implies some realistic estimate of future costs. By definition, this is one element of the budget, the other element being an estimate of future income.

There is no set cost for a research institute. The budget can be formulated only after due consideration of such factors as the type of work to be carried out, the level of output desired and the framework of local costs. In practice, final decisions are usually based on such factors as the amount of money that may reasonably be expected to be available, the rate at which qualified personnel may be available to the institute, the rate at which such personnel can be properly integrated within the organization, the range of services desired from the institute, and the extent to which these services may reasonably be expected to be utilized.

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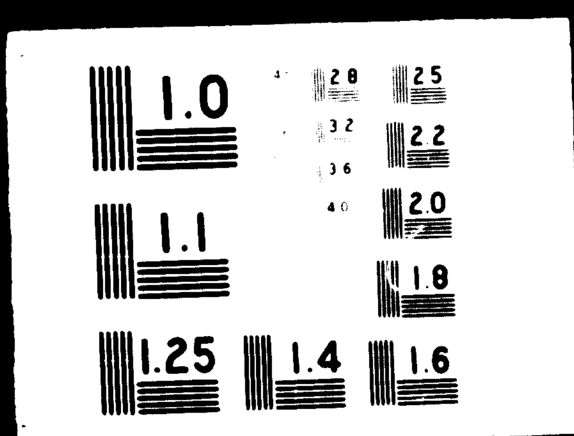

An analysis of these factors provides the basis for deciding whether the creation of an industrial research institute is, at this time, feasible and justified and for defining its initial size and scope. This analysis, therefore, is a key element in determining the probable success of the institute. It involves elements of both a technical economic feasibility survey and an operations analysis. In view of the vital decisions necessary at this point, outside consultants are often retained to assist in the analysis and in the formulation of the specific plans.

NEED FOR LONG-TERM FINANCIAL PLANNING

An industrial research institute may be created strictly as a government department agency to carry out investigations and to provide services to promote development in the national interest. In this case, the Government's commitment to provide in its annual budgets for the financial support of the institute is, in effect, a continuing one. Although a number of such organizations are in existence, they are not necessarily the best model for a developing country to follow in its first venture into development and applied industrial research.

A research institute can become self-supporting on the income from its services and research contracts. To have this as one of the institute's long-term objectives can help it to maintain a practical outlook as it develops and also provides one means of evaluating its progress. At the same time, the close contacts it implies with industry may be expected to provide mutual stimulation. The goal of being self-supporting is, however, almost impossible to attain in a developing country; the decision to create an industrial research institute entails committing large sums for its support over a period of years and probably decades. The extent to which, and the rapidity with which, a self-supporting status can be achieved primarily through industrial contracts depends not only upon the capabilities of the institute but also upon the rapidity with which the national industrial base develops and upon the attitudes of the local industrial managers.

The experience of a number of research institutes in developing countries indicates clearly that a firm commitent for the initial capital costs plus adequate working capital for at least a five-year period should be available before the institute is actually started. Even though the institute is intended to become self-supporting, a financial subsidy in one form or another may still be required after the initial five-year period. The importance of this sound financial foundation cannot be overstressed. The creation of an industrial research institute is an important step in national development. Such an organization must be assured of adequate financial support until it has established itself in the community. Without such support, the chances of failure are high; and such a failure would severely handicap any subsequent attempt to establish the necessary facilities even with sufficient funds. It is better to delay the start until the necessary financial support is forthcoming than to gamble on early support from industrial contracts or on the hope that the support will become available from somewhere and, in this way, run the risk of severely prejudicing the future.

Sources of financing

Probably no two industrial research institutes have started in the same manner, have developed the same internal organization, or have been intended to cover the same range of activities. Some are government organizations; some are private; and still others are a blend of the two. A few industrial research institutes are designed to make a profit; most are organized as non-profit institutions. Some are supported solely by government funds; some are supported by industrial contributions, possibly imposed by government regulations; some, mostly in developed countries, exist strictly on the income from their services and research contracts or are supported by an endowment or by an independent income source; but most derive their operating revenue from a combination of at least two of these sources.

In countries where the industrial base is still in a relatively early stage of development, the initial financial support, both for capital and operating costs, will probably come from the Government. But if some industrial base has developed within the country, it is desirable that industry be encouraged to make some contribution to the initial financial support of the research institute. Experience has shown that if industry is involved in establishing the institute, industry and the institute will co-operate in the future more closely than they otherwise would.

Support by the Government may, in some cases, be supplemented by financial assistance from an external source, such as a philanthropic foundation, an international organization, or the aid programme of a more developed country.

THE PLANNING BUDGET

Since the scarcity of money is often a limiting factor in establishing and operating a research institute, the preparation of a budget is an integral part of the initial planning. Income, whether in the form of a subsidy or fees for industrial services and research, and costs should be forecast for at least a five-year period. Especially in the initial stages of planning, such estimates are subject to a considerable margin of error. The five-year "planning budget" should therefore be revised and extended annually.

The planning budget is an over-all projection of expenditure and income. Normally, no attempt is made to provide a detailed breakdown under any of the main headings of expenditure, at least in the initial stages of the institute's development. For example, although provision is made for the purchase of equipment and a certain sum allotted, the line items are specified only in a general manner. In the same way, provision is made for staff costs, but these are normally not broken down into sub-items. The main purpose is to provide general guidance to ensure that the projected expenditure is realistically correlated with anticipated income. Once the institute is actually in operation, the "planning budget" is normally supplemented with an "operating budget". This budget breaks down, in considerably more detail, the anticipated expenses and income for the current year of operation. In some cases, the operating budget is revised quarterly and extended for the following four quarters. Revision and extension of the operating budget at least twice a year is recommended.

The items within the planning budget, as well as their respective share, vary widely, according to such factors as location, size, scope and operating principles of the institute. Therefore, there is no such thing as a "typical" planning budget. This chapter will, however, outline some of the items that might be included and attempt to set forth some general guidelines that may be helpful in the initial planning.

For convenience, the planning budget may be broken down into the following categories: capital costs, operating costs and income. A representative planning budget is shown in example 3.

Capital costs

Capital costs comprise items of major value with a relatively long-term useful life expectancy. For the purposes of the planning budget, capital costs

Example 3

PLANNING BUDGET
(thousand dollars)

Anticipated total staff	*First* 20	*Second* 35	*Third* 50	*Fourth* 65	*Fifth* 85
			Year of operation		
a) Costs					
Capital costs					
Land	—	500	—	—	—
Buildings	—	50	350	—	—
Equipment					
Non-technical	25	15	25	20	20
Technical	—	—	70	60	65
Working capital	30	50	—	—	—
Operating costs					
Staff	90	150	175	240	300
Materials and supplies	15	30	50	70	80
General expenses	15	25	45	70	80
Library	20	30	30	40	40
Building amortization or rent	10	15	30	50	60
Indemnity reserve	10	10	15	20	25
Staff training	25	50	25	—	—
Capital and operating costs	240	925	815	570	670
Purchased services	40	100	100	100	70
Total costs	280	1,025	915	670	740
b) Income					
Local government	430	920	430	430	430
Industrial contributions	50	50	50	—	—
Foreign aid	40	100	100	100	70
International assistance	50	50	—	—	—
Income from clients	—	—	40	100	180
Total	570	1,130	620	630	680

may normally include such items as land, buildings and equipment. The equipment may be further subdivided into the categories of non-technical or office equipment and technical or laboratory, research and pilot-plant equipment.

Land

Experience has shown that the successful industrial research institutes are usually completely autonomous entities. There is often a tendency to attempt to incorporate the research institute within a government ministry or a university. Although this may reduce the capital investment, such arrangements normally do not work out satisfactorily. It is, therefore, recommended that the institute plan for its own independent facilities. This usually involves the acquisition of land and the construction of buildings.

Site selection depends on many factors unrelated to financial planning and is not, therefore, within the scope of this discussion. One principle, however, should be stressed. The initial planning budget should provide for the acquisition of sufficient land to enable future expansion as required. In general, the initial site should consist of at least 10,000 to 15,000 square metres. If possible, the site should be located adjacent to an area that might subsequently be acquired, in its turn, should the character of the institute's work require even further expansion in the future.

Frequently, especially when it grants an initial subsidy for the institute, the Government provides the site on which it is to be constructed. In such cases, a fair value should be established for the land, and it should be carried on the institute's books at that amount. Otherwise, the assets of the institute will not be properly reflected.

Buildings

As with site selection, the size and type of the initial institute buildings will be dictated by other than strictly financial considerations. There are, however, certain "rules of thumb", developed though experience, that may be helpful in preparing the initial budget.

For the administrative staff and for non-laboratory research, such as technical-economic feasibility studies, production-engineering studies, and other management-oriented services, a floor space of approximately 20 square metres per staff member is generally adequate. For laboratories, an average of 60 square metres per staff member is usual.

The relatively high cost of laboratory construction must be recognized at the outset. Laboratory facilities require extensive distribution systems for electricity, water, gas (if available), and often steam, vacuum and so on. Special ventilation problems are involved, and there may be special air-conditioning requirements. High floor-loading capacities are often required. Floor surfaces have to be of a special abrasion- and chemical-resistant type. As a result, laboratory construction is usually from 20 to 30 per cent more expensive than normal commercial buildings of equivalent floor area. Furthermore, many items of building equipment, such as fume hoods, laboratory sinks and benches, special electrical distribution systems, auxiliary power sources, and fire protection systems, may have to be imported. This further increases the cost, even though the institute may be granted exemption from customs.

As a general comment, it is usually wise to calculate space requirements generously. It is expensive to make small, piecemeal additions, and nothing inhibits the growth of a research institute more than overcrowded quarters for the personnel, who must, in the last analysis, generate the increased work.

The institute buildings are also an important part of the institute's public image. Although money should not be lavishly wasted on unfunctional decorations, the budget should provide for the construction of solid, tasteful buildings befitting the reputation for technical excellence that the institute wishes to acquire in the long run.

Equipment

The equipment requirements depend strictly on the work to be performed by the institute, possibly to an even greater extent than the buildings and land. As a general principle, the planning budget should provide amply for both office and research equipment. A poorly equipped research institute does not inspire confidence in potential clients. Acquisition of office equipment should somewhat precede its actual need. On the other hand, more caution and foresight should be exercised in the purchase of the research equipment. A common failing in new research institutes is to purchase elaborate and expensive laboratory and research equipment in advance of a determined requirement, only to find that the need never materializes or that, by the time it does, much superior equipment has been developed for the purpose. Generally most, if not all, of the technical equipment will have to be imported, and it may well be more economical to pay for air freight on one particular piece of equipment for which there is a clear and urgent need than to order in advance an item that is never efficiently utilized.

Working capital

Like any industrial enterprise, the institute needs working capital to ensure that it can meet its day-to-day expenses. After some years of operation, the accumulated reserves may provide adequately for this; the initial planning budget, however, should make provision for it.

The amount of working capital required depends on the projected scope of the institute's operations and the arrangements for its financing. If the initial operation of the institute is being fully subsidized by the Government or some other financial source and the annual subsidy is made available at the start of each fiscal year, working capital equivalent to 25 per cent of the annual operating costs would probably be adequate. If other financial arrangements are contemplated, the estimate for working capital should be increased accordingly.

General guidelines

The experience of research institutes in developed countries indicates that the investment in buildings and equipment is often roughly the same as the annual operating costs. In a research institute that concentrates heavily on laboratory work, the investment in buildings and equipment may reasonably exceed the annual operating costs by perhaps 20 or 30 per cent. On the other hand, in an institute mainly concerned with non-laboratory activities, the investment in buildings and equipment might well be only 70 to 80 per cent of them.

In a less developed economy, salaries and wages (a major factor in operating costs) tend to be lower, building costs may average about the same, and equipment costs tend to be somewhat higher than in a developed country. Therefore, in preparing the five-year initial planning budget, the estimated investment in buildings and equipment may exceed the estimated fifth-year operating costs by as much as 40 per cent for a laboratory-oriented operation or be approximately equal if the institute is expected to concentrate on non-laboratory activities.

As another rule of thumb, experience shows that in developed countries, the cost of equipment for laboratory research is usually approximately 75 per cent of the cost of the building required to house it and the operating staff. Therefore, in such an operation, a reasonable breakdown might be $80 invested in buildings and $60 invested in research equipment for each $100 of estimated fifth-year operating costs.

Timing of capital expenditure

In the preparation of the five-year planning budget, it is obvious that not all of the projected capital expenditure will occur in the first year. The organization of an industrial research institute takes time. Qualified staff must be found. They will need training in the specialized problems of institute research. The assimilation of new staff members places a burden on an already overloaded administrative staff; therefore, additions must be phased to keep at a manageable level. Accordingly, the institute's over-all development should be scheduled in an orderly fashion.

It is not uncommon for a new research institute to begin functioning in rented quarters. The first year might well be devoted primarily to acquiring the key staff members and to drawing up detailed plans for the institute's development. Such planning might include a more rigorous definition of the institute's scope, broad plans for the initial programme of activities and consideration of possible building sites.

In the second year, additional staff would be engaged and assimilated. Some might be sent abroad for specific additional training. Some broad non-laboratory research programmes, for example, technical-feasibility studies of potential new industries, might be started. The building site might be acquired and an architect retained to work with the institute's staff in designing the initial building or buildings.

In the third year, staff additions would continue. The purchase of research equipment would commence. The initial building programme would be completed and officially opened. The staff would move into its new quarters. More books and periodicals would be bought for the library. The volume of research under way would also expand materially.

On such a schedule, capital expenditure in the first year would be very small; it would tend to be heavy in the second and third years and decrease in the fourth and fifth years, when it would be mainly for research equipment.

Operating costs

The operating costs depend largely upon the pattern of local costs, the planned size and scope of the institute and the traditional patterns of organization within the community. Only general guidelines can be given, but the following discussion will provide at least a checklist of the costs that should be considered.

Staff

Salaries and wages normally constitute the largest single item of operating costs. In fact, in the more developed countries, where salaries are high, they may well make up as much as 75 per cent. In the less industrialized countries, 50 per cent may be more typical. Since the staff costs depend directly upon the projected size of the staff, the distribution anticipated between professional and non-professional staff and the local salary scales, it is impractical to generalize on these costs.

In estimating staff costs, one point especially should be kept in mind. Many countries provide for a special payment to permanent employees upon termination of their employment. Such payment is often termed "indemnity" and usually amounts to one month's pay for each year of employment. If such a procedure is the practice in the country where the institute is to operate, staff salary calculations should be adjusted accordingly. The institute should build up a reserve that would permit payment of full staff indemnities at any time. In a typical planning budget, this would involve providing a thirteen months' salary for each staff member for each year. In the final institute accounts the actual indemnity obligation would be calculated at the end of each year and adjustments made in the cost calculations for the new year to provide the proper reserve.

In view of the indemnity obligation, a fairly long period of probation is desirable for new employees if the local labour laws and practice allow it. There is no real way of judging an individual's aptitude for applied research and how he will work in an industrial research institute except by trying him out. Thus, especially in a country without a tradition of research, a relatively high turnover in new staff members can be anticipated. This is not necessarily a reflection on the individual, but merely shows that his special aptitudes are not suited to an industrial research institute. A one-year probationary period before an employee is made permanent is therefore suggested for all new employees.

Materials and supplies

The category "materials and supplies" includes items used in research programmes and in the operation of the institute, such as chemicals, paper and accounting forms. It also covers minor items of laboratory and other equipment that are not separately listed in the accounts as capital assets as well as items required for the maintenance of buildings and equipment. Normally, these expenses may average from 15 to 30 per cent of the staff costs, the higher figure being representative of a research institute that conducts a large number of laboratory investigations.

The amount budgeted for these items in the first years of operation may exceed these figures because initial stocks of such supplies have to be built up.

General expenses

The costs normally included in the category of general expenses cover such items as utilities (water, gas, electricity, heat, telephone, and telegraph), postage, travel, membership of technical societies, taxes (if the institute is not tax-exempt) and the cost of promotional literature. The total of such items may be expected to amount to between 25 and 40 per cent of the staff costs.

Library

Since the library is important to the institute, and to the country at large as part of its technological resources, the cost of books and publications is often included as a separate item in the planning budget. The annual costs may be expected to be between 10 and 20 per cent of the staff costs for an institute with a total staff of 100 or fewer. As, however, the library's books constitute an important working tool and it is usual to build up a sizable reference library as soon as possible, yearly amounts of about $20,000 are commonly budgeted for the library during the first few years.

Building amortization or rent

The institute will probably start work in rented quarters. The planning budget should, therefore, provide for the payment of rent. Once the institute moves into its own buildings and rent is no longer required, provision should be made for building amortization usually over a period of 25, 30, or even 40 years. It is, however, recommended that building reserves be accumulated faster than this. The manner in which this is done may depend upon local financial regulations. However, as the institute grows, additional space will be required As the character of the research changes with time, extensive and relatively expensive modifications to the original buildings may become necessary. A reserve for such expansion and alteration should be built up in advance. It would appear reasonable to budget from 15 to 20 per cent of the staff costs annually for this purpose.

Availability of external technical assistance

A Government of a developing country may find it advisable to enter into an agreement with an international organization or an established research institute of international repute for initial managerial and technical guidance, support and training. Such an agreement usually lasts from three to five years. Since its cost can be a major item of expense, it is usually considered separately in the planning budget, even though much of it may be borne by the international organization or a bilateral-aid programme.

The cost will depend upon the services desired, as well as upon several other factors. If the institute can draw its initial staff from professionals with extensive industrial research experience, it may require assistance only on the organizational and administrative side. On the other hand, if, as is more likely, the initial staff is not experienced in industrial research, more extensive technical guidance will probably be desired. An agreement with an established research institute might even provide for the training of some key employees in its laboratories.

After the institute is well established and there is no further need for external technical support, occasions may still arise when the institute wishes to retain the services of an expert to supplement the skills of its own staff for a particular programme. Such services generally involve short-term consultation with the staff in formulating the work programme and possibly some later assistance in analysing the results and in preparing the final report with conclusions and recommendations.

INCOME

So far as the budget is concerned, the critical item is the estimated income. If the anticipated receipts, whether from governmental subsidies, philanthropic grants, international aid programmes, industrial contributions, payments for research, or other sources, do not equal or exceed the projected expenditure, then this will have to be reduced or additional sources of income found. Although there always is a certain element of risk in research, since the results cannot be accurately forecast, a responsible administration of a research institute should not gamble on its finances. Too much is at stake both for the institute and the country.

Chapter 9

PROJECT ACCOUNTING

The planning budget is concerned primarily with the over-all cash flow, in and out; the breakdown of expenditure into categories need not, therefore, be particularly detailed. For example, a certain sum is allocated for salaries; the planning budget must make sure that this amount of money is available from some source, but the specific salary of each staff member is not of great importance from the over-all financial point of view.

When the institute is functioning, however, the focus of interest shifts. Management must allocate the available resources for specific tasks and purposes. The operating budget reflects this allocation, and the accounting system provides a periodic review of how the resources were actually utilized. Budgets and accounting systems do not, and cannot, control research costs. In the last analysis, only the research worker can do this. In the same way, financial considerations are no measure of the effectiveness or the quality of the research. Keeping costs within the budget does not necessarily mean that a good research job has been done. Quality evaluation is a task of technical supervision. Budgets and cost data are merely two of the tools that management utilizes in its over-all appraisal of research effectiveness.

Although the operating budget may break down other expenditure, such as capital costs, in more detail than the planning budget, the main difference between them lies in the treatment of research costs. The budget system and the accounting system must be integrated if they are to provide the information needed by management. Therefore, both systems must be developed along parallel lines.

Annex 1 shows a representative breakdown of accounts for an industrial research institute. Sub-accounts will be desired for many of the items, but these will vary with each organization. According to individual variations in organization and local procedures and regulations, some of the suggested accounts may not be required and others may be added. The list presented, however, may provide a checklist.

The present chapter is mainly concerned with the principles of accounting procedures; but these principles also apply to preparing operating budgets. There is no one best financial or accounting system for a research institute. Local regulations, traditional patterns, and internal requirements must be accommodated. In order to evaluate a research project, however, management must be able to decide how much it costs. The need for project cost data is obvious if the institute is conducting sponsored research for clients. It still exists even though, for example, the institute is wholly subsidized by the Government and occupied only with self-generated programmes relating to national development. If there is to be effective control and effective results, each study conducted by the institute staff should be specifically authorized; the accounting system should be capable of reporting, with reasonable accuracy, the total costs attributable to any one study. This requires a job-cost system or, in other words, project accounting.

Overheads

The aim of project accounting is to distribute the institute's total operating costs equitably among the respective projects undertaken by it. For this discussion, it is assumed that the institute is concerned primarily with research projects; however, the same accounting principles should be applied to general industrial service functions, such as management seminars, government-supported technical assistance to industry, or technical consultation for government agencies. Each service function should be clearly identified, and the accounting system should provide management with a realistic apportionment of cost to each one.

Unfortunately, many expenses in a research institute cannot be directly attributed to a particular project. These include the costs of building maintenance, operation and amortization; taxes; general utilities, such as light, heat, water etc.; general repairs; library costs; and administrative costs, including depreciation of office equipment. These "indirect" costs may also include some of the costs of technical supervision, the cost of generating new sponsored projects, including the time spent by the professional staff on promotional visits to plants and on general discussions with industrialists and on preparing promotional literature, as well as research project proposals for clients. Up to 20 per cent of the time and consequently the salaries of the research staff may be spent on such activities.

Furthermore, a researcher cannot be expected to spend all his working hours on his assigned research projects. He must spend some time keeping abreast of technical developments in his field. A certain amount of his time is occupied in general institute and research section meetings where general policy questions are discussed. Time is required to prepare sectional budgets and to consider future requirements of research equipment. Some time should be available for authorized preliminary investigations to assess the potential of ideas that might be worked into a major research project. In addition, there may be times when the researcher is "between assignments" waiting for a new programme to be authorized. Such a list could be extended almost indefinitely.

Distribution of overheads

The various indirect costs may be charged in different ways in the accounting process. They may be distributed uniformly over all of the work done by the institute, or specific indirect expenses may be distributed only to those activities for which they were incurred. For example, the costs of the accounting department might be distributed as a uniform percentage against the cost of all projects. On the other hand, the amortization of the major items of technical equipment might more fairly be charged to those laboratory research projects using the equipment concerned.

Many methods of distributing general overheads have been used. Some of the more common are: as a percentage of a total direct cost; as a percentage of direct charges for salaries and wages; as a set charge per area of floor space utilized; or as a set charge per hour of direct staff time. In general, any reasonably equitable procedure is satisfactory. However, the first two seem to be the most widely used, and one or the other of these is recommended for consideration.

Direct versus indirect charges

The general principle of distributing overhead charges is well established and well accepted. There is, however, considerable difference of opinion regarding what costs should be handled as direct charges and what as indirect. Again, there is no one set of rules that is right or best in every case. In general, the higher the percentage of total research costs charged directly against the individual projects, the lower the overhead rate will be, and the more nearly the costs will be apportioned to each individual project on an equitable basis. On the other hand, the costs of collecting and handling the charges tend to increase as more of the research costs are put in the "direct" category. Therefore, each institute organization must strike its own balance. For example, it would probably be more efficient for a completely subsidized institute, with little or no activities sponsored by individual clients, to operate on the basis of fewer direct charges and more indirect. This would minimize the accounting costs, but at the same time provide a somewhat less accurate figure for the actual costs applicable to each individual project. On the other hand, in an institute conducting a high percentage of work on a contract basis, a higher percentage of direct charges would be justified to ensure that each client firm is charged as equitably as possible for the services it uses.

The basic decisions about direct versus indirect charges must be made by management before the accounting system is established. Some of the methods of handling various research costs will be discussed in the following section on accounting procedures.

Accounting procedures

Many factors contribute to the success of an industrial research institute. However, in addition to the necessity of sound initial financial planning discussed in chapter 8, a good accounting system is one of the most important elements. Research costs are difficult to control at best. If accountants could control these costs, any system satisfying their requirements would suffice. The true control of costs, however, is in the hands of the research staff. Management can provide guidelines through sound budget planning, but the real control is all too often after the fact. It is essential, therefore, that both management and research personnel be provided with up-to-date information on project costs and in such a form that they can easily understand the over-all picture.

For the purpose of internal control, each formal activity within the institute should have an identifying account number so that all costs attributable to that activity can be identified, collected, and reported to management. This applies not only to individual research projects, routine activities and general industrial or government services, but also to internal institute activities such as the operation of the library, the cleaning of the laboratories and offices, or the cost of administration. Many of these items are relatively standard in any industrial cost-accounting system; the items discussed below, however, are of special interest from the standpoint of the financial administration of research institutes.

Project authorization

Each institute activity should be specifically authorized in writing. This "Work authorization sheet" should set out the account number identifying the activity, the title of the account, the scope of the work or activity to be accomplished, the maximum expenditure authorized, the time in which the activity is to be completed, the person responsible for the activity, the source of the funds (general institute budget or the client, when work is performed under a contract), billing and reporting instructions in the case of contract work, and any special instructions or conditions. One copy should be given to the person responsible for the work, (variously termed the project leader or the division or section chief) as his authorization to proceed, and another copy should be given to the accounting department as its authorization to establish the account and accept the charges thereon. An example of a work authorization sheet is given on page 59.

In the case of internal institute activities, such as the operation of the library, the maximum authorized expenditure is set by the institute's operating budget, and the accounts are normally authorized on an annual basis. In the case of contract research, the scope of the work, the maximum expenditure, the time allotted for the project, and the billing and reporting instructions are specified in the contract or the research proposal.

Cost reports

The total charges on each account should be collected and reported to management with a copy to the person responsible for the account, normally on a monthly basis. The amount of detail in the cost report varies according to need. If the reports are too detailed, money is wasted in handling unneeded data, and the essentials may be lost in the maze of detail. On the other hand, the report must provide adequate guidance to the individual who is responsible for operating within the authorized budget. If the issue is in doubt, it is generally preferable, at the start, to have too little detail than too much. The absence of required detail usually brings a request from the person needing it; however, too much data rarely causes any comment.

Example 4

WORK AUTHORIZATION SHEET

Project number *Title*

Client

Scope of work

Division *Project leader*

Starting date *Duration (months)* *Completion date*

Total funds allocated *Average monthly rate of expenditure*

Title of proposal *Date*

Billing instructions

Reporting instructions

Special conditions

Signature *Date*

As a minimum requirement, the summary should show the period for which the account was authorized, the number of months remaining, the total funds authorized, the amount spent or committed during the current reporting period, and the funds remaining. Normally, this minimum report is insufficient for proper cost analysis and future planning. Primarily for the benefit of the person responsible for the project, it is recommended that the costs be broken down into the categories outlined below. If any adjustment has to be made in expenditure rate, the project leader will then have a reasonable basis on which to decide where the specific changes can be made most easily. A specimen project cost report is shown on page 60.

It is important that these reports be made available promptly. The longer the delay between the end of the accounting period and the time the report is available, the less control can be exercised over expenditure. Time can be

Example 5

Division

PROJECT COST REPORT FOR

(Month/Year)

Project No.		*Project leader*
	Title	
		$
Starting date	*Completion date*	*Total appropriation (A)*
	$	$
No. of months elapsed (B)	*Expenditure to date (D)*	*Past monthly rate (D : B)*
	$	$
No. of months remaining (C)	*Unexpended balance (A—D—E)*	*Future monthly rate (E : C)*

Costs	*Current month* ($)	*Total to date* ($)
Staff time		
Overhead		
Materials and supplies		
Technical services		
Use of equipment		
Direct purchases		
Travel		
Miscellaneous		
Total		

Signed ____________
Accounts Department
Date ____________

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especially critical in the case of relatively short-term projects undertaken under contract. Project cost reports should be available within not more than five working days after the close of the accounting period, and preferably within three. If complete reports cannot be completed within this time, it is advisable to make available preliminary cost estimates based only on staff time. Although these may be accurate only within about 10 per cent, they may prove invaluable to the project leader, if he can have them within a day or so.

Some of the primary cost categories that occur in research institute accounting are discussed below.

Staff time

The basic, and usually the major, element determining the cost of research and development activities, is time--the time of the people engaged in the study. In project accounting, one of the primary problems for the accountant is to determine how much time was actually spent on a particular activity. When the individual researcher is assigned full time to a specific project, the cost of his time is easy to assess. When such a researcher is assigned to work on two or more projects concurrently, however, the problem becomes more complex. As a rule, he can only estimate the amount of time he has spent planning, preparing for and working on each of the projects, and his estimate must be accepted for costing purposes.

Most research institutes record the allocation of staff time by means of time cards. With a few exceptions, such as some of the technical service groups that will be discussed later under the heading "technical services", each staff member should record daily how much time he spent on each of the projects on which he was engaged. Normally, time should be recorded to the nearest hour or half hour. It is recommended, especially with the smaller research institutes, that the time cards be collected on a weekly basis and processed by the accounting department. This eliminates the large pile-up at the end of the month and makes it easier to find out quickly the charges against each of the accounts. Example 6 shows a specimen time card on which the time spent is recorded against the account numbers of specific projects or of routine activities. Individual time cards are filled in by staff members every week. Each working day is assumed to have eight working hours and each week five working days.

In research, as distinct from development projects, the total costs of similar projects can usually be estimated with fair accuracy by multiplying the number of hours of staff time spent on the project by some factor *k* derived on the basis of experience. Unfortunately, *k* varies with the local situation and the work involved; its value can be determined only by referring to detailed accounting records of previous projects. Once the local *k* factor is known, this technique may be needed for making preliminary cost estimates. However, it is recommended that the accounting department be geared to provide rapid and accurate reports on costs so that such "shortcut" techniques do not become necessary.

Time spent by the research staff on activities other than their assigned projects should be charged to appropriate accounts. As was mentioned earlier, research personnel must spend some time keeping abreast of new developments in their field. This activity should be encouraged, and a special "overhead" account should be established for this purpose. At the same time, management should see that staff do not charge excessive time to this activity. Some reading is directly related to the projects on which the researcher is engaged, and he must decide against which account number it can appropriately be recorded.

There should also be an "overhead" account to collect the charges for time involved in "promotion activity" to develop new activities and research projects. If desired by management, the accounting system may provide for sub-accounts to cover such specific activities as industrial contracts, preliminary

Example 6

STAFF TIME CARD

Month *Year* *Name*

Account No.	M	T	W	T	F	Total	Remarks
Project A							
Project B							
Project C							
Holidays							
Sick leave							
Annual leave							
Total	8	8	8	8	8	40	

Chief of section *Date*

pre-proposal laboratory or reading investigations, and actually preparing the research project proposal. Management must be in a position to assess the cost of developing new research work. The researcher should attempt as far as possible to concentrate on such activities during those periods when his time cannot be productively used on an assigned project.

The time spent on holidays and sick leave should also be entered on the individual time card under the relevant account numbers so that the weekly total of hours recorded on the card equals the number of regular working hours.

Cost accountants at research institutes have developed many different systems for costing staff time. Each has advantages and disadvantages. For the purpose of most industrial research institutes, however, it is recommended that a charge-out rate be established for each staff member. This charge-out rate includes the cost of fringe benefits, which may often amount to from 20 to 30 per cent of the net pay. The total of the staff member's annual pay, plus fringe benefit costs, plus any necessary contribution to an indemnity reserve is divided by the expected net working hours for the year (number of working hours in the year less holidays and an allowance for sick leave) to determine the charge-out rate.

Materials and supplies

Materials and supplies constitute another element in the cost of research. This category includes miscellaneous chemicals, electronic components, log books, construction materials, and dozens of other items, such as stationery, that are consumed in the course of the work. In this context, "materials and supplies" refer to the items normally stocked in the institute storeroom and withdrawn for use on project activities. Special materials or equipment that must be purchased specifically for a given project are charged to it.

Although the items falling into the category of materials and supplies are normally not consumed in great quantities on any one project, an industrial research operation does require a tremendously wide variety of such items, many of an unusual character. As a result, especially where commercial sources of supply are not highly developed, the institute storeroom must be adapted to accommodate small numbers of a great many different items.

Accountants do not agree on the best method of handling storeroom withdrawals. Since most of the items are of relatively minor unit value, one group is of the opinion that the cost of recording charges for such items is greater than the amount recovered. They therefore favour handling the entire storeroom operation, including purchase of the stock, as an overhead item. The other group believes the cost of the items used should be recorded and charged against the account for which they were withdrawn. For a number of reasons, the latter procedure is recommended for industrial research institutes, especially in developing countries.

First of all, a record must be kept of all withdrawals. This is the only practical way to maintain a current inventory of material on hand. Each stock record card should note a maximum and minimum level. When the minimum is reached, the storeroom attendant should automatically fill in a purchase order to bring the level back to the maximum. Such levels must be adjusted periodically when required by changes in delivery schedules and the volume of the institute's activities. The unit cost of the last order can be entered on the stock record card, and relatively little extra effort is involved in transferring the costs of withdrawals to the appropriate accounts. Second, sources of local commercial supply may be restricted; thus materials of higher unit value must be stocked in the storeroom if delays in working are to be avoided. Third, many institutes permit employees to withdraw items for personal use from the storeroom. The charges for these items are entered on a personal account, which is subsequently cleared by a payroll deduction. Such a concession often saves the staff member money and can, therefore, be counted as a fringe benefit of his employment.

Technical services

As suggested earlier, it may, as an exception, be preferable in the case of the technical service groups, to collect staff time, as well as materials and other charges, under accounts for each of these groups. These items should also be entered with project account numbers for reference, and they will ultimately be transferred to the project accounts. In this way, the cost of a specific operation can be identified, and certain overhead costs can be distributed more equitably.

Typical technical service groups include the machine shop, the analytical chemistry laboratory, the mechanical testing laboratory, the glassblowing shop, the instrument laboratory, the report-processing group and possibly the library. The repair and maintenance group may also be set up as a technical service section if there is a repeating need to segregate the costs of specific building modifications or other activities of this group.

Machine shop

Work to be done by the machine shop is normally authorized by a shop order. This shop order should give complete details and specifications of the work desired, with a sketch if appropriate. The account that will ultimately be charged is indicated, as is the name of the staff member initiating the order, so that further details may be requested if necessary. The shop order should preferably be prepared in quadruplicate. A job number is assigned by the shop supervisor; one copy is returned to the staff member requesting the work; one copy is forwarded to the accounting office; one copy is given to the machinist responsible for the job; and the fourth copy is retained in the shop office. All charges are entered against the shop order. When the work is completed, the total is transferred to the proper account. The charges against the shop order include, as used, direct labour, materials, and direct purchases, as well as the shop overheads. Labour costs are computed in the same way as general staff time. Shop overheads are usually calculated as a percentage of direct labour. They are designed to cover the amortization and maintenance of the shop equipment, the power and incidentals consumed in the operation of the equipment, and an allowance for the cost of shop supervision and the time of the shop personnel that cannot be utilized productively. In this way, the expenses of the machine shop are removed from general overheads, and the undistributed costs of the machine shop are applied more directly against the institute projects utilizing the shop facilities.

If the machine shop is involved in the construction of major items involving extensive direct purchases, it may be desirable to enter these commitments directly against the final project account at the time the purchase order is written. The purchase commitment, therefore, will appear on the monthly cost statement. When delivery is made and the invoice paid, the charge can be entered on the shop order and the commitment removed from the project account by journal entry. In this way, the actual cost of the item constructed will be shown in the charge transferred from the shop order to the project account, yet the monthly project cost records will more accurately reflect the funds actually committed at any one time.

Analytical laboratory

The analytical chemistry laboratory is also usually established as a service group so that its general overheads are distributed to the projects using its services rather than being spread uniformly over all institute projects. In many institutes, this procedure is especially desirable because the analytical laboratory makes quality control testing for outside clients as well as current analyses for the institute projects. Although a research institute should normally not compete with commercial facilities, adequate commercial testing facilities are often not available in developing countries. In these instances, the outside users of the analytical services should bear their fair share of the laboratory costs and overheads.

If a significant amount of outside work is done in the analytical laboratory, it may be desirable to establish fixed rates for the standard analyses. These rates should be calculated to cover the analyst's time, the materials, the use of any major equipment involved and a reasonable share of supervision and general overhead costs. The rates will have to be adjusted periodically as the volume of work in the analytical section changes. The rates should also sometimes be adjusted so as to make them acceptable within the context of the general industrial conditions of a country.

In passing, it may be noted that most established research laboratories have found it desirable to discourage the general research staff from making their own routine chemical analyses. Experience shows that these analyses can be made at a lower cost and with a consistently higher level of accuracy in a central, specialized laboratory than by the individual researcher.

Mechanical testing laboratory

The comments with regard to chemical analyses are also pertinent to mechanical testing. Research institutes, especially in the developing countries, are often called upon to make mechanical and allied tests for outside clients on a service basis because such facilities are not otherwise available.

Most of the equipment needed for mechanical testing is expensive and subject to damage or loss of calibration if mishandled. It is, therefore, desirable that the mechanical testing laboratory be set up as a technical service group with properly skilled technicians to conduct the necessary tests, both for the institute staff und for outside clients. As in the case of chemical analyses, it may be desirable to establish fixed rates for the routine tests. These rates may include the cost of machining the required specimens in the institute shop. To encourage industry to make use of such facilities, rates should probably be reduced to a level that merely covers expenses.

Instrument laboratory

The instrument laboratory normally provides a number of important services for a research institute. These include: instrument loan, instrument calibration, instrument repair and special physical measurements.

Modern technical research requires a great many scientific instruments. Some of these are standard but of a specialized nature and are normally assigned directly to the research section in which they will be used. Others are highly specialized and non-standard (as far as the institute's general activities are concerned); these will normally be purchased directly from the funds of the research project for which they are required and, in the case of work sponsored by an outside client, are considered the property of the client.

Still other instruments and equipment are general in nature and may be used from time to time by various research sections. Examples of such items include: balances, various types of electronic instruments and meters, cameras, temperature controllers and recorders, pyrometers, oscilloscopes, stop watches and timers, tachometers and strain gauge equipment. When such equipment is needed by the institute but is not required on a full-time basis for a particular research section, it is most efficient to assign the item to the instrument laboratory. It is then available to any researcher as required on a loan basis. Each instrument has a use rate established on an hourly, daily, or weekly basis as appropriate. The project borrowing the unit is charged with the use rate for the period the unit is withdrawn from the instrument laboratory. The calculation of use rates will be discussed under the heading "Use of equipment". The project using the instrument is responsible for any damage.

In addition to lending out instruments, the instrument laboratory is normally responsible for the periodic calibration of all general instruments in use by the institute, whether purchased by the institute or by a project. Test results can only be as accurate as the instruments used to obtain them. The frequency of calibration depends upon the type of instrument, the use to which it is put and other factors. The instrument laboratory should maintain a calibration record for all instruments at the institute. The cost of calibrating the loan instruments is usually included in the use rate. In the case of instruments assigned to the research sections, the cost may be included in the use rate, if one is applied to the unit, or it may be charged to the project or projects on which the instrument is currently being used. In the case of project-owned equipment, the calibration costs are charged to the project.

The cost of repairs occasioned by normal wear and tear are usually handled in much the same way as the calibration costs. Repairs of specific damage are charged against the project on which the damage occurred.

The physical measurements made by the instrument laboratory staff may be of a routine nature, in which case they may be handled like the mechanical tests from the accounting viewpoint; or they may be specialized, in which case the staff time, materials, use of equipment, and other charges are made on the same basis as the other research activities.

Report processing

Since the major product of an industrial research institute is the research report, special effort is justified to ensure that the research results are marshalled in a clear, concise and complete form and presented in a manner to promote confidence in the work and to reflect credit on the institute. Consequently, the preparation of all formal reports in a central report processing section is recommended. The processing of a technical research report may require several different operations, including typing, drafting, photography and printing. The total costs involved in converting the draft into a completed report can most conveniently be identified by assigning a report work-order number to each report to be reproduced and collecting all charges against that number. The total is then transferred to the project account.

As in the case of the other technical service groups, the charges should be calculated to cover unused time, supervision, authorization of equipment, materials etc. For convenience, many institutes base their charges on number of pages typed and copies reproduced, with the art work charged on the basis of hours of work required. Charges are adjusted as the technical service account tends to show a "profit" or a "loss".

Use of equipment

It is usually considered desirable to recover the cost of the major institute-owned capital equipment needed for research by direct charges against the projects using the equipment. This can be done conveniently through a "use-of-equipment" charge. This charge is calculated by dividing the acquisition cost, plus any installation expenses, by the anticipated years of useful life to obtain an annual amortization value. This figure is increased by an amount estimated to be sufficient to cover the annual costs of maintenance. This total is then divided by the number of hours per year the equipment is expected to be used. The cost of any utilities or materials consumed per hour is added, and the result is the hourly "use-of-equipment" charge for this piece of equipment. A specimen calculation is illustrated below. Cards identifying the equipment, the number of hours used and the project involved are turned in to the accounting office periodically, and the appropriate charges are entered against the project.

The use rate may have to be re-evaluated annually in the light of experience if the actual hours of use or the maintenance costs deviate significantly from the estimates made in the rate calculations. Equipment assigned to the technical service groups is handled as outlined in that subsection. No use rates are assessed against project-owned equipment unless large amounts of utilities, such as electricity, water or gas, are consumed.

Direct purchases

Materials, equipment, and services purchased from suppliers specifically for a particular research programme are charged to the appropriate project account.

Example 7

USE RATE CALCULATION

Equipment no.	200-5-12	Description	*Heat-treating furnace*
Division	*Metallurgy*	Purchase order No.	67-136
Cost	$1,437.00		
Shipping	68.00		
Installation	120.00		
Total cost	$1,625.00		

Anticipated life	10 years
Annual amortization	$162.50 (total cost/anticipated life)
Annual maintenance	50.00
	$212.50
Expected annual use	200 hours
Hourly cost	$1.06 (annual maintenance/expected annual use)
Electricity/hour	$0.30
Muffle cost/hour	$0.40
Hourly use rate	$1.76 (hourly cost + electricity/hour + other consumables/hour)

As mentioned in connexion with machine shop accounting, it is often good practice to commit the estimated delivered cost to the project account when the purchase order is written. This provides management with a more accurate estimate of the funds remaining. This can be especially important when items must be ordered from abroad and delivery schedules may be slow. When the invoice is paid and the actual acquisition costs are known, the proper charge is entered in the project account and the original amount committed is removed from it by journal entry.

If the institute accounting system distributes overheads as a percentage of direct charges, it may be desirable to make some special arrangement with regard to direct purchases. Otherwise, if large purchases were made for an individual project, this project would end up paying a disproportionate share of overheads. Accordingly, overheads might be assessed on only a given increment of cost, perhaps the first $50, of any such direct purchase. The increment is selected to provide an overhead income sufficient to cover the costs of processing the order.

Travel

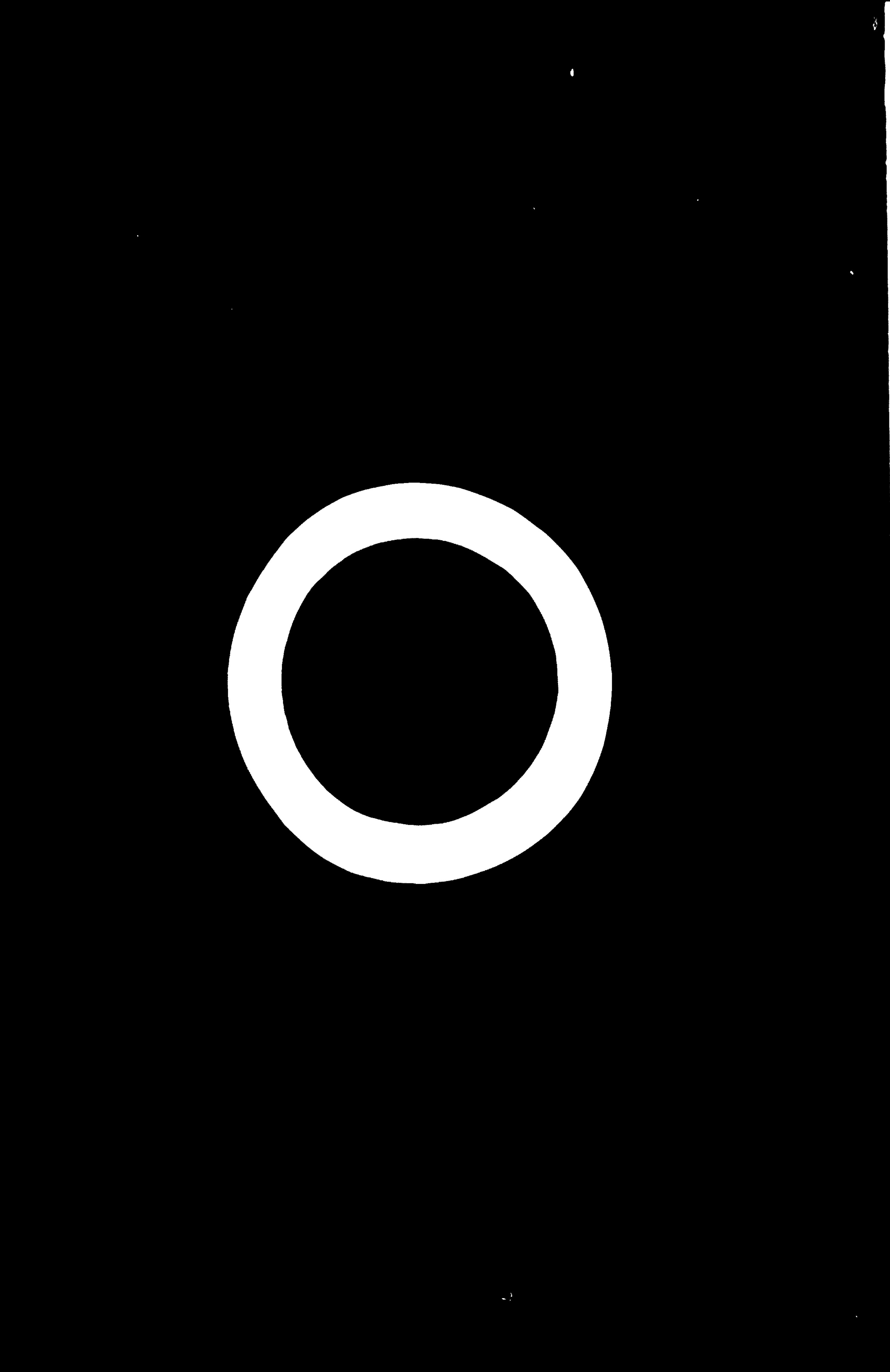
Travel costs, transportation and living expenses or *per diem* allowance incurred as a result of work on a particular project are usually treated as direct costs against it. Even if overheads are assessed as a percentage of direct charges, however, it is not unusual to exclude the travel costs from the overhead calculations. The justification for this is that direct travel costs are responsible for few, if any, overhead costs. The charges for the time of the staff member while he is travelling carry the normal overheads.

There is no uniform system for the reimbursement of living costs while on official institute travel. Some organizations provide direct reimbursement of all reasonable expenses; some require special justification for all expenses over an established daily norm; and others provide a fixed *per diem* allowance regardless of the costs actually incurred. The established patterns of the country in which the institute operates are probably the best guide. Where an option is clearly available, the advantages appear to rest with the reimbursement of all reasonable expenses, but a relatively close check should be kept to see that the requested reimbursements are, in fact, reasonable. Representation expenses, within limits, are also generally allowed.

Miscellaneous costs

There are other costs, usually minor, that are sometimes carried as overheads and sometimes considered as direct project charges. Among these are such items as shipping costs, postage, and telephone and telegraph charges. The most practical method for deciding on the disposition of such expense is the cost of entering it in relation to the amount recovered.

Normally the cost of major shipments of material or equipment is considered a direct cost. Long-distance telephone calls and telegrams may be handled as direct charges, but local telephone calls are normally included in overheads. Most postage costs are absorbed in overheads, but an exception may be made if a particular project, such as survey projects, requires extensive mailings or the shipment of fairly large quantities of materials through the post.



Chapter 10

DRAWING UP RESEARCH PROJECT PROPOSALS AND CONTRACTS WITH CLIENTS

The institute's management, the research staff and, especially in the case of contract research, the client must clearly recognize that it is impossible to make a valid prediction of the cost of solving a problem through research: a research project is established to carry out a specified investigation. It is hoped that the study will provide a feasible solution to the problem, but it is not possible to guarantee it. However, a relatively accurate estimate of the cost of the proposed project can usually be made. The first step is to prepare a research project proposal.

THE RESEARCH PROJECT PROPOSAL

The completeness with which the proposed work can be outlined in advance depends upon the nature of the investigation. For example, one investigation may be designed to determine the optimum operating parameters for an established process. Here the nature of the problem makes it possible to define fairly accurately the experiments that should be carried out to permit a valid analysis. Another investigation may be seeking a new process to achieve a particular goal. The investigator may envisage several possibilities with many interrelations and have no way of anticipating which, if any, will be successful. In this case, the investigation may be tackled in successive stages with an evaluation at the end of each. Chapter 5 contains a full description of the methods employed. Such projects are usually costed and authorized stage by stage.

The actual planning of the research project is a technical exercise and has been discussed in Part I, chapters 3 and 5. The completed research project proposal, however, is of concern to the financial administration, since it forms the basis of the project budget, normally contains estimates of the time and cost of the work, and (in the case of externally sponsored research) usually becomes a part of the research contract. An outline for a research project suitable for use by the financial administration is given in annex 2. This may be compared with the fuller outline (example 1) given in chapter 3, which was drawn up by the research staff as a work programme.

COSTING THE PROJECT

Costing a research project should be a joint effort between the research staff and the accounting staff. Although the researcher may have sufficient experience and the necessary knowledge of institute costs to prepare the estimate himself, his time can usually be spent more efficiently if he has help from the accounting department. In any event, the estimated costs should be subject to financial review before the proposal is accepted by the institute's management or presented to a prospective client.

The estimation of research costs becomes progressively easier with experience. After a few projects have been completed, a new one can be estimated almost as a matter of routine. The assurance with which the estimate can be made depends to a great extent upon the completeness with which the work programme has been formulated. The breakdown of research costs presented in the preceding chapter provides a convenient basis for cost estimation.

The starting point is normally staff time, which usually represents the largest direct cost. If the work programme has been properly thought through, a reasonably accurate estimate of the man-hour (or man-month) requirements can be made. Example 2 in chapter 6 shows such an estimate. The distribution among supervisors, professional staff and technical assistants should also be reasonably well established by the type of work involved. In some cases, the staff members to be engaged in the work will be known, and their charge-out rates can be used directly. If not, the rate ranges within each category are usually sufficiently narrow to make the average suitable for cost-estimating purposes. In estimating the manpower requirements for the project, some consideration must be given to the desired rate of progress. Most research projects will have an optimum rate at which the work can proceed most efficiently. Sometimes the prospective client may need the results in a shorter period of time and a higher rate of effort is justified, even though the total cost may be somewhat higher. Also, consideration should be given to possible periods during the work when certain project personnel cannot be effectively used on it. Where possible, arrangements should be made to utilize this time on other projects.

Except for unusual cases, which will be apparent from the outline of work, the cost of materials and supplies required directly for the project will be minor. Since conditions vary from institute to institute, the best basis for estimating is the experience from previous projects of a similar nature. In the absence of such experience, an allowance of 10 per cent of the estimated staff costs should provide amply for this category in all but very unusual situations.

The costs of technical services may be somewhat more difficult to estimate. In the case of non-laboratory work, they will probably be minor. The main item will be report preparation. In the case of investigations involving laboratory work, the scope of the work will be fairly well defined in the work programme. If equipment construction is necessary, the machine shop foreman should be able to provide reasonable cost estimates from a general description of the requirements. If standardized costs have been established for chemical analyses and mechanical tests, cost estimation will be simplified, since the volume of work can be assessed with reasonable accuracy from the work programme. If such costs have not been standardized, the heads of these sections should be consulted for assistance in estimating them. The needs for the services of the instrument laboratory should also be reasonably clear from the work programme.

The details about submitting reports should be spelled out in the research project proposal and should permit a suitably accurate estimate of these costs. Here again, the estimating job is simplified if standard costs have been adopted.

The requirements for the use of major equipment covered by an institute use rate will be covered in the work programme. The cost of any specialized equipment that will have to be purchased, by the institute in the case of an in-house project or by the client in the case of contract work, should be clearly identified in the project proposal.

The anticipated costs of direct purchases may vary widely, depending upon the stocks of the institute storeroom and the nature of the research project. Most of these special needs, however, will be identified by the nature of the work outlined in the work programme. In some externally sponsored research, it may be desirable to obtain some of the base or starting materials directly from the client so that they are representative of the materials with which he is working. These requirements should be specified in the project proposal and a clear understanding reached as to whether the client expects any payment for such materials.

The possible need for outside consulting services[2] should also be considered when costing the direct purchases. As mentioned earlier, it may be desirable at times to supplement the available staff with short-time, specialized consulting expertise. The need for such assistance normally becomes clear before or during the preparation of the work programme. The cost of such service may vary considerably. Estimation of the costs is usually easier if the new institute has developed a close working relationship with one of the established research institutes or is benefiting from the presence of international experts provided by international technical assistance programmes.

Travel and miscellaneous costs are, as a rule, relatively minor. Again, any special requirements should become apparent during the preparation of the work programme.

From the foregoing discussion, it should be clear that the ease and assurance with which the costs of a proposed research project can be estimated depend directly on the thoroughness with which the work programme has been prepared. Estimation of research costs in this manner is highly recommended not only because it can produce the most realistic prediction of the costs involved in the work, but also because this procedure helps to ensure that the research staff has foreseen the problems and has some systematic plan for dealing with them. There are cases (and they should definitely be considered as exceptions) where a detailed work programme cannot be prepared in advance and the research is undertaken only at a given "rate of effort". Such projects are the most apt to create problems for institute management because, by their very nature, there is no advance agreement on the work to be accomplished or the specific approach to be made. Cost estimation of their programmes can, at best, be only an approximation. In fact, the only practical procedure is to establish the research

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[2] Advice on using such services will be found in the *Manual on the Use of Consultants in Developing Countries*, UN Publication, Sales No. 68. II. B. 10.

budget and then adjust the rate of effort on the project, as it proceeds, to keep the costs within that budget. As a rule of thumb, the total project costs (including institute overheads) will normally be at least double the cost of professional staff time involved.

Experience shows that initial cost estimates, especially among the newer research institutes, tend to be on the low side. Therefore, after the estimate is prepared in the best possible manner, it is usually wise to increase each cost element by a factor of from 10 to 15 per cent as a contingency allowance. In general, no one complains when a project is satisfactorily completed for less than the estimate, but there may be complaints if the work has to be curtailed in the final stages because of insufficient funds. As more experience is gained in cost estimation, this contingency allowance can be reduced and eventually eliminated.

Principles of costing multi-discipline projects

Many research projects require co-operative efforts from several of the research groups or sections within the institute. In fact, this team approach is one of the major advantages of a poly-discipline industrial research institute. The principles of cost estimation are the same for a team effort as they are for a one-man project.

Cost estimation begins with the preparation of the work programme, as described in the previous section. Management normally appoints one staff member as project leader. It is then his responsibility to co-ordinate the efforts of the team. Each research section involved prepares its portion of the work programme and estimates the cost of that part of the work. The project leader then consolidates these programmes and estimates into the over-all research project proposal.

Although the individual section estimates are often not broken down in the final project proposal programme, they are available within the institute for the purpose of technical and financial control. In the project accounting, the work of each section is usually identified by a separate sub-account under the main project account number. Separate work authorization sheets and cost records are prepared for each sub-account, as if they were individual projects, and the consolidated report is prepared for the project leader who is responsible for over-all co-ordination.

Provisions customarily included in contracts with clients

Research work for an outside client normally involves some kind of official agreement between the institute and the client. For small projects this may involve merely an exchange of letters. In most cases, however, a formal contract is recommended. The use of a standard contract form helps to ensure that the institute client relationships and respective liabilities are clearly understood; it also ensures that all clients are treated alike. These factors are particularly important in areas where contract research and services are new and not clearly understood.

The basis for the agreement is usually the research project proposal with its details of work and estimate of time and costs. Since this proposal is normally mentioned in the research contract, it is especially important that the institute should guarantee only to use its best efforts, within the financial limits set by the agreement, to work towards a desired goal. The effort may and should be promised, but specific research results cannot be guaranteed. For technical and engineering services, the contract may be non-committal.

The legal form of the agreement and some of the specific points covered will depend upon local standards and conditions as well as upon procedures adopted by the institute. In nearly all cases, the agreement will identify the parties and provide a short definition of the scope of the work that can subsequently be used for identification purposes. The actual work to be done is usually defined by reference to the research project proposal.

The starting date and the duration of the work are usually specified. For example, the statement that the work will be started within 30 days after acceptance of the agreement by the client may be considered typical. Often, the agreement will also set a maximum period for the client to accept the research proposal. Beyond that date, the institute cannot guarantee to have uncommitted staff available to undertake the work.

The terms of payment should be set out in detail. These are subject to wide variation. Most industrial research institutes work on the basis of the reimbursement of actual costs as previously defined and agreed upon. In some parts of the world, however, the fact that the payment due may vary if calculated on a "cost-incurred" basis is not readily understood, and a fixed price basis may be preferable. In such cases, it is even more important that the work to be done is clearly specified in the project proposal. Otherwise, it may be difficult to convince the client that he received what he paid for. A detailed work programme is also required so that the institute can avoid losses through underestimation.

In some cases, the contracts specify that all or part of the costs are payable in advance. In other cases, they are payable monthly or quarterly on the presentation of invoices either for fixed amounts or on the basis of actual costs incurred during the preceding period. Some institutes operate on a cost-reimbursable basis, but with fixed billing, provision being made for the return to the client of any unexpended funds at the completion of the project.

The amount of detail included in invoices is a matter of policy. When billing is on a cost-incurred basis, the invoice may show only the total costs incurred for the period, or the total may be broken down in accounting categories such as staff time, materials and supplies, technical services, use of equipment etc. In general, the short form is recommended unless the client specifically requests the extra detail. If billing is on a fixed basis, the invoice may show the actual expenditures so the client can see how costs are running in comparison with billing. In the same way, a memo invoice showing actual costs can be supplied when payment is made in advance. However, it is recommended that such detail be provided only when specifically requested by the client. In the case of fixed price contracts normally no cost information is provided to the client.

Some contracts also provide for the assessment of interest at a specified rate on any unpaid invoices outstanding after a stipulated period, such as 30 or 60 days. But experience has shown that clients are very unwilling to comply with such provisions.

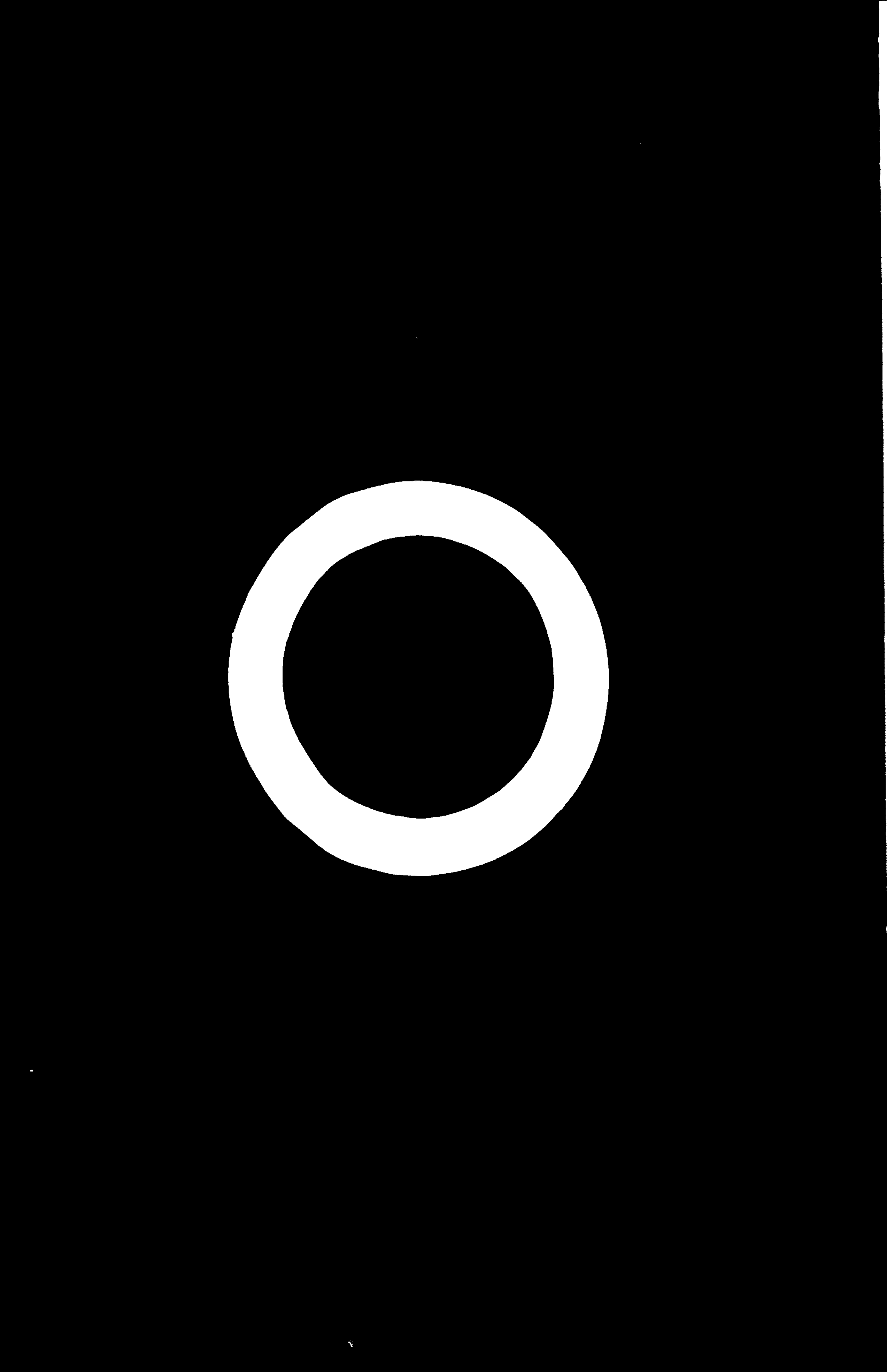
Contracts usually provide that the work can be terminated at any time by the client subject to, for example, 60 days' prior notice in writing. Provision may also be made for similar termination by the institute; however, the client will usually accept the institute's recommendation if it appears that the research will not be fruitful. Many contracts also specify that the client has the right to renew the contract, if he wishes, for an additional period under the same conditions as before. Normally, the institute welcomes such extensions, but the client may feel a clause of this type gives him additional protection.

Nearly all agreements used by industrial research institutes specify that the patent rights to any inventions or patentable discoveries made as a result of the sponsored research project shall become the property of the client. When staff members are engaged on sponsored research, the results of their efforts are the same as if they were actually on the payroll of the client. Research agreements also commonly provide that neither the institute nor the client can make specific reference to the research in advertising without the written approval of the other. A form of agreement between an institute and a client sponsoring a research project is given in annex 3.

The agreement usually provides that the institute will hold confidential any proprietary information furnished by the client as well as all results of the research. It also usually includes the stipulation that none of the results will be published by the institute or its staff (proper provision must be made in their contract of employment) without prior approval of the client. The agreements sometimes include a time limit on this prohibition; however, conditions vary widely, and it is recommended that specific client approval be obtained in every case.

The essentially confidential nature of many contract research and service projects may create a serious ethical problem for institute management, namely, how soon after completing an engagement with one client the institute can undertake related research for another. There is no practical contract provision that can resolve this question. Each case must be decided on its own merits. In effect, institute management must consider the situation from the viewpoint of the first client. If the institute holds information from the first project which, if used on the proposed new project would be detrimental to the interests of the first client, then it would be advisable not to undertake the second project. In short, it is better to lose one contract than to lose the institute's reputation for integrity.

ANNEXES



Annex 1

SPECIMEN ACCOUNTING SYSTEM

ACCOUNT NUMBER	ASSET ACCOUNTS
1	Land
10	Buildings
20	Assets in bank
30	Petty cash control
40	Accounts receivable – current
45	Accounts outstanding – prior periods
50	Stocks
60	Building equipment
70	Furniture and fixtures
75	Non-technical equipment
85	Technical equipment
95	Library volumes
	LIABILITY ACCOUNTS
100	Accounts payable – employees
110	Accounts payable – suppliers
120	Advance payments and reserves
130	Reserve for depreciation
140	Reserve for staff indemnities
	OPERATING ACCOUNTS
200	Technical equipment costs and income
210	Technical service divisions expenses and income
220	General administrative expenses
230	Technical administration expenses
240	Library expenditure
250	General office expenses
260	Building services expenses
270	Public relations expenses
280	Sponsorship development expenses
	GENERAL EXPENSE AND INCOME ACCOUNTS
300	Payroll
310	Depreciation

320	Rent
330	Interest
340	Automobile and truck expenses
350	Postage
351	Telephone and telegraph
352	Gas
353	Electricity
354	Water
355	Coal
360	Vacation
365	Sick leave
370	Project costs
380	Project overheads
390	Project income

Annex 2

OUTLINE FOR A RESEARCH PROJECT PROPOSAL

A. *Introduction*

1. General problem statement
2. Why problem is important
3. Research objectives

B. *Background*

1. General origin of the problem
2. Prior and related work on problem
   - *(a)* By others
   - *(b)* By institute
3. If old problem, what is new in proposed approach

C. *Proposed work programme*

1. Development of background
   - *(a)* Literature survey
   - *(b)* Information from client
   - *(c)* Other
2. Outline of programme
   - *(a)* Initial approach
   - *(b)* Possible alternatives
   - *(c)* Detail of stages, if appropriate
3. Special considerations, where appropriate
   - *(a)* Equipment availability
   - *(b)* Multi-discipline approach
   - *(c)* Equipment or materials to be furnished by client
   - *(d)* Other

D. *Reports*

1. Type and schedule of reports

E. *Time and cost*

1. Time required for research
   - *(a)* Total or by stage
2. Estimated cost
   - *(a)* Total or by stage

Annex 3

FORM OF AGREEMENT BETWEEN AN INDUSTRIAL RESEARCH INSTITUTE AND A CLIENT SPONSORING A RESEARCH PROJECT

This Agreement confirms a mutual understanding between the Industrial Research Institute (hereinafter referred to as "the Institute") and *(full name of client)*, (hereinafter referred to as "the Client"):

1. The Institute proposes to conduct for the Client a research project (hereinafter referred to as "the project"), relating to ". . . . . "

2. This offer is valid until . . . . If this agreement is signed by the Client in the place provided at the end of this document and delivered to the Institute on or before that date, it shall become a contract between the two parties, subject to the following terms and conditions:

3. The Client requests the Institute to carry out the project within a period of . . . . . months. The Institute agrees to start work on the project within . . . . days after the date of delivery of the signed agreement. The Client agrees to pay the Institute for its services in connexion with the project a total sum of up to, but not exceeding . . . . . . The Institute undertakes to use its best endeavours to complete the work programme outlined in the research project proposal ". . . . .", dated . . . .

4. The Client agrees to pay the Institute for its work on the project in monthly instalments on presentation of a statement of accounts. Payment shall be made within thirty days. The Institute reserves the right to suspend work on the project if payments are not made within this period. The Client agrees that instalments remaining unpaid after sixty days from the date of presentation of the statement of accounts shall be subject to interest, payable to the Institute, at a rate of 10 per cent per annum.

5. The Institute undertakes to submit to the Client at the intervals stated in the research project proposal referred to in paragraph 3 above, progress reports on the project. The Institute further undertakes to keep careful records of all work carried out under this agreement.

6. The Institute agrees that all inventions and discoveries made as a result of work on this project shall be the property of the Client. The Institute undertakes to prepare at the request of the Client, and at his expense, the documents required to register and work patents on such inventions or discoveries. The Client agrees to pay the cost of this documentation over and above the total research costs set out in paragraph 3 above.

7. The Institute undertakes to endeavour in good faith to keep confidential, unless it obtains the Client's specific authorization in writing to the contrary, all information relating to, or derived from, work on the project, including any proprietary information supplied by the Client, provided that nothing shall be deemed secret or confidencial that is described in any prior publication or patent or is a matter of common knowledge within the industry concerned.

8. The Institute and Client undertake that neither will, without prior written consent of the other, make any public reference, in advertising or other material, to the work of this project in such a way that the other's name is used or implied.

9. The Client may terminate this agreement at any time on sixty days' written notice to the Institute. The Client shall have the right to extend it, on terms agreed between the Institute and himself, for a period equal to the duration of the present agreement, provided that notice is given in writing at least sixty days before it expires.

For the . . . .
(name of client firm)

Signed . . . .
(full name and title of client's representative)

Date . . . .

For the . . . .
(name of Industrial Research Institute)

Signed . . . .
(full name and title of Institute's representative)

Date . . . .

Annex 4

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