OCCASION

This publication has been made available to the public on the occasion of the 50th anniversary of the United Nations Industrial Development Organisation.

DISCLAIMER

FAIR USE POLICY

CONTACT

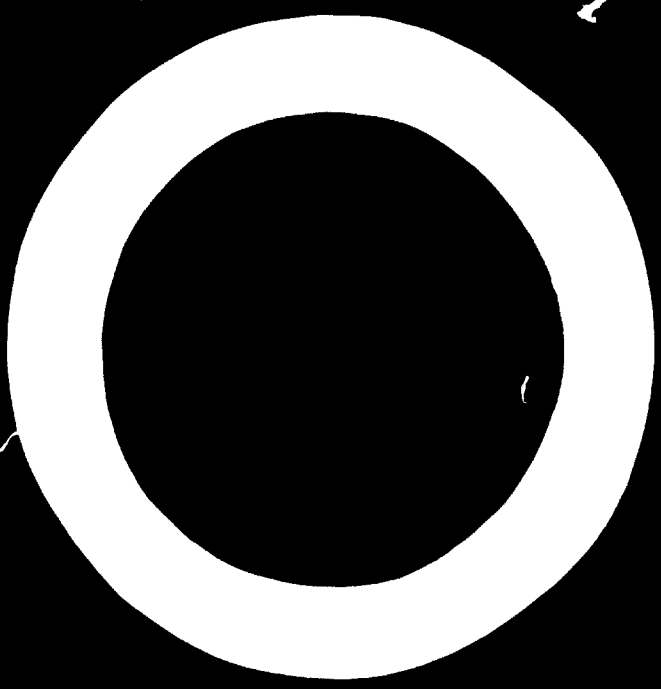
Please contact publications@unido.org for further information concerning UNIDO publications.

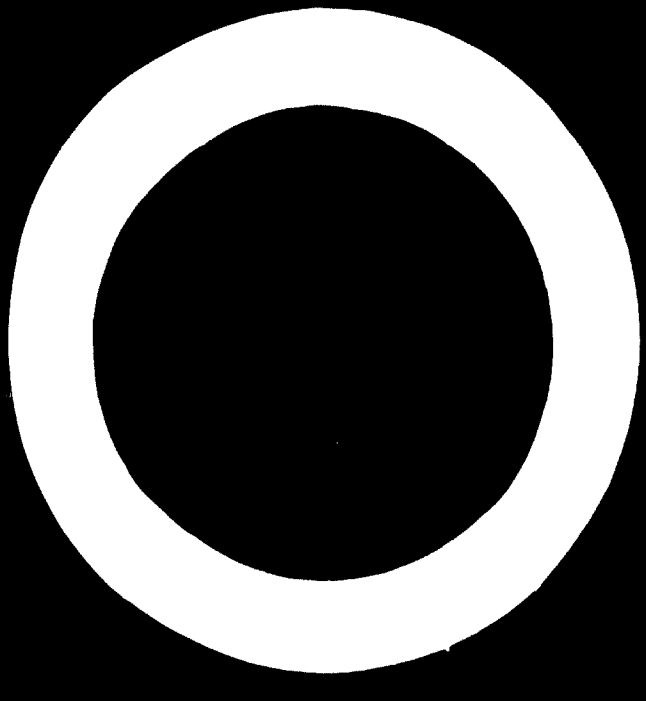
For more information about UNIDO, please visit us at www.unido.org

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

MANUAL ON THE MANAGEMENT OF INDUSTRIAL RESEARCH INSTITUTES IN DEVELOPING COUNTRIES

UNITED NATIONS





Department of Economic and Social Affairs

MANUAL ON THE MANAGEMENT OF INDUSTRIAL RESEARCH INSTITUTES IN DEVELOPING COUNTRIES

UNITED NATIONS
New York, 1966

The designations employed and the presentation of the material in this publication do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations concerning the legal status of any country or territory or of its authorities, or concerning the delimitation of its frontiers.

ST/CID/6

UNITED NATIONS PUBLICATION

Sales No. : 66.II.B.3

Price : $U.S. 2.—

(or equivalent in other currencies)

FOREWORD

A United Nations Inter-regional Seminar on Industrial Research and Development Institutes in Developing Countries was held in Beirut, Lebanon, in December 1964 for the purpose of seeking ways and means to strengthen existing and future industrial research and development institutes in developing countries.

In the course of the deliberations it became apparent that, of the many problems faced by such institutes in developing countries, that of management is of paramount importance. The problem stems primarily from the difficulty of finding persons for appointment as institute managers or directors who have the training and experience pertinent to the peculiar requirements of industrial research institutes.

To be sure, high-level manpower in general and in the technical fields in particular is hard to come by in most countries, especially so in the developing ones. As far as industrial research institutes are concerned, the difficulty of finding qualified technologists, engineers and industrial economists and sociologists, great as it is, is even exceeded by that of finding an institute manager qualified from both a technical and an administrative standpoint.

The United Nations Centre for Industrial Development, guided by the views of the Beirut seminar, decided soon afterwards to undertake the publication of this manual as a means of providing practical guidelines to institute managers and others in the field of industrial research, a step which received the endorsement of the Committee for Industrial Development, a subsidiary body of the Economic and Social Council, at its Fifth Session in May 1965.

The primary objective of the manual is the raising of managerial efficiency in industrial research institutes. While it is difficult to overemphasize the importance of proper management to the success of such an institute, the potential usefulness of the manual is not limited to this area nor to the related one of training industrial research personnel, including future managers. The manual will find applications also in the hands of executives and policy-makers connected with the conduct of industrial research both in government departments and ministries and in private industrial and commercial enterprises. Economic planners and administrators, chambers of industries, technical assistance experts on international

or bilateral aid programmes will, it is hoped, also find in it useful information when dealing with problems pertaining to industrial research management. In particular, those who are faced with the task of planning and setting up new industrial research establishments will find many useful guidelines.

The manual is the product of co-operative effort between the Centre for Industrial Development and numerous technical experts with long practical experience in industrial research management. It therefore reflects the views of people active in the actual operation of industrial research both in the developing and the developed countries. A background report which served as the basis of the manual was prepared by the Centre for Industrial Development with the assistance of Lawrence W. Bass. This was sent to several honorary correspondents in different countries who have wide experience in this field for their views, comments and criticisms. Useful comments were received from the following honorary correspondents : R. R. Adams, Industrial Research Expert, Beirut, Lebanon; L. Barber, Project Manager, Institute of Public Administration, Mogadiscio, Somalia; D. W. Hill, Director, The Cotton, Silk and Man-made Fibres Research Association, Shirley Institute, Didsbury, Manchester, England; I. Malecki, Deputy Secretary-General, Presidium and Council of the Polish Academy of Sciences, Warsaw, Poland; Emmanuel Lartey, Co-ordinator of Industrial Research, Ghana Academy of Sciences, Accra, Ghana; D. C. Minton, Jr., Director, Battelle Memorial Institute, Columbus, Ohio; J. D. Mooney, Consultant, New York; Manuel Noriega Morales, Director, Instituto Centro Americano de Investigación y Tecnologia Industrial (ICAITI), Guatemala City, Guatemala; R. W. Richardson, Project Manager, Instituto de Investigaciones Tecnologicas, Bogota, Colombia; J. A. Ritchey, Senior Consultant, Aswan Industrial Development Centre, Cairo, United Arab Republic; I. Y. Sayed, Member of Board of Directors and Executive Director of Management Consulting Centre, National Institute of Management Development, Cairo, United Arab Republic, and F. N. Woodward, Director, Arthur D. Little Research Institute, Musselborough, Midlothian, Scotland.

An expert group held a series of meetings at United Nations Headquarters in New York between 27 September and 7 October 1965 to study the initial report as well as the comments received from the various consultants and to advise on the final draft. The meetings were attended by : Lawrence W. Bass, Consultant; S.M.A. del Carril, Presidente, Instituto Nacional de Tecnologia Industrial, Buenos Aires, Argentina; Francis Godwin, Project Manager, Sudan Industrial Research Institute, Khartoum, Sudan; E. S. Hiscocks, Director, Tropical Products Institute, London, England; C. G. Manuel, Commissioner, National Institute of Science and Technology, Manila, Philippines, and P. C. Trussell, Director, British Columbia Research Council, Vancouver, Canada, as well as by staff mem-

bers of the Centre for Industrial Development including Azmi A. Afifi, Chief, Industrial Institutions Section.

The consensus of the comments received from various countries indicated that the manual should be kept simple and should deal in a clear and practical manner with the actual needs, problems and conditions existing in developing countries. These objectives of simplicity and practicality are reflected throughout the manual. Wherever examples from developed countries have appeared, their purpose has been merely illustrative and the underlying consideration regarding the need for adaptation to local requirements is always implied if not expressed.

The manual covers all of the major areas that involve managerial decision and action in the conduct of industrial research.

Chapter 1 examines the role and significance of an industrial research institute as a national technical resource. It points to some of the historical origins and gradual evolution of institutional industrial research and its growing impact in developing countries. Some of the advantages of industrial research within an institutional framework are examined. The chapter stresses the need for flexibility on the part of research institutes if they must be capable of serving economies that are by nature always changing.

Chapter 2 discusses the scope and variety of services that an industrial research institute may provide. These are treated under four categories : routine services, techno-economic services, general technical services, and research and development.

In chapter 3 the various institutional patterns and organizational forms are discussed. The need for freedom of action for the institute within the over-all national policy is emphasized. The roles of the board of management, the institute director and other senior research and administrative officers are examined. Three forms of organization are identified, namely, the simple form, suitable for a small institute; the more complex form, suitable for an institute with broad coverage of many specialized areas, and the type of organization which employs the multi-discipline project-team approach in dealing with research problems.

Chapter 4 deals with the planning and control of research programmes. Special attention is given to the basic principles involved in project planning, evaluation and execution, whether the projects are initiated by the institute itself or requested by clients, the various stages of research from idea to commercialization and other types of technical as well as economic and management activities to be found in an industrial research institute.

Financial administration is the subject of chapter 5. Points dealt with include sources of institute funds, the administration of capital and operating budgets and working capital, estimation and evaluation of costs of projects and the control of technical effort.

Chapter 6 deals with personnel administration in its various aspects, such as recruitment, training, assignment and supervision of responsibilities, service contracts, staff evaluations, and renumeration and superannuation.

Chapter 7 discusses the relationships between the industrial research institute and its clients. It devotes special attention to the subjects of clientele development, contractual relationships, the selection of areas of operation and the media for external relations.

Finally, in a work of this nature a certain amount of repetition is inescapable, perhaps desirable. In a few cases, some concepts and principles mentioned at one point in conjunction with related concepts and principles for the purpose of completing an over-all picture, have been re-introduced in their proper setting for an individual and more thorough treatment so as to accord them their proper emphasis. This procedure is not inconsistent with the didactic intent of the manual.

Any questions pertaining to the manual as well as comments, criticisms and suggestions may be addressed to :

The Industrial Institutions Section,
Technological Division,
Centre for Industrial Development,
United Nations,
New York, N.Y. 10017,
U.S.A.

CONTENTS

Chapter 1

THE INDUSTRIAL RESEARCH INSTITUTE AS A NATIONAL TECHNICAL RESOURCE

More than ever before, the view has become widely accepted within the last decade that the availability of certain basic technical and investigative services, easily and readily accessible to a broad range of users within a country, is as essential to successful industrialization of the country as is the availability of investment capital. In theory these services could be provided in a variety of ways which have been evolved over the centuries. But, logically, the developing countries wish to avoid repeating the painful process of evolution and, in the light of advanced practice in the industrialized nations, to organize these services in such a way as to make the most effective use of the available and often very limited technical resources.

The accepted instrument for this purpose today is generally called an industrial research institute, although its work is by no means limited to research. As defined for the discussions that follow, an industrial research institute is an organization for rendering locally various technical services and for carrying out scientific, engineering, economic, or socio-economic investigations on industrial projects believed to have ultimate practical significance, whether such projects are initiated by the organization itself or proposed by individual establishments, investors, industry associations or government agencies. The clients, including government agencies, asking these services of such an institute may pay part or all of the cost.

Historical development

The concept of the industrial research institute is relatively recent. The history of such institutions goes back only to the first decade of this century. Well before this time, however, a few privately established technical organizations had demonstrated successfully the merits of carrying out research and development under contracts with clients, who sponsored and supported specific assignments. Also, in some countries close working relationships had been developed between university faculty members and industry for conducting research on important industrial problems.

Originally it was thought that institutions of applied research could best be organized within the complex of a university. The popular belief was that this relationship would provide a ready-made pool of technical

talents from among the faculty members, who, while continuing their teaching activities, could at the same time take part in the applied research work undertaken on behalf of clients. Furthermore, it was felt that the use of the available facilities and equipment of the universities for this additional purpose would avoid the expenditure of large sums of money for separate buildings with the necessary laboratory furniture, basic equipment and instruments.

Such an arrangement, however, usually leads to the assignment of project work to post-graduate students because the experience that these students might thus acquire is thought to be a further advantage. But lacking an adequate background, and because they are preoccupied with the competing requirements of their curricula, such students are seldom in a position to be able to afford the time or bring to bear on the research project the professional competence expected by the clients. The faculty members themselves, however high their competence, have even less time to give to outside work.

History shows that the success of an industrial research institute depends upon making a rate of progress satisfactory to the clients. This requirement has led to the practice of establishing a separate pool of permanent staff by institutes even in those cases where the university connexion is still maintained. In such cases the faculty members sometimes continue to participate on a part-time basis in the work of the institute, but the backbone of the staff usually consists of full-time investigators. The latter may of course participate in the educational work of the university by devoting some fraction of their time to teaching or to directing thesis problems of graduate students, when and if this may be done without serious interference with their obligations to the research institute.

Similar problems are to be encountered with regard to shared physical facilities, except perhaps libraries. Actually it is seldom found feasible to use the same equipment simultaneously for instruction and for client's research. Often the equipment required is of different types; but even when identical the scheduling of its use becomes difficult. Furthermore a researcher can seldom rely on the accuracy of adjustment of apparatus used on alternate days by inexperienced students. Thus, whatever the original intention, in the end an industrial research institute invariably finds it necessary to acquire its own facilities.

Indeed, the later chapters, dealing more fully with institute services, special organizational and administrative requirements, staffing problems, contractual relations with clients and similar matters, will show why an institute can serve most effectively if established as an entity in itself, with a reasonable degree of freedom of action within the framework of the national development policies.

It is worth emphasizing in this connexion that the role of an industrial research institute in relation to parties external to it is essentially advisory

and consultative, and should be impartial and above all non-political. The institute does not determine industrial development policy. Its job in industrial development is simply to find answers to practical research problems and to provide needed technical services and information, confidentially or otherwise, as may be required by its clients. It is the ability of an institute to do this competently, independently and without bias that determines its capacity for effective service to any national programme of development.

Advantages of industrial research institutes

Conservation and Efficient Use of Diversified Talents

An industrial research institute is a valuable national asset that is likely to grow as the economy expands. It has that element of permanence that is lacking in *ad hoc* research schemes and investigations which rely mainly on the short-term assistance of an expert. Being essentially an indigenous institution, the institute enjoys the support and participation of the various sections of social and economic life. This enables it to be sensitive to the practical needs and problems faced by the local industry and to identify itself with the over-all economic aspirations of the government and country.

A most important factor to be realized is that a diversified technical organization has a greater potential for problem solving than individual units or specialists operating separately. This superior efficiency is attributed to a phenomenon often called " cross-fertilization ". It has been recognized that the lone scientist or engineer, or the too narrowly specialized group in a single field, however competent and valuable for certain purposes, is not the ideal answer to solving complex technical problems.

The industrial research institute, therefore, offers the effective scientific milieu for a collection of technologists, engineers, industrial economists and sociologists to work simultaneously in a co-ordinated manner rather than separately. This enables them to view and deal with all aspects of a given problem in such a way as to achieve the practical solutions which are continuously demanded by the large variety of industrial activities. The variety in types of problems suggests the need for a diversity of disciplines to be represented, to the end that though the institute may operate on the principle of assigning one man full-time to a particular problem, he is nevertheless in intimate contact with a group of colleagues with a wide range of backgrounds and experience. Furthermore such a staff member has access to the senior administrative staff for advice in diagnosing his problem and planning the approach to its solution. In sum, a researcher tackling an assignment within an industrial research institute enjoys the benefit of being in a technical community which affords him advice, consultation, stimulation and encouragement.

For a country with a limited supply of technical personnel, such an institutional arrangement is the most economical way of utilizing what little staff there is and avoiding possible under-utilization of some capable individuals in isolated and narrowly conceived research undertakings.

Sharing of Laboratory Facilities, Equipment and Library

The accumulation of the technical facilities required for a given problem is quite costly. The investment that exists in a well-equipped laboratory often approximates the total annual operating costs of the organization. In other words, if the yearly budget for operations is, say, one quarter of a million dollars, or its equivalent, then the investment in buildings, laboratory furniture, basic laboratory equipment, and special instruments and apparatus may well be about the same figure also.

Although, as already pointed out, the sharing of facilities between the activities of an industrial research institute and the altogether different (teaching) activities of a university presents serious difficulties, the situation is quite different with respect to sharing of facilities by the various activities within the institute. In fact, because the combined facilities of an institute are shared by numerous projects, the wide variety of instrumentation available constitutes very valuable assistance to the progress that can be made on an individual project, to say nothing of the financial economy. It would be very difficult to justify for the use of one man, in the separate laboratory of an individual industrial establishment, the wide range of scientific tools with which he needs to be equipped to carry out his work in optimum fashion.

Flexibility and Diversity of Services

Another important advantage of industrial research institutes is that they are able to employ their staff in a manner that successfully meets the requirements of projects involving various technical inputs and disciplines. As an example, if an industrial firm decides to go into a quite different line of operation and needs to explore the potential in terms of scientific requirements, it would incur a considerable expense to recruit, train and support the needed group of specialists inside the factory organization. Further, there would be an implied commitment to keep them employed on a long-term basis in the area of their specialities, even though the results of the exploratory investigation might cause the management to lose interest. The industrial research institute with a fairly permanent staff of experts in various fields can make the proper manpower available to undertake this study and, when it is completed, can use the same personnel on other projects.

There is also the experience that those manufacturing establishments which do maintain their own teams of technical staff are confronted from

time to time with very heavy overloads of work. The pool of technical talents in an industrial research institute, however, provides a means of taking care of temporary excess demands for technical services.

Training of Specialized Personnel

In a developing economy the industrial research institute offers a particularly valuable venue for the training of young scientists, engineers and economists in the practical aspects of research work. The great importance of this is clearly evident from the historical development of institutes in the developed countries. In the first decades of this century, few enterprises had their own research and development departments. Apparently the prestige of working in industry had not been established in the minds of trained scientists. Research facilities available in industry were not impressive, particularly when compared with those in universities. Research staff were generally small and did not provide anything like the same degree of intellectual stimulation to their members that modern scientific communities provide to theirs. The industrial research institute offered a half-way house between the university atmosphere and the laboratory of an industrial establishment, and young research personnel could rise to high positions, such as that of Director of Research and Development in the research departments of companies that had sponsored the projects that formed the basis of their training.

In developing countries this aspect of providing a means of entry into industrial research and development is of even greater importance than it was to the now developed countries when they were in a comparable era. Scientists and engineers who have completed their advanced training, especially those who have done so in universities of the advanced countries, are sometimes at a loss to know how they may fit into the industrial world of their home countries. Frequently opportunities are lacking and have to be developed by educating the managements of industrial organizations as to their needs for an internal organization to generate new technology.

Obviously in developing countries the start must be slow, extending over a number of years. This means that the new researcher in one such nucleus of a research unit would be almost alone in a strange world, without the benefit of contact with other researchers. Further, he would probably have had little contact with applied science during his period of training and might not know how to go about establishing himself in this new atmosphere. And while there may be a great opportunity to accomplish important work for the benefit of the country, the prestige of industrial science may not have developed sufficiently to give him the professional gratification that is needed. Finally — and this is an extremely important point — the executives of the industrial establishment may not have the particular background, understanding and sympathy for research and development

which are necessary to equip, motivate and guide the young scientist who has joined them.

In summary, then, the scientists, engineers, economists and other professional technical staff in an industrial research institute have the benefit of a stimulating and congenial environment within which to make a contribution to the advancement of their national economy. The younger staff will receive advice and guidance from their senior colleagues. The facilities will be good and the library adequate. The executive staff will provide training and direction, and there will be a sympathetic atmosphere for professional growth. All in all, the surroundings approach the ideal for the transfer of professional talents from an academic background into productive work in applied science.

Keeping Industries Up to Date

For the expansion of their industrial operations, the newer economies have generally relied to a considerable extent on information and know-how from the more advanced countries. The industrial research institute is an excellent medium for collecting industrial and technological information from all available sources, domestic and foreign, and disseminating it to local industrialists and other users. Frequently the necessary equipment for these new operations is also purchased abroad. This is, of course, a sound practice for speeding up the progress of the economy, and is preferable to taking the much longer course of generating a technology internally that is already available from other sources. In fact, the same practice is often found in mature industrial economies, whereby a company or establishment will go to outside sources to acquire the processes, products, information, equipment and new skills required to make a more rapid entry into a new type of business.

Frequently, however, the newer countries may not take into consideration the necessity for continuing improvement and change in technology and facilities obtained from abroad. The new plant may have been installed and put into operation largely through the use of external engineering skills. If it is to continue to be of maximum utility in the economy, it must sooner or later face new requirements, such as the adaptation of new types of raw materials that are available or modification of products in order to fill more effectively the needs of customers. If this necessity for improved or new technology in the installed plant is not recognized soon enough, the effectiveness of the operation gradually diminishes until a point is reached at which something fairly drastic must be done rapidly.

Unfortunately, at such a late stage the new technology cannot be obtained at once just for the asking. The groundwork should have been laid through planned, active research and development which may require many months or even years. Therefore, the requirements of the future

must be recognized well ahead of the time when they become imperative needs. This means the advance programming of research and development activity in an orderly sequence that takes into consideration the time-consuming nature of technological progress.

The important research and development projects in a given establishment can rarely be undertaken satisfactorily on an accelerated schedule merely by engaging a scientist or engineer, even though he has had extensive background in the particular industry. The many reasons that support this conclusion have been observed in their effect over the years in the more advanced industrial countries. For one thing, when an establishment first employs a scientist or engineer, normal experience is that there are many immediate short-range problems on which he is likely to be used. The major problems for which he was engaged constantly suffer for lack of attention because of these other demands on his time. Until he was available, the handling of such matters was probably done in a less satisfactory way. However, as soon as he can be called upon, he begins to find a constant demand for advice, experimentation, and assistance in a series of day-to-day assignments. This is certainly a very useful service to the establishment, but it is not getting the research and development done.

Recognition of this course of events frequently leads companies to take one of two steps : either they may very carefully segregate the individual supposed to be doing research and development so that he is not continually diverted into the short-term service type of work or, alternatively, they may decide to place the research in an external laboratory or organization which, because of physical and organizational separation, can more successfully concentrate on the main task — and incidentally bring to bear upon the problem a larger staff and superior facilities.

The Institute as a Channel for Utilizing Foreign Technical Skills

In developing countries the use of foreign consultants and contractors is of great importance in accelerating the transfer of external technology to their economies. A broadly based industrial research institute can offer effective and discriminating channels for contact with foreign organizations.

Because of the institute's range of activities with various industries within the country, its staff will naturally become well acquainted with many foreign scientists, technologists and engineers. It can provide clients with general assistance in diagnosing their problems and the types of technical skills which may be obtained abroad. It can aid in assessing the various sources of information and in serving as a liaison for adapting foreign knowledge and experience to local conditions.

These general services may be rendered to sponsors as an additional advantage outside the scope of a particular project. Out of them can arise specialized assignments to carry out specific investigations on the means of obtaining and implementing foreign skills.

Chapter 2

SCOPE OF SERVICES OF INDUSTRIAL RESEARCH INSTITUTES

In the numerous developing countries where they have already been established, experience shows that industrial research institutes may be called upon for a wide range of services to individual establishments and public agencies. In fact, the scope of services now being offered by some institutes in the newer economies already parallels those offered in some highly industrialized countries. This is not surprising, since the requirements for industrial progress are basically the same, and the available alternative sources of help are generally few.

RANGE OF NEEDS

Special local conditions notwithstanding, all developing countries are seeking essentially the same things in their industrialization programmes : more local manufacturing, greater diversification of products, more efficient production and a better competitive position. All are seeking to mobilize more financial capital for the purpose and want to make its investment go as far as possible. All are faced with essentially the same handicaps and for similar reasons, any differences being mainly in degree. On the whole, therefore, the gaps to be filled are also similar.

The particular technical and techno-economic services needed by governments, investment and development agencies, and existing and potential industries in these countries have been identified many times through competent surveys and confirmed through direct examinations and inquiries of factories, public industrial authorities, private investors and industrial banks. These services, whose absence or inadequacy is retarding the rate of industrial progress, make a sizeable list.

From idea to finished product, the needed assistance includes : technical information and reference library services; surveys of industrial possibilities; technological, socio-economic and market feasibility studies; examination of the soundness of proposed industrial investment projects and their redesign when necessary; pre-project planning and pro-forma costing; applied scientific research and pilot-plant development (for new or improved products, by-products, processes, use and adaptation of local raw materials, cost reduction, adjustment of processes to special local production condi-

tions and the like); economic plant location; efficient factory layout; scheduling, handling and storage of materials; increased productivity; development of industrial standards and specifications; testing and quality control; technical trouble-shooting; emergency production aids; production costing systems, and the full modern spectrum of production engineering and technical management counselling. A more exhaustive list might include certain other items, although in fact most of them would prove to be offshoots or combinations of the foregoing.

Whatever its selected pattern of services, the over-all role of an industrial research institute is to assist the industrial sector of the economy, in a consulting and advisory capacity, toward the ultimate goals of industrial development on a national, regional or local level. For this purpose its services should be readily and equally available to all types and sizes of industry embraced by the economy — public as well as private — and to government departments, planning bodies, financial institutions and other public or private agencies having a part in the development process.

The decision of a particular industrial research institute to provide some or all of the services mentioned depends upon the stage of development of the country, the availability of human and material resources, the organizational structure and aims of the government, and to some extent whether any part of the needed services may be already provided adequately by other existing local organizations. It is important to note, however, that while certain of the listed services are individually separable, many are so integrally involved with others that they cannot be performed effectively in isolation. Thus in selecting the limits of its work such an institute does not, in fact, have a completely free choice; for in order to render certain of the enumerated services effectively (or in some cases to render them at all) it must equip itself also for certain others, whether it chooses to offer these others as direct services or not.

In practice, the activities of an industrial research institute do not necessarily break down precisely as listed above, especially as the majority of actual industrial problems require combinations of various services for their solution. For discussion here it may be more useful to review briefly a number of the most common services, examining certain categories of work in slightly greater detail and including mention of a few special services supplementary to the basic list.

Routine services

Information services are generally among the first to be offered and the first to be used, and are essential components of any such institute. An extensive and up to date library of industrial technology and applied science must be maintained for the purposes of the institute's own work in any case, and its value is enhanced if it is made available for use by local

industry and others as well. In addition to its technical books, the library should include industrial equipment catalogues, directories of suppliers abroad, official standard specifications of principal supplier countries and leading trade journals in lines of production of local interest. Exchange arrangements should also be established with overseas libraries.

Information services backed by both library and technical staff can usefully include :

(*a*) Technical inquiry services which offer answers to specific questions posed by industry on production methods, industrial management matters, general engineering problems, types of equipment, marketing considerations, patents and so on;

(*b*) General industrial information which often refers to trends and possibilities for using specific raw materials, industrial products and processes, industrial projects and programmes, and a wide variety of matters of a general nature;

(*c*) Technical digest services which review available literature and extract technical information;

(*d*) Training manuals for use by the technical staff and managements of industries.

Analysis and testing, while incidental to the main work of an industrial research institute, are also often among the first services to be called for by clients of a new institution and frequently provide an *entrée* to work of greater scope. Even where there are already governmental or private commercial analytical laboratories available, there is likely to be a demand for special or unusual work of this kind outside their daily routines or beyond the range of their equipment, or for the services of an independent referee or confirming laboratory in matters of dispute. The institute should not, of course, seek to drive perfectly good and well-established routine laboratories out of business through unjustified competition, but only to supplement the services already available in whatever manner may be called for. On the other hand, the research institute because of its other work will probably have available a greater diversity of superior testing facilities than can be found in ordinary analytical and testing laboratories.

Patent development and licensing assistance often assumes importance for industrial research institutes in developing countries whether originally envisaged or not. The heavy volume of internally initiated research in such an institute sooner or later involves the organization in the handling of patents and their licensing, sometimes as the country's first domestic source of such commercially exploitable rights. It thus naturally becomes a recognized centre for information on such matters and a logical point of contact with other sources of patented processes and products, both at home and abroad, through its own local and overseas legal counsellors in this field.

Contact with Foreign Technology, not only in respect of patents but through general liaison with sister institutes and other organizations abroad on a wide range of technical matters, can often prove to be an invaluable added contribution of an industrial research institute to the progress of the entire country.

TECHNO-ECONOMIC SERVICES

The value of an industrial research institute in a developing country is measured to a large extent by its ability to reduce its technical findings to practical matters of cost, finance and business considerations, and thus to assist industry in its usual problems involving simultaneously both technical and economic aspects. The ratio in which these two factors are involved varies greatly. Strictly speaking, there are very few such institute operations in which a distinct separation of technical and economic features is possible without loss of the institution's practical orientation. As distinguished from those which are primarily technical, however, there is a wide range of customary services often categorized as techno-economic, of which some examples may be given here.

Feasibility studies represent a most important function of an industrial research institute in a developing country for they require a combination of technical and techno-economic work of a very practical sort. In connexion with proposals for new or expanded industrial projects, or applications for industrial loans, such studies extend into process comparison, raw material problems, local production conditions, market estimation, pro-forma costing and the like, and are called for by development banks, private investors, industrial firms and government agencies.

Marketing studies represent an integrated process involving more than mere selling. It affects production and is meanwhile affected by it. An industrial research institute can, for instance, develop and improve marketing functions for a single establishment or an industry. It can assist in determining the potential market : who is the potential consumer, what and when will he buy, and how much is he expected to buy? Through market research this data can be gathered, analysed and put to work for the industrial enterprise in planning its production. The institute can assist the management of a factory in the planning so as to offer the right merchandise in suitable quantities, at convenient prices, and at the right time and place. It can advise on packaging, labelling and branding of products, as well as on creating the desire of the consumers to buy a particular product. It can also advise on many other problems connected with marketing, such as storage, transportation and marketing finance.

Techno-economic analyses by an industrial research institute provide top management in industry with comprehensive or long-range information on which to base plans for expansion, optimum use of resources and

improving economic returns. The function is concerned primarily with analysis of growth opportunities for an enterprise, taking into account trends and socio-economic conditions, and alerting the management of an industry to new or developing factors that may affect its long-term policies or production programmes. Similar information and advisory services by the institute may be provided at the request of a national economic planning body from time to time. Because a well-organized industrial research institute has an integrated staff with a wide range of skills, it is well suited to assist the government in carrying out assignments of this type, which require, for best results, joint inputs from the scientific, engineering and economic disciplines, including the social sciences.

Raw material surveys needed by developing countries may involve only a specified material for a particular project; or they may be comprehensive investigations of a country's raw materials generally — organic or mineral — with a view to using them most advantageously for socio-economic development. The studies required are techno-economic in scope. They must include characterization and assessment of volume, location, accessibility, economy of collection and transportation, and evaluation of quality in terms of direct marketability or utility as raw materials for processing. Obviously an industrial research institute with a staff of broad competence is well suited to carry out such projects.

Management and production engineering services include a broad complex of work involving some of the functions already mentioned, as well as advice on organizational structure, factory manning, economic factory siting, efficient plant layout, raw material and production scheduling, accurate cost accounting and many other aspects of successful industrial plant operation. For industrial development these elements are no less important than the choice of product and the decision to manufacture it. In major industrial countries many such services are readily obtainable from specialized consulting firms. This is seldom true in a newly developing country, however, and it devolves upon the industrial research institute to provide them since they are integrally linked with most of the problems undertaken by such an institute.

Productivity improvement is, of course, a basic aim of much of the work of an industrial research institute. It is not, therefore, a separate type of service, but is concerned equally with every factor that enters into industrial production, whether technological, economic, sociological or psychological, since productivity is simply the ratio of output to total inputs of all kinds.

The over-all problem of industrial productivity must be clearly distinguished from that of labour productivity, which is only one of its various components and not necessarily the one most in need of improvement. Thus the role of a broadly staffed research institute is to approach the problem in its entirety; for when productivity is measured only in terms

of labour productivity — as it sometimes is — there is a double danger. In such a limited concept the tendency to blame labour for a low rate of industrial output may not only obscure the real interrelated factor causing the low output, but may also place labour in an unfair situation which can lead to serious conflicts.

General technical services

In a developing country especially, an industrial research institute is in a unique position to offer industry a multitude of special services on the broad line between routine services and research. They are largely of a technical nature, often urgently needed and often unavailable from other sources. A few examples of these will suffice.

Production standards and specifications are necessary for the maintenance and development of markets, for meeting competition and for the rational administration of import and export trade. They are concerned with the uniformity of composition and measure and the safety and quality of merchandise, all designed to protect the consumer. Work in this field includes both the studies necessary to establish reasonable standard specifications for local conditions and constant testing by a neutral laboratory to see that the products conform to the specifications. Many countries, to save the dual cost of a separate standards laboratory, find that these services can very well be provided by an industrial research institute.

Quality control, which a research institute can help to put in practice within the factories themselves for operation by their own personnel, is concerned with the systematic use of analytical techniques and inspection methods and procedures to ensure that raw materials, intermediates and finished products meet required specifications. Quality control results may be incorporated in programmes directed toward analysis of efficiency of production operations.

Equipment evaluation can be an especially useful service to a developing country. Very often there will be dominant industries in one or two traditional lines involving numerous similar plants. For these an industrial research institute can serve as a central facility in which new or improved equipment is tested in collaboration with representatives of the industrial establishments concerned.

Trouble-shooting covers many varied services, often of vital importance economically, which may be extended by the institute to assist industry in solving its physical operating problems. The problems may require the knowledge and experience of a scientist, engineer or technologist, but often call for relatively short-term work to put things right. However, if they cannot be solved readily, arrangement may be made to conduct a more thorough research study involving the services of a team of several disciplines.

Research of several major types is, of course, among the primary functions of an industrial research institute and, as the activity indicating the highest technical level of the institution and often accounting for the largest single portion of its budget, is the function from which the institution derives its name. The work is generally of a longer-term nature than that of the other services. It is further distinguished by the fact that, although advanced technical knowledge is an essential tool, highly specialized experience of the " expert " variety is frequently less of a requisite than imagination and ingenuity. The reason for this is that, since research is exploration into the unknown, no expert knows the answer to a research problem — for if he did it would not be a research problem at all.

It is appropriate to note here that what is commonly known as fundamental research is not ordinarily one of the primary functions of an industrial research institute. The term generally describes the search for new knowledge without immediate regard to its practical utility. It is the historic type of investigation, often called " pure research ", conducted in an academic atmosphere. It is mostly carried out in universities and similar institutions, which are its proper venue, for the purpose of advancing the frontiers of man's knowledge generally, for satisfying the scientific curiosity of the investigators and for developing theories to explain natural phenomena. It is the classical tool for training advanced students in the logic and methodology of scientific inquiry and analysis. It is often the source of new technological breakthroughs, but these are usually worked out subsequently by other scientists oriented toward practical problems, who make use of this new scientific knowledge in any manner that has a bearing on the solution of some industrial or everyday problem.

With this preliminary qualification — which itself is not to be regarded as a rigid exclusion — it will be useful to touch briefly on the more predominant types of research normally undertaken by the institutions dealt with here.

Basic research, which is more aptly called " oriented long-range research " in many industrial organizations in advanced countries, denotes the use of scientific methodology for development of new knowledge in selected fields of present or potential practical interest to the clients. But even here the work is not primarily concerned with immediate commercial objectives. It is conducted not only for the results it may itself yield in the future, but also to maintain effective contact with the world of science, from which pertinent information may be obtained to solve the problems of an enterprise, industry or national economy. Oriented long-range research projects are normally rather similar in character and theoretical content to " fundamental research ", but they are slanted toward specified areas of potential industrial interest. Five years or more of sustained effort is

often required before the results of such work are implemented on an industrial scale. There may be valuable interim by-products of knowledge from such projects, however, and they may have utility in solving current applied problems.

This type of research is usually supported, even in highly developed economies, only by the largest companies in science-based industries. In such enterprises its magnitude may amount to 10 per cent or more of the total research and development budget. In developing countries, where the industries are not yet accustomed to major investments in speculative research, such projects are most commonly sponsored by government, if at all, or they may be undertaken on the institute's own initiative as discussed in a later chapter.

Applied research, often termed "product-directed" or "process-directed" research, is concerned with the evaluation of existing knowledge originally evolved through fundamental research, whether carried out within the particular organization or elsewhere, for adaptation to specific commercial products, processes or innovative development. This form of research and the subsequent stages of final development for commercialization ordinarily represent the greater part of the research conducted by an industrial research institute. Its specific objectives, some of which have already been mentioned, include the development of new or improved products and processes, adjustment of existing processes to special local production conditions or to the particular characteristics of available local materials, reduction of production costs, development of special preservation and packaging methods and of new uses for local raw materials, and the recovery of by-products.

There is sometimes a popular tendency to give disproportionate attention to the last of these. Considerable glamour surrounds investigations to create new and unsuspected uses for locally available materials, to recover useful values from industrial or agricultural wastes or to upgrade the form, properties and utility of by-products.

New uses for local materials are well worth looking for, but seldom does the industrialization of a newly developing country depend on finding them. If the country's technical resources are limited, it should keep such an effort in balanced perspective, lest too large a percentage of the resources become dissipated in the hope of discovering some wholly new and hitherto unheard of industry, while the more promising opportunities of more familiar forms of industrial production are left untouched.

There are many examples of projects for using waste materials which have attained notable success. Often the recovery of these values contributes to the economic advantages of the primary process from which they were derived. Utilization of wastes often counteracts the expense of disposal and may be obligatory in order to eliminate nuisances. Similarly, improving the properties of and economic return from by-products which hitherto

were sold in low price ranges, for example, as basic fertilizer components or animal feeds, increases the total income of the establishment both through greater monetary return and an enlarged scope of operations which tends to reduce overheads.

There are, unfortunately, a great many more examples in which the technical work has been wasted because of failure to evaluate the economic aspects thoroughly. The volume of waste or by-product may not be large enough to justify the expense of recovery or upgrading, a situation which should be, but often is not, revealed by undertaking an engineering analysis of the proposal. There may be an opportunity for improving the primary manufacturing process, which will reduce the quantity of waste or by-product below economic level. Finally — and this point is often overlooked — if the recovery is put into operation, the wastes are no longer to be regarded as having zero value when they enter the new process; sound accounting practice requires that they bear their share of the plant overhead expense. Furthermore, their recovery will often necessitate changes in the primary process which will add to their cost.

When a study for waste recovery is under consideration by an industrial research institute, the management would therefore be well advised to suggest a preliminary analysis. This should cover not only the technical feasibility of the concept, but also the projection of economic factors concerning the volume of material available, the impact of recovery on the primary process and the competitive situation of the markets which are contemplated. Only if these are favourable should the proposed research and development be financed and carried to completion.

Development, in the present context and as a service of an industrial research institute, is a term generally referring to any pre-commercial study to determine the technical feasibility of laboratory findings when transferred to equipment approaching full-size plant in general design and operation. When carried out on a semi-plant scale, such work provides data needed for the design or adaptation of commercial-scale plant and permits confirmation of engineering and economic estimates. Projects of this type usually require two to five years before their results are introduced into commercial operations.

In a wider sense, the term includes both process and product development, and what has just been described is mainly the former. Product development most commonly refers to work, on laboratory or pilot-plant scale, undertaken toward the introduction of new, better or more economical products, their manufacture from new materials or by new methods and so on. It may often be the type of activity involved in shorter-range projects for expanding existing product lines of a given industry.

Chapter 3

INSTITUTIONAL PATTERNS AND ORGANIZATION

General considerations

Industrial research institutes can be government organizations, private organizations or something intermediate between the two.

Numerous privately operated industrial research institutes exist in the developed countries and a smaller number of similar institutes will be found also among the developing countries. In the latter countries, however, the initial support will almost inevitably come from the government, although as the institute develops an increasing proportion of its financing may well come directly from industry.

Experience has shown that the normal government administrative practices are sometimes inconsistent with the requirements of an industrial research institute. It is desirable, therefore, that some mechanism should be devised to provide for continuity in the financing and operation of the institute and to assure stability of staffing, while enabling the institute to work within, and in aid of, the over-all government programme of industrial and economic development.

Because the operations of an industrial research institute do not fit well into strict government administrative systems, a device which has been used very successfully is for the government to appoint a council or board of management. This board and the chief executive appointed by it are given different designations in different places. The former is sometimes known as the council of industrial research, the governing body, board of governors and the like. The latter is usually called the director. Powers are vested in the board by the government and the board in its turn is responsible for the technical, financial and administrative operations of the institute. Its policies are executed by a director who is appointed and may if necessary be dismissed by the board.

The terms of reference of the board normally provide for representation on it of those sections of the community which may be affected by the operations of the institute. Thus the government, industry, science, management, labour and so on may have representatives on the board which may well have a total membership of ten to fifteen. It will normally be a requirement

that the board shall meet periodically to transact its business. In the very early days of a new institute it may be necessary for the board to meet fairly frequently — perhaps six times per annum — but experience in many countries has shown that at a later stage the number of meetings can well be reduced to three. At its meetings the board will, in addition to setting broad policies, consider the staffing of the institute, the expenditure of money available to the institute, and the programme and progress of the institute's technical work. Normally the board will report annually to the appropriate minister of government, giving a full account of its stewardship. The legal structure and internal financial operating procedures of the institute must be compatible with the particular social and political system of the country. Probably the most important function of the board will be to receive from the director, for annual review and approval, a programme of work for the institute.

The director occupies a key position in the institute and the board will need to search for a man with the many qualifications necessary to hold this position. In the first instance, the director should have a scientific or engineering background and should possess a sound record of achievement. His work and interests should be directed towards applied research. It is important that he should be a good judge of men, particularly for their technical qualifications and capabilities, and he should be an able organizer with some business acumen and administrative skill. He should have a co-operative attitude towards people outside the organization and the ability to inspire his own staff to action rather than to talk. At times he should be prepared to make unpleasant decisions when such are necessary in the interest of the institute. If he has technical achievements to his credit, so much the better. It is important that he should be prepared to delegate responsibility, but also to hold people accountable for the delegated responsibilities. He is expected to protect the research workers from unjustified criticism or interference from any member of the board of management or from a source outside the research institute. Though he is essentially a technical man, he should have also the ability to talk and write about technical matters in a manner understandable to the layman.

When the director has been appointed by the board, he should, in the first instance, be supplied with a small staff to enable him to organize the operations of his institute. The circumstances of his appointment will indicate whether his institute is to be multi-purpose or specialized. In many developing countries the first requirement is for a multi-purpose institute, and the director will first survey the region and determine in which areas technical assistance is most urgently required. He will also bear in mind the longer-term requirements of the area, and these considerations will enable him to determine the number and disciplines of the staff he will require. It will also enable him to determine what facilities he will require in the way of buildings and equipment.

In all probability, the early technical work of the institute will be advisory and will include the provision of industrial information together with some laboratory work, such as materials testing. As the institute gains in experience and becomes better known, requested research programmes will be introduced. The director will need to be able to persuade government or local industry to use and develop the results of the work of his institute. He should also be able to introduce and adapt to local industry processes and techniques developed elsewhere.

Where a private industrial sector is to be served, the institute must be able to carry out investigations on a confidential basis. Complete confidentiality is not always necessary, however. Sometimes an industrial organization will need work to be done in which the institute itself is also interested as an " in-house " project. In this case, sharing the cost of the investigation can be arranged, and the result of the work will be available to both the client and the institute. Sometimes the industrial client wishes merely that the specific applications of the investigation be confidential to him, but will allow the institute to publish any technical methods developed during the work. Here the client normally pays for staff time, special materials requirements and an element for overheads. But if the client wishes full confidentiality, then he should pay the full cost of the project, and the institute should be empowered to maintain complete secrecy of the results. The institute should carry out investigations based on the director's survey of the local economy, and in the first instance these investigations should be aimed at the speedy satisfaction of local requirements.

It is sometimes necessary, for technical reasons, for some part of an investigation to be subcontracted to another research institute having the special skills or equipment required. In all cases, the director must be prepared to terminate those investigations which show little chance of success or of assisting the economy of the area. This is most important. The history of research institutes shows that it is extremely easy to start investigations and extremely hard to terminate them.

To aid its information and advisory work, the institute will build up a technical library but will also obtain assistance from the numerous other institutes in the world with longer experience.

Although, as already pointed out, the director will have over-all responsibility for carrying out these functions, he will, of course, select a staff of capable people to assist him. The members of the board of management can also provide a valuable service by making the institute and its potentialities known as widely as possible.

Organizational structure

In a new institute it is important that the organization shall develop from the scope and nature of the work. It is not appropriate that a scheme of organization should be laid down and the work made to fit the scheme.

Also, in the early days labels should not be attached to particular members of the staff. As the operations of the institute develop, those members of the staff most capable of taking control of sections of work will demonstrate their ability, and it is only when the staff reaches such proportion that their work cannot be supervised adequately by the director that a more formal organizational scheme will need to be developed. Even then, rigid sectionalism must be avoided because it is most important that the talents of all the staff shall, as necessary, be brought to bear on any problems being investigated. Even when sections are created for management purposes, every effort must be made to instill into all the staff that their loyalty is to the institute as a whole and not to some small section of it. The project-team system is of great assistance in this connexion and this method of operation will be discussed later.

Chart 1. SIMPLE FORM OF ORGANIZATION OF AN INDUSTRIAL RESEARCH INSTITUTE

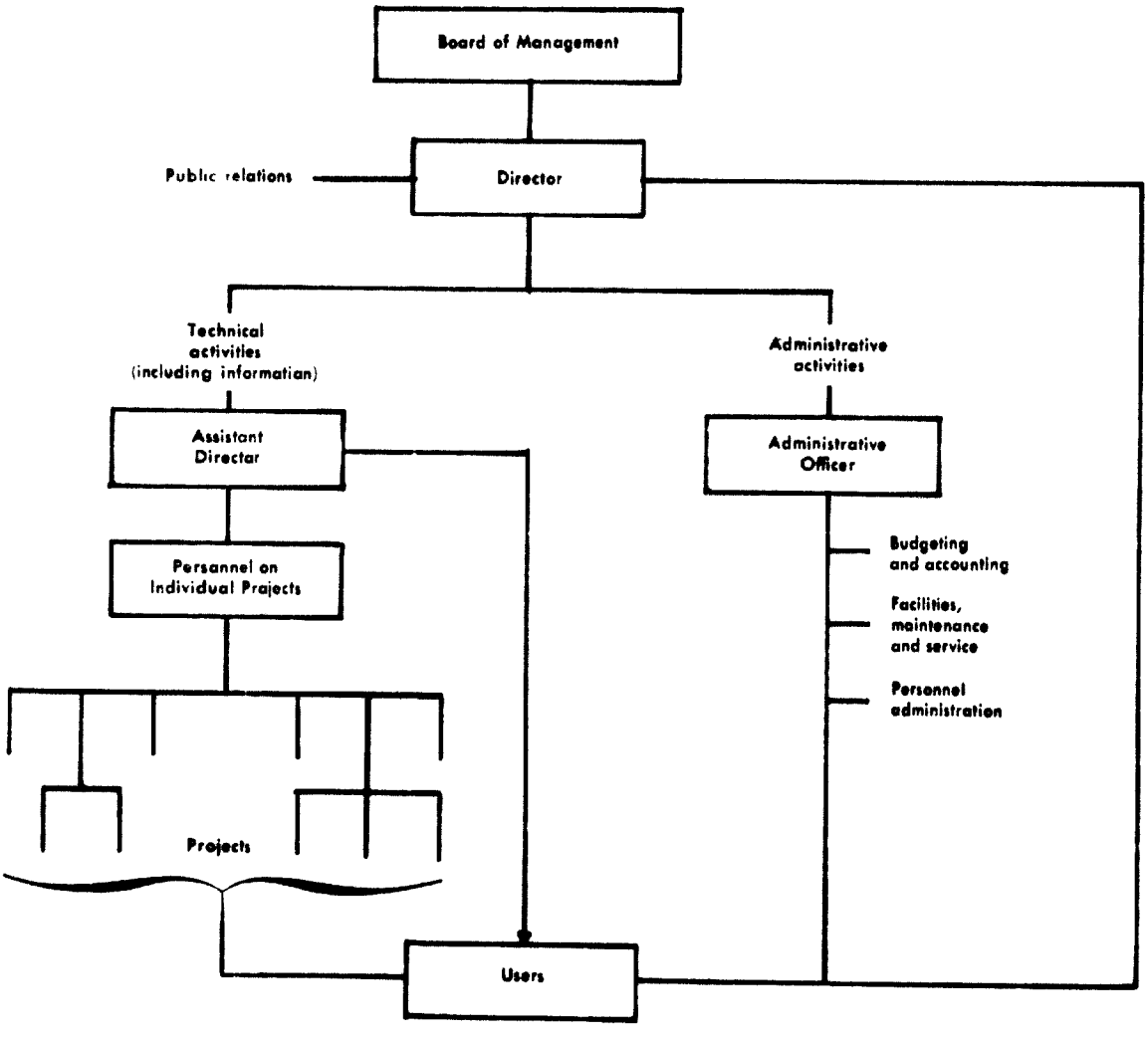
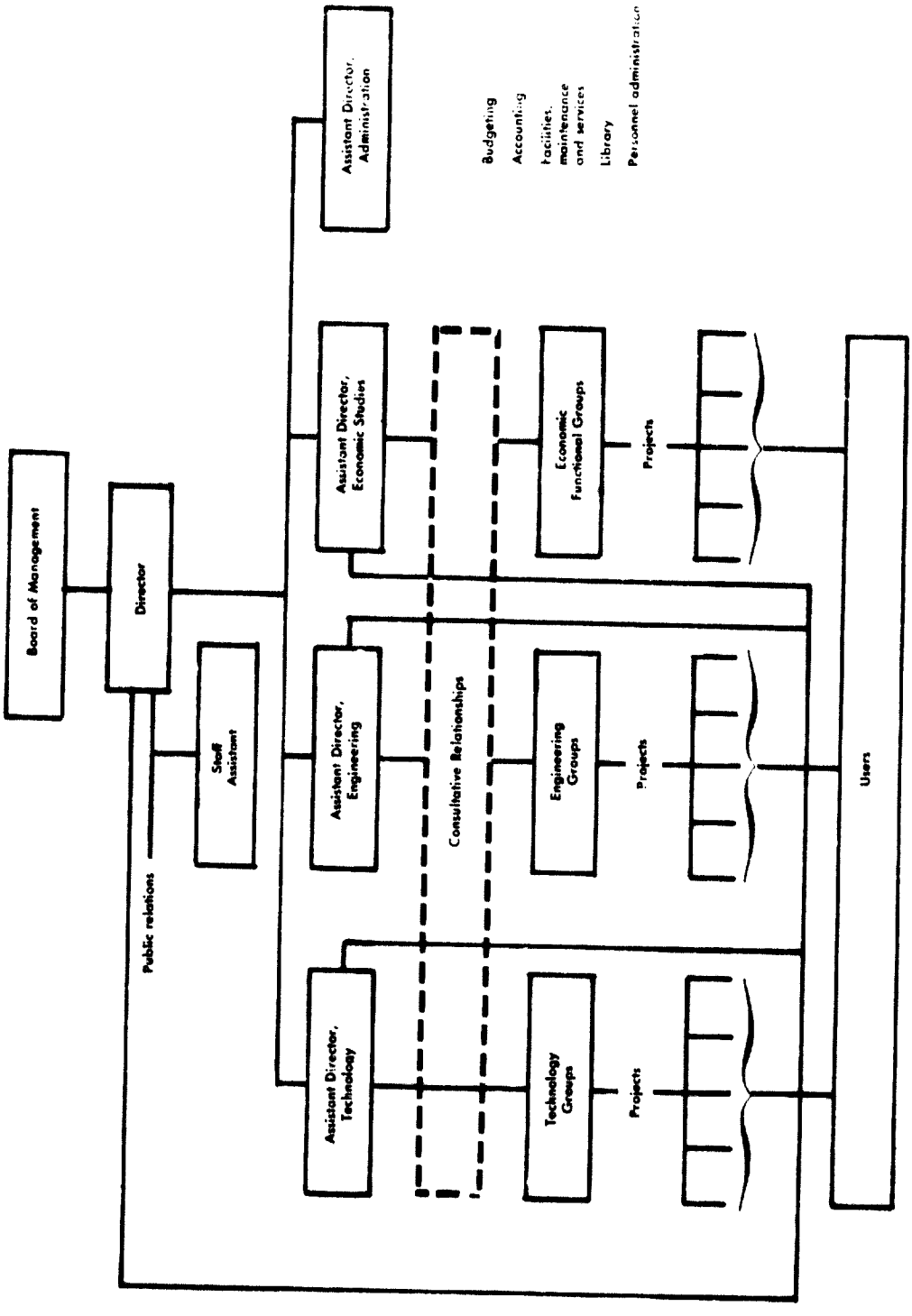


Chart 2. ORGANIZATION PLAN OF A COMPREHENSIVE INDUSTRIAL RESEARCH INSTITUTE

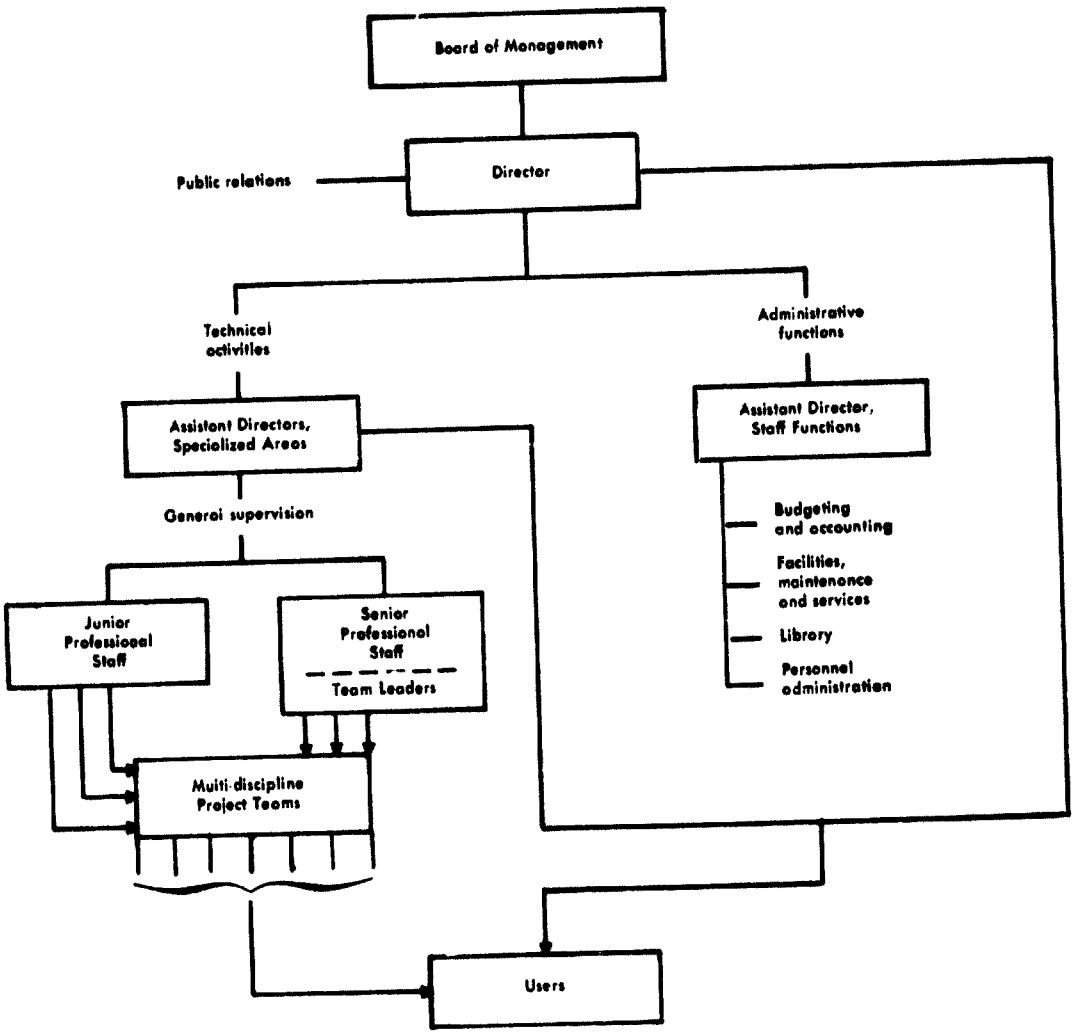


Institutes of various types, whether uni-purpose or multi-purpose, exist or will be required in various countries. Fortunately, however, the organizational patterns of most types of industrial research institutes will be essentially similar — at least in their early years.

During this period, while the institute is operating in a somewhat limited field, a simple type of organization will suffice. Such an organization is illustrated in chart 1. It should be emphasized here that the charts and comments which follow are purely illustrative. It is realized that developments in various countries are unlikely to follow exactly the same pattern at every stage because the social, legal and industrial conditions will differ.

Each institute must, therefore, become a part of its immediate environment and must develop with it. Institutes, like living organisms, must adapt themselves to their environment or perish.

Chart 3. SCHEME OF OPERATION OF MULTI-DISCIPLINE PROJECT TEAMS



As an institute grows, its fields of interest will expand and a somewhat more sophisticated organizational pattern will be evolved. Chart 2 is an example of such an organizational structure. The descriptions of the branches will, of course, vary with the requirements of the actual work of the institute.

Finally, mention should be made of the trend toward the use of multidiscipline project teams or " task forces " to provide a collection of different professional skills in order to give a more comprehensive answer to an assignment; the pattern of organization suitable for such an administration is illustrated in chart 3 and discussed in detail in a later section.

Simple form of organization

This form of organization is typical also of research and development departments in private industrial companies, in which case the " users " are the various operating and staff departments in the establishment which request help from the research and development department.

It has been emphasized that it is advantageous to have the individual professional men who are working on a project (or the project leaders if the team approach is adopted) maintain direct contact with users regarding the details of results and planning of future activities. The director supervises them and guides them in this liaison. He, too, needs to participate in the general liaison with users, preferably concentrating on high echelon contacts and only in an unobtrusive way on the details of the work. In this way he can maintain suitable relationships with the managements of the establishments that support the individual lines of work and leave most discussion of technical matters to the project personnel.

As the work of the institute expands, one or more assistant directors may be appointed to act in the same manner by sharing supervision of the technical work. The areas of technical responsibility are usually split up among the assistant directors in accordance with their respective fields of interest and experience and along the lines of scientific disciplines of groups of similar technologies. It is then logical to organize the science or technology groups under one assistant director and the development groups under a second. With further expansion, the work may be further subdivided in a parallel manner and often the larger-scale work, such as design and operation of pilot plants, will be placed under a third assistant director.

Even in a very small institute the director should not be expected to deal with the details of administrative requirements such as the purchase of equipment and materials, storekeeping and inventory control, the servicing and maintenance of buildings, accounting and so forth. These functions should be entrusted to an administrative officer who will be responsible to the director. As the institute grows in size, so will the administrative section, but great care should be taken not to allow the administrative

section to grow out of proportion to the technical section. At all times the administrative functions should be kept as simple as possible. It should always be remembered that the administrative functions are merely a tool to assist the technical work of the institute and must not be regarded as an end in themselves.

Even a small institute will require elementary workshop facilities for metal-working, wood-working, electrical wiring, glass-blowing and the like. In the very early days, many of the simple workshop operations may be carried out by the technical staff. But as the institute grows, the workshop may well divide into separate shops for the different types of operations. In a large institute there may be a system of central workshops, but even then each technical group should have available to it a small shop in which simple jobs can be done by the technicians or even by members of the technical staff. These small shops are often called preparation rooms.

In the larger institute it may be necessary to set up a design and engineering-drafting office. In this office detailed engineering drawings can be prepared for the construction of more elaborate equipment. Although the general management of central workshops is often regarded as a function of the administrative division, as in the chart, great care must be taken to see that technical staff have direct access to the workshops and can discuss their requirements directly with the technicians. In some institutes the technicians assist the technical staff in the use of the equipment they have helped to construct, and this enables the technicians to feel that they are personally involved in the investigational work of the institute. In some institutes the really skilled technicians are given a status similar to that of technical staff.

In the preceding paragraphs the organization has been discussed in terms of technological and engineering programmes, but even an industrial research institute which concentrates in the areas of economics and managerial subjects follows a similar pattern. The groups that may develop are, for example : marketing economics, manufacturing economics, management controls, such as operations research, and economic development.

Organization of an institute with broad coverage of many specialized areas

Some of the larger industrial research institutes expand their competence to offer to users professional services in a wide range of categories. They will carry out studies in areas of science and technology such as long-range research, product and process development and the like. They offer competence in engineering activities, such as pilot-plant development, engineering, economic analysis and production management. They are also prepared to give assistance in many areas of economics and business administration.

The form of organization that this type of institute may adopt is illustrated in chart 2.

The board of management and the director have the same general responsibilities mentioned earlier. The director, because of the broader scope of activities, has still heavier demands on his time for relationships with potential and present users; for this reason, the chart indicates the addition of a staff assistant to help him in various ways such as organizing lists of contacts, providing the background for speeches and other activities directed toward establishing a fruitful relationship with key figures in the industrial community and the government.

Because of the wide variety in disciplines represented, each of the three divisions of technology, engineering and economic studies is in effect an industrial research institute in itself. Each could be headed by an assistant director, and in fact they may be subdivided further by having more than one assistant director in each of these three general fields, each with responsibility for organizing staff and supervising activities in his designated area.

An additional aspect is involved in many broad project assignments, namely, the necessity for cross-co-ordination of the skills of these three major sectors. An important project may involve, for example, not only the laboratory formulation of a product, but also the development engineering for perfecting process and estimating investment in plant and operating costs, together with a study of the market outlook for the material or device. The cross-fertilization among these diverse activities is indicated by the dotted oblong labelled " Consultative relationships ".

Because of the expansion in administrative functions necessary to take care of internal matters by providing services to various different groups of disciplines, the staff activities under the assistant director, administration, have expanded, although the list of major functions under him is the same as those in the simpler chart.

MULTI-DISCIPLINE PROJECT TEAMS

The most recent trend in management of technical activities, in private enterprise and government organizations as well as in industrial research institutes, is to effect an integration of a range of disciplines into a co-ordinated attack upon a problem. In essence, this approach requires the use of project teams made up of individuals with diversified backgrounds and experience. The scheme has demonstrated its effectiveness in accelerating the movement of projects from inception to commercialization and is a useful means for limiting the number of formal divisions in the institute. This system also facilitates the participation in a project of experts from outside the institute.

The operation puts new demands on managerial skills. The setting up of a system which crosses the usual formal organizational lines involved in

structures such as shown in charts 1 and 2 requires adjustment on the part of the professional staff.

Advantages of Multi-Discipline Project Team System

This managerial philosophy has as a major advantage the injection of specialized information from a collection of professional specialists and makes for optimum timing and emphasis instead of relying on communication from echelon to echelon upward and crossways, as in a formal organization. The major change is that, through the operation of a project group, the varied professional skills and experience required to reach an optimum solution are brought to bear simultaneously in an appropriate mixture. If the project starts as a laboratory investigation, views are concurrently expressed from engineering development personnel and from marketing specialists to assist in guiding the small-scale work in appropriate practical directions. This makes for increased efficiency in planning the work at earlier stages, so that the programme is adjusted to the economic necessities for success.

Difficulties standing in the way of progress in the solution of a problem are brought to the surface at earlier stages; this speeds up decisions regarding the future programme including decisions to discontinue or change direction. The fact that both those involved extensively in earlier phases and those to be involved later are all co-ordinated in the team expedites the transfer of background and information from step to step. Because participants from other groups who will have primary responsibility in later stages are part of the team, they gain an early acquaintance with activities which they will have to carry out.

The system makes use of the total pool of technical talents in all parts of the organization and therefore avoids the tendency in specialized sections to build up large staffs to handle all facets of a problem internally. This method of operation leads to more effective use of technical manpower in the organization because of the built-in pressures on the administration for evolving managerial skills in deploying the total resources of trained personnel.

A major benefit comes about through the stimulus to the morale and professional development of the staff because the system gives them contact with a wider scope of technical activities and makes them feel a greater sense of responsibility for the success of the projects and deeper satisfaction in professional achievement. A project-team approach leads to a technical organization with fewer administrative echelons; it therefore encourages the dynamic use of technical personnel at the working level instead of placing them in a pyramidal structure. All parts of the staff are more closely knit together by the impetus to unite their joint efforts in carrying a project through from inception to successful commercialization.

Pattern of Operation

It is modern managerial practice to consider that the best organizational structure for creative professional work consists of two parts : first, a formal pattern, as illustrated in the preceding charts, to provide channels of communication and authority on administrative aspects involved in establishing the place of the individual in the structure as a whole; secondly, an informal pattern by which this group of individuals carries on the actual technical work on the projects assigned to them.

A schematic outline for project-team operation is shown in chart 3. In actual practice this scheme is superimposed on the formal pattern of charts 1 or 2, which express organizational relations; the major difference from them is that, instead of giving one individual or group sole responsibility for work within a specialized sphere of competence and background, a senior member of the professional staff is assigned responsibility for enlisting participation of a diversified group over whom he does not have direct administrative control, but who are associated with him in the actual work of carrying the project objectives forward.

The merits are shown by considering a team that might be drawn from the organization shown in chart 2. Here, instead of a project group selected for the first phase of an investigation only from, say, the technology-oriented staff, the team leader would bring into direct participation individuals from not only that division but also from the engineering and economic divisions. Even in an organization based entirely on a science group, such as a basic research programme, this scheme would lead to the inclusion of scientists from more than a single limited discipline.

Principles of Organizing Task Forces

The first step is to select a project leader with responsibility to carry out a major phase of the investigation. He should participate in defining the goal, preparing the justification for the study, outlining the programme of attack, setting the target date, classifying the types and amounts of various professional skills needed and preparing a cost estimate of the work involved — procedures discussed in greater detail in chapter 5.

When this project outline has been prepared and agreed to by those concerned, the director, in consultation with the team leader, then makes arrangements for the amount of time required from the individuals having the types of technical skills that were incorporated in the outline. They will be dispersed among other groups, each reporting in the formal organization to some superior. Their services will often be required only on a part-time basis, and the approval of the superior in their group is required for setting aside the appropriate amount of their time for each particular project. The rest of their time is allocated in a similar way among other projects and duties.

The scheduling of manpower utilization under this means of operation requires alert managerial practices. Where the individual project system is used, the full time of one or more members of the staff is rather rigidly allocated to this work. When the project-team system is introduced, this demands a sophisticated form of scheduling of the programmes of all technical personnel throughout the organization, in order that the total time available from each may be distributed to best effect among various projects.

This system of team organization bears considerable resemblance to that used in many large engineering offices. In a structure similar to that shown in chart 3, the staff in a particular section consists of a supervisor, senior project engineers, engineering specialists (in fields such as structures, electrical systems, piping, plant layout, materials handling and so on), and a pool of designers and draftsmen, corresponding to the block labelled "Junior Professional Staff". These latter are assigned in accordance with the needs of different individual projects by a chief draftsman. This total staff is then deployed, under general supervision, in accordance with the fluctuating needs of individual projects and the requirements for injecting with proper timing and emphasis the professional skills that are requisite.

Techniques of Supervision

In order that all involved may be kept informed, adequate communication of results and their interpretation must be provided. The question of reporting to users will be treated in a later chapter, but here it should be stated that for a working group and for those in supervisory positions some suitable form of written summaries should be prepared for circulation at time intervals appropriate to the nature of the problem. These written reports should be supplemented by oral presentations and discussions, including internal meetings of teams when a project task force system is used, and by further review with supervisors at higher level at less frequent intervals, in order that comprehensive judgements may be formed on the progress toward the objectives.

Concurrently a check must be made on the rate of progress in terms of utilization of budget. Similarly, the rate of progress at various time intervals must be evaluated in terms of the schedule of performance developed for the internal programme to comply with the terms of agreement with the client.

Chapter 4

THE PLANNING AND CONTROL OF RESEARCH PROGRAMMES

General considerations

An industrial research institute can operate effectively only through careful planning and control of its research programmes, both those initiated externally (sponsored programmes) and those generated internally ("in-house" programmes), the latter being those supported by the institute with funds from its general budget for the purpose of creating new knowledge and professional competence in important problem areas. An institute soon realizes that its most valuable asset is the time of its technical staff, and, unless this is utilized fully, the potential of the organization will not be realized. The planning and control of the programmes will reduce the wastage of this valuable human resource.

In an efficiently operated industrial research institute, about two-thirds of the time of technical staff is usually available for project work. This figure omits time spent on exploratory work, general reading of literature, information service, attendance at scientific meetings, conferences with visitors or any other time not directly applied to a specific project. To achieve this level of time utilization the technical staff frequently must distribute effort and time on a number of programmes carried along simultaneously. This is particularly true for those above the technician level.

The output of the institute can be further increased by assigning responsibilities for all the projects to supervisors. Most frequently, sponsored programmes are a responsibility of an assistant director or a senior member of his group. Whereas the responsibility for the initiation of sponsored programmes falls mainly on the client, that for in-house programmes falls entirely on the institute itself. Here, organization of programmes must be planned on a broader basis and proposed projects should be discussed at periodic meetings of the director with senior staff members. Following each such meeting, the director should decide what programmes are worthy of internal support. On some occasions available funds will be insufficient to underwrite all the worthy projected programmes; on others more funds may be available than there are worthy ideas. In the latter case, it is sound policy to retain funds until well-conceived programmes have been formulated.

Once annually all authorized programmes, both "in-house" and sponsored, should be reviewed at a meeting of the director and senior staff members to determine if the over-all operation is in harmony with the broad objectives of the organization.

Outlines for proposed studies

A careful analysis and review of the individual projects on which the institute is engaged should be carried out periodically to ensure that the skills of the staff are being used effectively. Frequently the analysis takes the form of concise statements of the object of the work, its potential value and the amount of research effort estimated as necessary to carry it to a conclusion. A typical project evaluation outline is shown below. It consists of :

Title
Objective
Justification summary
Plan of work
Personnel required
Facilities required
Estimate of duration and effort required
Assignment of responsibility
Authorization

A project evaluation outline (form 1) should be drawn up for all major projects requested by a client or proposed as internal projects by the institute. An outline of this kind is necessary before a formal proposal can be submitted to a client, but in this case it is often only for internal use in framing a proposal for authorization of the proposed work. Similarly, for internal projects, a description of the contemplated investigation is needed so that the director can judge it on its merits in comparison with other proposals for expenditure of staff time and other resources.

In-house projects

In addition to doing sponsored work for outside clients, most industrial research institutes conceive, plan and carry out investigations of their own. The judicious selection of these programmes is vitally important to the ultimate development and success of the institute, as they will form the areas of competence for which it will become recognized.

Form 1

PROJECT EVALUATION OUTLINE

Date .....

No. .....

Title .....

Objective .....

Justification summary

1. Technical .....

.....

2. Economic .....

.....

3. Value to client or institute .....

.....

.....

Plan of work .....

.....

.....

Personnel required .....

.....

Facilities required .....

.....

Duration .....

Estimate of effort in technical time and cost .....

.....

Assignment of responsibility .....

.....

Authorization .....

Signature ..... Date .....

In-house programmes should be related to the industrial environment of the country and should be selected to yield results that can be reduced to commercial exploitation in a relatively short time, possibly within two to five years. Preferably the programme should not be on an isolated subject, but one that lends itself to expansion into a broader area of industrial research. In this way the experience gained from one programme may be carried into future programmes, thereby enabling the institute to establish technical depth in a particular research area. For example, the institute may decide to work on a programme on extractive metallurgy on one ore common to its country; later this competence in extractive metallurgy may be applied to other minerals. This establishment of areas of competence by in-house programming is in accordance with the fundamental principle for the operation of an industrial research institute, namely, that to be successful the institute must specialize in particular areas of research rather than attempt to be a " jack of all trades and master of none ".

A controlling feature in the selection of an in-house programme is the availability of qualified staff and of equipment. The selection should be done by research men with creative ability and should be oriented towards applied research. A lack of equipment, on the other hand, is likely to create difficulties and delays in carrying out projects.

A very desirable feature of an in-house programme is the element of novelty. Sometimes the novel idea for solution of a problem comes before the programme is started, at other times after the programme has been commenced. In any case, areas of research which have been thoroughly worked over using conventional techniques are not likely to be fruitful and should be avoided.

Research proposals for in-house programmes should be drafted along the following guidelines :

(*a*) Statement of the problem. What are the goals to be achieved? Are they feasible? Are novel ideas involved?

(*b*) What is the potential value of the results to the following?

(i) *The national economy*

What is the value of the proposed project to the industrialization programme of the nation?

Does it call for the exploitation of the country's natural resources?

Does it improve the country's balance of payments position and conserve foreign exchange?

Does it require the development of new types of manpower skills and training?

Does it furnish new employment opportunities?

(ii) *The research institute*

Does it assist in establishing an area of continuing research competence in the institute?

(*c*) What programme of work is required to meet the objective?

(*d*) Is there any close relationship between the proposed project and other work being done at the institute?

(*e*) Has the same research project been proposed to the institute before? Why was it rejected?

(*f*) What are the manpower requirements by category? Can they be met by the institute? If not, should they be met through recruitment or by securing outside assistance?

(*g*) Does the proposed project need special equipment which is not available in the institute?

(*h*) What are the raw materials needed and can they be acquired?

(*i*) What is the tentative over-all cost of carrying out the project and, if possible, the projected cost of a commercial operation?

(*j*) What are the tentative completion dates of the major stages involved?

Research proposals can have different degrees of detail. But the uncertainty of research work makes it more advantageous for research proposals to be as short and concise as possible. It avoids burdening research workers and supervisors with a mass of details. A further simplification is the standardization of research proposals so that they have the same form and degree of detail.

An in-house project should be budgeted and cost-accounted in the same manner as sponsored projects and should be evaluated periodically to determine if it should be continued, expanded, reduced, postponed or terminated. Depending on the size of the project, evaluation should be done quarterly or semi-annually.

The in-house programme should not be regarded as a "fill-in" programme for spare time of technical people. Once it has been approved, it should be assigned for study and carried out expeditiously. This does not mean, however, that one investigator may not also work on sponsored projects during the period he is carrying along an in-house project. Very often the in-house projects are of longer duration, so that he may work on many shorter-term sponsored projects during the period of an in-house project. When this procedure is followed the investigator should complete the sponsored projects as quickly as possible.

Distasteful as it may be, it is extremely important to terminate an in-house programme whose results look discouraging. It is the nature of research that some programmes will fail no matter how capable the technical staff.

The number of in-house projects in progress at any one time will depend to a large extent on the amount of staff time available. However, the careful selection and initiation of a few, say five or six projects, will

give a much greater return than several projects that have been hastily approved and are casually evaluated during execution.

A staff member should be assigned to each project and the member should be responsible for supervising the work, reporting and overseeing the financial aspects.

Major stages in research projects

To illustrate the character of work and the nature of evaluation feasible in both sponsored and in-house projects of different types, a generalized case history is presented in the following sections, tracing the course of research and development from original concept to commercialization. The following stages are discussed :

Exploratory research
Applied research
Product development
Process development
Field evaluation
Market testing
Re-evaluation before commercialization

An industrial research institute may undertake, either on the request of a client or as an internal project, one or a combination of some or all of these stages of research. For example, to determine what use can be made of an existing raw material, the work might start with exploratory research aimed at establishing its major constituents and their potential value. As promising results are obtained, the successive stages of product and process development might then ensue, culminating in a recommendation for commercialization. On the other hand, the objective may be to adapt known technology to local requirements for the purpose of developing a modified product or process. Or, a field evaluation may be required to determine the potential utility of an existing product for a new practical application. Finally, the institute might be asked to collect, analyze and co-ordinate all available information on a proposed operation and offer a technical, manufacturing, marketing and economic evaluation.

Exploratory Research

This type of research requires the same scientific imagination and analytical ability as does academic research, but is distinguished from it by having a clearly defined objective. It may, for example, be concerned with exploration of a new chemical reaction or a new physical phenomenon, but the goal of the work is to determine its applicability to practical problems.

Applied Research

Let us suppose that an idea for a new product or process has been formed from a study of the literature or been developed out of exploratory research carried out in the laboratory. If the idea promises practical utility for a client, or warrants support as an internal project, the concept is reduced into the form of a project proposal. This is discussed with the management and manufacturing staff of the client, or with other appropriate groups, including those responsible for marketing. A similar type of evaluation should be carried out on internal projects.

It should be emphasized that the idea has not really been translated into a specific product or does not represent more than a general notion for a process. It is a concept which needs to be examined in detail before its specific utility can be determined. Some small-scale exploratory work may have been carried out to make sure that the idea has been tested by experiment. If the conclusion, after a critical examination, is that there is a probability of success, a project is set up to carry on applied research.

This project is established to determine the range of applicability of the idea or phenomenon and to define its potential utility. If the goal is the development of a new product, a small-scale laboratory method of preparation must be developed; if it is the development of a process or phenomenon, the range of conditions for operation must be explored. Next, a series of compounds, products or devices is prepared and evaluated by screening methods that have been selected or developed for this purpose. After scrutinizing these products or processes for their comparative potential advantages, one or more products or one or more variations of the process are ready for further development.

Product Development

When the decision has been reached to undertake the development of a product, the amount of effort and cost involved should be confirmed by a technical and economic evaluation.

The project then involves the following :

(*a*) The general performance requirements should be defined by preparing preliminary specifications for the product and the applications it must meet.

(*b*) The availability of necessary raw materials should be checked, including quantities which can be obtained, their composition, their suitability for the proposed process and their cost in commercial grades and quantities.

(*c*) Confirmation of the practicality of manufacturing the product should be carried out by making small samples of the preferred compositions from representative raw materials to provide evidence

that the proposed process will yield a product in satisfactory quantity and quality from the starting materials which are considered to be most suitable.

(*d*) Screening methodology was proposed in the preceding phase of the work, and these techniques should be used in improved form for initial confirmation of the suitability of the product for the use that has been specified.

(*e*) Preliminary economic screening should then be carried out, but the evaluation cannot be conducted in depth because sufficient information is not available. In this analysis, specialized experience should be obtained as necessary from other sources, such as market research or an engineering evaluation group in the industrial research institute, or these same groups in the organization of the client. The estimates should relate to :

(i) Market size, type and estimated selling price

(ii) Distribution system

(iii) Rough estimate of factory cost of product in relation to the range of selling prices

(iv) Competitive situation, both as to existing types of products on the market and marketing strengths of companies already in this field

(v) Patents, licenses or other restrictive factors

(vi) Estimation of minimum economic size of plant and volume of production

Preparation of representative samples for evaluation.

The raw materials should be selected with care and in such a way as to ensure that they are representative of those available on a commercial scale. The method of preparation should be examined for manufacturing feasibility, and for this scrutiny a laboratory scientist would be well advised to call for the consultative assistance of a process engineer, either from within the staff of the institute or from the sponsor.

Examination of the samples should include determination of their stability under conditions of use and storage. Techniques for controlling quality on a manufacturing scale should be considered. The product may be marketed in a package rather than in bulk; therefore the preliminary requirements for packaging should be determined at this stage.

During the steps of trying various raw materials, carrying out the preparative steps and making small samples for evaluation, the original process for manufacturing will probably have been modified. Even though no modifications have been developed, a final review should be made of the projected operations to confirm their suitability for commercial-scale production. The preferred process details should then be incorporated in

a programme for the preparation of representative samples of product for intensive internal evaluation.

Internal evaluation of product.

The test methods which were originally developed for screening purposes and subsequently refined as the work progressed should be thoroughly reviewed; they should be looked at not only from the point of view of suitability for quality control purpose, but also from that of determining whether or not they reveal accurately the characteristics of the product that are important to the customer. A comprehensive evaluation of the representative samples prepared in the preceding steps should then be carried out by the methods finally selected. If the product still seems to meet the requirements of marketability, that is if it satisfies the needs of customers, it is ready for a more thorough engineering and marketing examination to determine cost of production and marketability on a commercial scale.

The cost of production as adjusted to process experience with different available raw materials and more refined processing methods should be reviewed, preferably with the co-operation of an experienced engineering evaluator. The market potential should again be evaluated with the assistance of either the market research group in the institute or a similar group in the client's organization. The evaluation should be as objective as possible, the advantages and disadvantages of the product should be weighed and its potential demand compared with that of competitive materials already on the market.

Even though all factors still favour pressing forward with the work on this new product, consideration should be given to other evaluations of special nature, such as dangers which may be experienced in storage, shipping or use. There may be specifications for this type of product which are established in the consuming industry, if it is an industrial product, or there may be an entrenched pattern of consumer acceptance, if it is an item for sale to the general public. There may be regulations on composition, use or method of distribution established by public authorities. These factors should be considered at an early stage and not be permitted to bar commercialization later.

If all the internal evaluations still indicate the success of the product, semi-final specifications should be written up, together with a detailed process description.

Process Development

The preceding stage has given a much fuller knowledge of the product, its qualities and properties and its potential success in the market. It has also established a preliminary process description which can be translated into a tentative flow sheet for carrying out the steps of manufacture.

The stage of process development involves :

(*a*) Carrying out large laboratory or small pilot-scale processing to reconfirm technical and economic feasibility

(*b*) Evaluating the customer acceptance of the product by carrying out tests in actual small-scale operations in customers' factories, or, if it is a product for the general public, by testing with consumer groups

(*c*) Working with the sponsoring agency to develop a preliminary marketing outline, including re-checking of proposed selling price, method for introducing the product into the market place and the general pattern of distribution that will be followed.

The programme should be based on the following information :

(*a*) A concise summary of information on the product and process from earlier work

(*b*) A description of the activities planned for large-scale process development

(*c*) Estimates of the amount of effort, cost and time for completion of the following phases :

(i) Evaluation of alternative process steps to permit final selection of the preferred sequence of operations

(ii) Completion of work to confirm the technical suitability of the process

(iii) Preparation of samples of the required size for field tests, which will be carried out either through trying the product in the manufacturing operations of customers, or by consumer preference tests in the case of a retail product

(iv) Estimates of the type of semi-works or large pilot plant that might be needed for further confirmation, or, if an intermediate stage can be omitted, semi-final estimates of the cost of installation of large plant, cost of production, and time required for installation.

Information from large laboratory or semi-pilot scale preparations of the product should be re-evaluated by the development engineers in terms of technical feasibility, materials of construction and dimensions of equipment, confirmation of the flow sheet, re-checking of estimates of operating costs and plant investment when projected to commercial scale.

The required pilot-scale equipment should then be assembled and the tentative process should be conducted on this equipment with careful evaluation of performance throughout; in some cases only selected steps need to be examined in this way, provided that evaluation is to be made only of production engineering aspects. If, however, the equipment is to be used for preparing samples for field tests, the entire operation will, of

course, have to be carried out. As a result of work on this scale, experience may show that improvements in various steps can be incorporated in the final process design.

Work on this scale permits a higher degree of accuracy in evaluating technical and economic feasibility. It should be carried out with the care and attention to practical detail warranted by an operation that appears to be destined for commercial scale.

As a result of this work the process has been defined, and after being carried out according to specifications, has been demonstrated to be capable of producing products of the quality required for marketing.

Preparation of samples for field testing in customers' plants or on consumer groups is the next procedure. A warning should be raised, however, against using a pilot plant for routine preparation of material for a longer period because of the high cost involved in this scale of operation.

Field Evaluation

The internal evaluation procedures mentioned in a preceding section need further confirmation by practical tests by selected potential customers to establish a sounder basis for believing that the new product will successfully find a market. Internal testing has been conducted, in most cases, by laboratory techniques or with small equipment, but the results of such tests have limited validity as criteria for determining performance on commercial scale. Further, those responsible for the development of a new product nearly always take an overly optimistic view of its merits. The results approach more nearly the reality of the market place when the evaluations are carried out critically by those who are potential purchasers. The procedures for industrial products and for consumer items are quite different in nature. Therefore, these two types of products will be treated separately in the following paragraphs.

Industrial products.

The first step is to lay out a schedule of the tests required to confirm the supposed utility of the material or process in actual practice. What are the most likely uses that it will find? What potential customers are most progressive in their attitude toward trying new things, and how many establishments of this kind should be approached in order to make the programme of evaluation comprehensive enough to give reliable answers? Through preliminary discussions with a few of them, an idea can be developed of the number and size of tests that will be needed to establish utility. From this information the amount of test material that should be produced in the pilot-scale operation can be projected. The product offered for testing

should be as nearly identical with that expected on a commercial scale as it is possible to make it. Further, the cost of producing this amount of material on a pilot-scale operation should be scrutinized to determine whether it is justified when compared with the potential benefits from introducing the new product directly into the market on a trial basis.

In order that the customers selected may carry out the plant trials effectively, written information about the product, its specifications, the anticipated advantages and directions for use should be written up and checked with one or more of them. Special precautions should be included, such as safety and regulatory provisions.

All is ready for trials, preferably on the smallest meaningful scale, in the plants of customers. If more than one customer is involved in the programme, it is advisable to make the trials first in one plant and to sharpen the directions for use from the information gleaned in this series of tests. This sequence of customer trials will permit emphasis in later tests on those properties of the product which give it advantage in the market.

From analysis of all the data obtained in these evaluation procedures, a detailed review of the tentative product specifications and a reconfirmation of the merchandising concept should be made. The pertinent information should also be incorporated in preliminary drafts of technical bulletins, labels, containers, shipping requirements and the like.

If all tests have been favourable, the information should be in shape for making a final review preparatory to commercialization.

Consumer items

For products of this type, the methods for field evaluation take a different direction. In general, the techniques used for internal evaluation are not adequate to give a reliable idea of how the individual customer will accept the product. While a certain amount of preference testing may well have been done during the course of development, the scoring obtained in this way is considered to be influenced by bias because of the interest of the personnel concerned in the furtherance of the project.

To obtain a more objective evaluation, it is customary to use panels representative of the average consumer. The product is often tested by "blind" comparison with some other product of similar character which is already on the market, but all samples have identifying marks removed and are coded by symbols which conceal the source. Many specialized testing techniques have been developed for food products, items of wearing apparel, household equipment and utensils and the like. The range of procedures is too extensive for discussion in a report of this length, but there is a great deal of information on them available in the literature.

Market Testing

A still more definite type of confirmation of market acceptance is to offer the product in a test market, either to a selected group of establishments for an industrial product, or for retail sale in the case of a consumer product, the customer being asked to pay for the material which he is going to use. Because of the high cost of producing large samples on a pilot scale, the selling price has to be set on the basis of expected cost of commercial-scale production, not on pilot-plant cost.

The establishment of a commercial price, of course, necessitates a very thorough review of costs, based on estimates for large plant operation at the planned volume of production. Both the investment in plant required and the cost of manufacturing, which can be estimated with more confidence at this stage, have to be taken into consideration. This gives the factory cost, which in turn must be adjusted for the expense of selling, the overhead costs of the establishment for administration and the like, and a margin of profit or economic return, so that the enterprise has sound justification for embarking on the risk of undertaking construction of the plant and production and marketing of the new product.

Re-evaluation before Commercialization

The results obtained with the new product, as produced in pilot scale, should be given a final detailed and comprehensive review by all key personnel who have been involved in all stages of the development. This is a vital precaution to be taken under the direct supervision of the managing directors to make sure that no important factor which might interfere with success has been overlooked.

Assumption of responsibility for making such a review with recommendation for implementation of commercial operation by the sponsoring establishment represents a considerable risk to an industrial research institute. Unless it is convinced that it has within its staff full competence to assess manufacturing requirements, marketing potential, production costs and the adequacy of financial return from sales, it should be very cautious about making a commitment for such an assignment. Failure of a recommended commercial operation can have severe repercussions on the reputation of the institute. This is not to say that competence to perform this type of service is impossible, but it is a very serious responsibility. Also to be taken into consideration is the ability of the staff of the sponsoring establishment to carry out the necessary manufacturing and marketing, in accordance with the final plans. When there is a skilled staff in the organization of the sponsor, everything should move forward in accordance with the projections; if some of these skills are deficient, the timing and economics of the operation may be drastically affected.

This final review and confirmation of a recommendation for commercialization should take into consideration the following :

(*a*) Has the technology been fully confirmed and is it free from any new threats from scientific or technological developments that have arisen since the original concept was worked out in earlier stages of the project?

(*b*) Have the engineering requirements of the plant been adequately detailed, together with the necessary manuals of procedures by which operations are to be controlled?

(*c*) Have the data for investment in commercial plant and those for the operating costs been adequately verified to justify installation of the commercial operation?

(*d*) Have the field or market tests confirmed the acceptability of the product for commercial use in terms of utility, selling price and performance in comparison with competitive materials, and have they established a sound basis for projecting market volume?

(*e*) Is the marketing plan realistic, and have the programmes for introduction of the product on a commercial scale been worked out with realism, taking into account all the promotional features that may be required?

(*f*) Finally, have the integrated estimates of manufacturing costs, selling and overhead costs, together with expected marketing revenue, provided economic justification for taking this weighty step of proceeding to final design of plant, installation of facilities, and initiation of marketing?

Then come the ultimate decisions for selecting the site, size and exact details of the plant, negotiation of firm sources of raw materials at economic prices, transportation arrangements for both raw materials and the shipping of finished product to the market, questions regarding waste disposal, analysis and projection of availability of and plans for training labour and specialized staff, provision of utilities, and, where necessary, living quarters for employees and other general facilities.

When all these factors have been taken into consideration, and final decision to erect the plant and start operation has been confirmed, the time required for installation of the plant and starting up operation leaves opportunity for the detailed preparation of the sales programme. This involves the establishment of relationships with middlemen who may be involved in getting the product into distribution channels to individual customers, although in the case of industrial products this will usually be done by the establishment itself. It may mean the negotiation of sales agreements and contracts with individual large or intermediate size customers or agents. It may involve a training programme to enable the men in the sales department to carry out their functions effectively. It may require

the development of specialized literature either for industrial customers or for background material for advertising or promotion of consumer products.

Conversion of laboratory information into commercial operation

This array of steps and stages in carrying a new product concept from small-scale experimentation in the laboratory or model shop to full commercial operation may well sound as though it were unnecessarily complicated. This sequence of procedures is, however, being successfully followed by industrial establishments throughout the world. Those with most gratifying records realize that they must make their mistakes on as small a scale as possible, in order to weed out doubtful ventures, and move forward with aggressive pace on those that show real promise. They realize also that failure to take into consideration all the factors listed in preceding sections may bring about catastrophic failure when commercialization is attempted.

The seriousness of such failures is even more important in developing countries. Most of them have to delay other major projects of socio-economic development, because of limitations on capital funds, to finance a new industrial operation. If the investment of technical, managerial and financial resources turns out to have been wasted, it is a calamity to the forward movement of the country toward its goals. And if an industrial research institute has participated in a major way in the final decisions for an unsuccessful venture, its prestige as a vital force in national development becomes tarnished.

Control of projects

It is vitally important to the success of an industrial research institute that the director, with the advisory assistance of his senior staff members, maintain effective control over the programme as a whole. In order to do this, he must also exercise general control over all the individual segments of the work.

The procedures which are most useful for the control function are the following :

(*a*) Keeping the definition of objectives up to date

(*b*) Periodic reporting of technical progress

(*c*) Control of costs, technical effort on and duration of projects

(*d*) Periodic evaluation of progress in terms of technical objective and also of administrative status, that is, budgetary and schedule performance

(*e*) Decision as to future course of action, that is, continuance, termination, expansion or reduction.

It is essential that this control of projects apply not only to those undertaken for clients, but also to those internally initiated. Unless the

latter are subjected to the same type of periodic re-evaluation they can use up much technical effort in directions that lead to no useful results.

Definition of Objectives

The stated objectives of the work, as embodied in the project outline, should be reviewed from time to time. The original objective may have been forgotten, at least in part, with the passage of time, and the work may have veered away from the initial plan. In some cases the directive should be revised or sharpened to take account of accumulated information and experience.

Periodic Reporting of Technical Progress

Because some of the questions included in the project proposal can hardly be answered or even predicted with reasonable accuracy, it is extremely important for the director of an industrial research institute to know what progress each research project has achieved, what stages have been finished and what work is planned for the future. He is then in a better position to decide on matters such as whether a research project should be continued, elaborated, subcontracted in whole or in part, held up or even terminated. In addition, he can rate, encourage and reward the performance of researchers and research teams.

Individual researchers or group leaders are required to submit progress reports. Progress reports contain different degrees of detail according to the use to which they are to be put. They usually state briefly what progress has been achieved in carrying out a project during the period it covers and what operations are still in process. Depending on the type of research undertaken and the type of organization in the research institute, progress reports may be requested at definite time intervals: monthly, quarterly, semi-annually or annually. Progress reports in more detail are often required after the completion of each major stage.

The choice of the reporting system should be made according to type of research projects undertaken and the importance of the progress reports to the institute's management in decision making. Research workers should not be overburdened with report preparation. When they think that their progress reports are not given the proper consideration by the management, tension arises between the two and researchers may become careless in preparing such material. The progress of some types of research projects, such as long-range research, is often recorded at less frequent time intervals. The ability of project leaders to prepare written presentations of their work varies, and often there is need for systematic training of staff on report writing.

Control of Costs on Projects

The type of administrative summaries depends on the types of research projects undertaken. A running account of the costs for each project must be maintained. The costs involve items of supplies, equipment, travel, administrative overhead and labour. The last-named is usually the largest item and is calculated from the amount of time each researcher spends on a project and his hourly salary rate, preferably corrected for the appropriate overhead expenses.

It is customary for each researcher to fill out a time card each day, assigning his time against projects. The cards may be collected weekly, semi-monthly or monthly for the purpose of deriving costs on projects. The costs on each project should be referred to the project supervisor as soon as available. Maintaining the cost of the project within the estimated cost is his responsibility.

Periodic Evaluation

The frequent evaluation of work in process helps to relate the various projects to each other and to determine their priorities. To assess the real value of projects, a committee consisting, for instance, of department heads can carry out this evaluation more advantageously than one person.

For reviewing the progress of a research project at selected times to decide whether it should be continued, abandoned or altered in priority or amount of effort, the following criteria may be used :

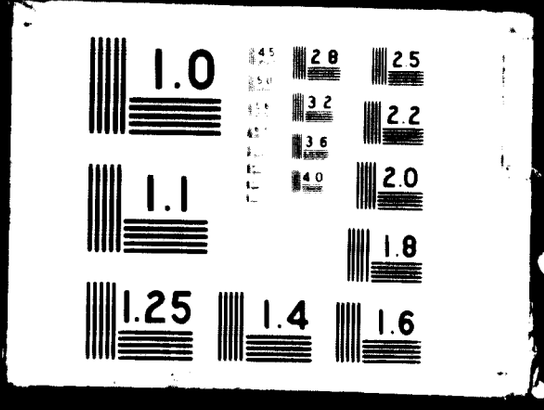
(*a*) What progress has been achieved during the period under review?
(*b*) Is this progress heading toward the desired goals?
(*c*) Has the work resulted in new ideas or prospects that should be explored? Should the work procedure be changed? Should the stated objectives be modified?
(*d*) Is the progress of the programme being retarded?
(*e*) Do the potential benefits of the project justify economically the anticipated cost and the continuing effort required to complete it?
(*f*) After the project has been completed, are the goals still technically feasible? If not, is there any definite evidence?
(*g*) Are the goals still important to the sponsor?
(*h*) How much more effort does the budget permit?

If a committee is assigned to carry out project evaluation, it should call on the head of the project and others who have been engaged in the work. They are better acquainted with the results of the research than the members of the committee and they may offer valuable ideas and suggestions which should be taken into consideration. In addition, in case the committee may decide to curtail or terminate the project, they have at least attended or participated in the discussion. This will reduce the tension or reaction from the researcher's side.

4.9.74

2 OF 3

03790



Decision as to Future Action

After major stages of research projects have been completed, they should be evaluated. Information on the total time required and the total cost incurred during the undertaking of the project, together with the results achieved, is needed. Here project reports are especially valuable. Criteria used for final evaluation of research projects may include the following :

(*a*) Have the project goals been achieved? Has any economic reason or technical problem developed which makes the goals impractical or the results unusable? Are these goals still important?

(*b*) What long or short-term contribution will the research results provide to :

(i) The national economy (in terms of import substitution, employment opportunities, conservation of foreign exchange and so on)?

(ii) The client (in terms of increase in productivity and profitability)? Is the application of research results still feasible? Are there some hazardous working conditions involved? What are the types of manpower skills required for application? What are the other facilities needed? How much should be invested? How rapidly will the investment be recovered through earnings?

(*c*) Have all alternatives (work methods, processes, products and so on) been considered?

(*d*) Have the research results been properly reported? Are they ready for commercialization?

(*e*) If new processes or products are developed, have the product quality and reliability been investigated and measured? Has the quality control system been worked out?

(*f*) Did the work result in some ideas that should be investigated further? Can they help in solving other problems in other areas?

(*g*) What are the serious problems that have arisen during the course of the work? Is management aware of them? Can this experience be used in solving other problems?

(*h*) Have the time and budget estimates been met?

Some organizations use a form to record appraisals, such as the following (form 2) :

Form 2

APPRAISAL RECORD

1. Project no. Date of this review
   Project title : Date of last review
   Laboratory :
   Investigation unit :
   Investigation head :
   Project leader :
   Date of initiation :
   Extensions :
   Level of effort :

   Professional man months ..... as of .....

2. Value and significance of results
   a. Technical value
   b. Practical value
   c. Comparison of results with original objective
3. Status of work
   a. Work originally planned and :
      i. Completed
      ii. Not completed
      iii. Not yet started (for on-going projects)
      iv. Not carried out (for finished or terminated projects)
   b. Work not originally planned but undertaken and :
      i. Completed
      ii. Not completed
4. Industrial development

   Accomplishments achieved which are :
   a. Already under commercial development.
   b. Now under development or should be considered for future development on a pilot-plant scale.
   c. Now under evaluation or should be considered for evaluation by industry or some other government agency.
5. Publications and patents
   (Published, issued, submitted and planned)
6. Recommendations

   That the line project be :
   a. Continued, and the research effort be used :
      i. Along the same lines
      ii. Along the following lines :
   b. Extended for ..... months, and the research effort be used :
      i. Along the same lines
      ii. Along the following lines :
   c. Discontinued, and a new line project be developed along the following lines :
   d. Temporarily suspended and the research effort be used to :
      i. Augment effort under the following line project(s) :
      ii. Implement research along other lines considered to be of higher priority and incorporated in the following research proposal :

Chapter 5

FINANCIAL ADMINISTRATION

General considerations

In considering the establishment of an industrial research institute, it is of utmost importance to provide for a firm basis of financial support for a reasonable period of years, until the organization has had an opportunity to establish itself in the national community. Any attempt to set up the operation without such support may lead to failure, and such an outcome will be a handicap to any new plans that may be proposed later on for a fresh start.

Initial steps in organizing the institute

After the board of management has been appointed, has set the broad objectives and policies of the institute, and has selected a director, the latter becomes the key figure in proposing a programme, an organization and a budget for the board's consideration.

First, the director begins recruitment of a very small group of senior technical personnel selected on the basis of major types of planned activities. He will need a secretary and a minimum number of other service personnel. He will lay out plans for future recruitment, which can only be tentative, because the personnel required later on will depend on the directions of work that show most promise. Experience shows that it is difficult to set up programmes and train staff effectively at too fast a rate. After the initial group of senior men have been recruited, it is advisable to expand the organization only as fast as the director feels that new employees can be assigned to useful project work. However, the staff will sometimes consist, in part, of persons from other organizations who will be absorbed into the new institute, and this will influence the rate of expansion that can be carried out effectively.

As a matter of convenience and speed, institutes often start in temporary quarters, such as laboratory and office space in an existing building or facilities remodelled to accommodate the staff for an initial period. Until the organization has been in operation for a few years, it is difficult to project future space needs in a realistic way. Furthermore, the planning of

an entirely new facility takes much time away from project work and is therefore best postponed until the programme has been well started.

Purchase of equipment is most effectively done by stages, rather than by trying to project all future needs for a long period. If the items are required to accommodate more immediate needs, the selection will be more practical.

Sources of funds

In many developing countries, industrial research institutes are financed chiefly by the government, which alone may have funds adequate for the purpose, both with respect to money for establishment of the institute, including facilities, and to provide a schedule of support for operating expenses over the years. This support may be authorized by an individual item in the general budget, or it may come from other government departments which establish allowances in their respective budgets to pay for the services the institute provides for them. Sometimes provision for support may be made in a comprehensive national plan (a five-year plan, for example), and it should include escalation to permit growth of programmes. Unexpended funds should be carried forward from year to year to give the institute a more stable financial base; this provision should apply to all types of financing.

In some cases the governments may provide only the funds necessary to maintain part of the activities, in order to give support to the basic in-house programme. Responsibility then falls on the institute itself to obtain from other sources (for example, industry associations, individual industrial establishments or other government agencies) additional financing for expansion of activities. The government should continue to contribute these general funds for in-house projects in order that the institute may expand its areas of competence. As its budget increases through projects for clients, the percentage coming from government may be a decreasing part of the total.

The government may enact legislation by which financial support is provided from industrial associations or establishments on some pro rata basis. The rate of payment may be based on turnover or volume of production; in at least one country it is tied in as a small percentage of any loans extended by a development bank. The legislation may make the contributions compulsory or it may involve optional decisions on the part of those who wish to participate.

Financial support from industry may be obtained either through individual establishments or through industry groups. It may be in the nature of fees for specific projects or for participation in general programmes for an entire industry.

In some cases funds for part or all of the programme, at least for an initial period, may be made available through philanthropic foundations,

either local or foreign. As has been mentioned earlier, some industrial research institutes become entirely self-supporting through contracts with clients, but this is difficult except in highly industrialized countries. They may be operated either privately or as public organizations.

BUDGET CONTROL AND ADMINISTRATION

In this discussion we shall distinguish between budgets for the routine operation of the institute — operating budgets — and those for the acquisition of major items of equipment and other large facilities — capital budgets.

Operating budgets

General principles

To establish a basis for forecasting financial requirements for the operation of the institute and a framework for controlling expenditures, the director of an industrial research institute must prepare a budget, usually for an annual period, for approval by the board of management. This is best done by synthesis from estimates of major expense categories obtained from those responsible for these activities and then adjusted according to priorities to fit within the expected total of available funds. An operating budget includes the following types of items : professional salaries, non-professional wages and salaries, materials and supplies, utilities, books, periodicals, and library supplies, travel for project work, technical meetings, building expenses, administrative expenses, purchased services.

It is normal experience that, because of uncertainties regarding the volume of support to be received from clients in the form of payments or inter-departmental transfers of government funds, the budget must in practice be flexible. It will require periodic review, preferably at quarterly intervals at least, to make those adjustments necessary because of the differences between projected income and the attendant variable expense to provide staff and operating necessities for the projects that are authorized.

As time goes on, historical perspective and increased size of the organization will give trend lines for income and expense which will make the budgeting process simpler and more meaningful. But because the size of operation may depend in part on the requests for service received from clients, there will always be fluctuations in the variances between forecast and performance.

Major categories of expense

The differences between costs of operation in various countries will of course be considerable. Unfortunately there is no comprehensive information about the expense of operating industrial research institutes in

developing countries. Even within highly developed countries there are wide variations between individual organizations, but the figures available are valuable for comparing the costs in one organization against average experience.

A breakdown of operating expenses by major categories, taken from a case history of an institute in a developed country established several years ago, is given below. This institute has a total staff of eighty-five.

PERCENTAGE BREAKDOWN OF OPERATING EXPENSES	*Percentage*
Professional staff salaries	50
Non-professional staff salaries and wages	12
Administration	6
Expenses, including supplies, minor equipment, travel, communications, etc.	25
New equipment	5.5
Amortization of building	1.5

If overhead in a given institution is defined as all expense other than professional staff salaries, the figures given above would represent an overhead of 100 per cent.

The next example, with a different type of breakdown, is based on the experience of an industrial research institute in a developing country. The figures are for the institute's fourth year of operation, when the size of its staff was fifty, about one-half of whom were of professional grade.

EXPENSE BUDGET

(In U.S. dollars)

		Percentage
Administration	27,000	10
Research plant operation and maintenance	13,000	5
Continuation of government research projects already in progress	40,000	15
New government project	40,000	15
In-house project	30,000	11
Reference library	20,000	7
General equipment	15,000	6
Public services	25,000	9
Client projects	60,000	22
	270,000	100

In addition, out of funds being provided by the government, $75,000 per year was set aside in a sinking fund for a new building, and at the end of the fourth year the total in this fund would have reached $300,000.

The ratio of professional to non-professional salaries will show considerable variation from country to country and from institution to institution. It will also be influenced by the pattern of projects, because some types of research and development need high inputs of professional skills,

while others are customarily carried out with the help of larger numbers of technicians and other sub-professional assistants. Further, criteria for classification into professional and non-professional categories show much variance in different organizations and countries.

The following table indicates a slightly different sort of expenditure relationships in fourteen government research laboratories, all under one general administration in a developed country. It shows for 1951/52 and 1952/53 what percentage of each laboratory's gross expenditure is accounted for by salaries alone, wages alone, and salaries and wages combined.

PROPORTIONATE EXPENDITURE ON SALARIES AND WAGES OF SELECTED RESEARCH ORGANIZATIONS IN A DEVELOPED COUNTRY FOR 1951/52 AND 1952/53

Organization	*Salaries as percentage of gross expenditure*		*Wages as percentage of gross expenditure*		*Total of salaries and wages as percentage of gross expenditure*	
	1951/52	*1952/53*	*1951/52*	*1952/53*	*1951/52*	*1952/53*
National physical laboratory	64.3	63.3	15.7	16.3	80.0	79.7
Building research station	59.9	68.9	14.2	14.8	74.2	83.7
Chemical research laboratory	73.8	71.9	7.2	7.7	81.0	79.5
Fire research organization	63.3	60.9	17.1	15.6	80.4	76.5
Food investigation	57.8	52.1	15.3	14.2	73.1	66.3
Forest products research laboratory	70.3	66.4	18.4	18.5	88.7	84.9
Fuel research	48.5	48.3	23.3	23.0	71.8	71.3
Geological survey and museum	57.1	58.5	8.2	8.3	65.3	66.8
Hydraulics research association	38.4	42.0	8.2	12.5	46.6[a]	54.5[a]
Mechanical engineering research organization	27.2	25.6	10.0	13.1	37.2[a]	38.7[a]
Pest infestation research board	65.7	66.9	7.4	7.6	73.1	74.5
Radio research organization	50.0	75.7	7.3	11.3	57.3[a]	87.0[a]
Road research laboratory	53.2	53.3	24.3	23.7	77.5	77.0
Water pollution research laboratory	68.2	65.2	10.7	11.5	78.9	76.7
AVERAGE	57.2	57.1	15.0	15.5	72.3	72.6

[a] If these figures are omitted, the averages become 76.7 and 76.1 respectively. During these years the hydraulics research organization, mechanical engineering research laboratory and the radio research organization were establishing themselves as separate entities, and their figures therefore represent a different set of circumstances from those of the other stations here listed.

Care should be taken not to interpret "salaries" as used in this table as consisting of the remuneration of professional staff only and "wages" as consisting of that of all non-professional employees. The source of the table does not indicate the types of personnel included under

each classification. Practice on this point varies : in some institutes certain non-professional categories, such as senior artisans are paid salaries, in others wages.

Accounting practices

The purposes of the accounting system in an industrial research institute are twofold : (*a*) keeping records of receipts and disbursements for financial control, the practices of which must conform to standard procedures of the country; (*b*) analysis of financial data to provide the management with information necessary for controlling operations in accordance with the plans and budget.

The accounting system should be operated in such a way as to interfere as little as possible with the performance of professional activities. The most important asset of an industrial research institute is the time of its technical staff. If accounting involves reporting in excessive detail costs associated with the work, it becomes an irritating nuisance to professional personnel and interferes with the use of their skills in project work. Instead of making them directly responsible for small items of expense, the best procedure is for the detailed records to be kept only as a means of accounting control and to distribute the costs to various technical activities, including sponsored projects, on a pro-rata basis in proportion to the largest item, which is professional salaries. Large individual items are, however, usually charged against the specific project for which they are incurred.

Capital budgets

In addition to the operating budgets discussed in the preceding section, good management of an industrial research institute requires the establishment of capital budgets for the cost of large items of equipment for general use, major building changes and new facilities. Large items of equipment or supplies for individual projects, which are to be paid for by the sponsors, are not necessarily included in this budget, but are considered as items in the budgets of the respective projects.

It is customary in beginning the preparation of a capital budget for the management to request from the various individuals in the organization the items which they feel are needed for the continuing work of the institute. Experience shows that nearly always the total of all items represents an expenditure considerably greater than can be taken care of from funds available during the budget period. Accordingly, it is necessary to review these carefully and to establish priorities among them. Some items will be postponed indefinitely, while others may be held over for consideration the following year. The composite of all items included in the final budget, which requires approval of the board, should therefore be in line with the financial resources that can be counted on during the year.

It should be emphasized that the inclusion of the various items in the capital budget does not constitute an authorization of the individual expenditures themselves, but merely helps to define the relationship between anticipated expenditure and available and/or anticipated funds. It is often the case that some of the items will not be needed at the beginning of the year, but are to be delayed for a few or several months, or even into the next budget period.

When authorization for purchase of an individual item is sought, most organizations have some formal procedure for a written request to be submitted through administration channels which describes the purpose of the item, the amount and the justification. Often there is a gradation in the manner in which final approval may be obtained. For small amounts within a certain cost range, one of the senior members of the professional staff may be able to give approval. For larger amounts it may be necessary for the director to authorize the expenditure. For still larger amounts, it may be necessary to obtain approval of the governing body or board of management.

Working capital

Just as in the case of an industrial establishment, an industrial research institute has need for working capital to carry the expense of current operations. Further, it needs to provide capital for expanded facilities, including buildings, equipment and special instruments, which will represent a major item in planning for future financial requirements. This problem is similar to that faced by industrial establishments in setting up reserves for the acquisition of new or replacement plants and equipment, as well as for current expenditures.

ESTIMATING THE COSTS OF PROJECTS

Once the nature and scope of a proposed project has been mutually agreed to by the institute and the client or has been defined as an in-house project, it becomes necessary, as pointed out earlier, to make an estimate of the manpower required, the time allowed to complete the programme and the cost of carrying out the study. Even where all costs are met by government, similar procedures should be followed. As stated earlier, skill in preparing these estimates is acquired through experience in similar situations, and it is to be expected that the projects undertaken by the institute during its initial period of organization and operation will often be based on budgets which are too low. The management must be prepared, therefore, to face occasional deficits in project funds during its early history, and this is one of the reasons why its financial plans must be realistically worked out to have sufficient working capital available to tide it over such demands on its resources. A precautionary measure which is often helpful

is to subdivide a proposed programme into a few major phases, each one of which is susceptible to better estimation of effort and cost, with the understanding that after the completion of one phase the next can be defined and estimated with more certainty.

Methods for calculating project costs

It is obvious that there must be some method of arriving at an acceptable cost on which to base agreements between an industrial research institute and its clients where the institute charges for its services. Similar procedures should be used for in-house projects. Various methods can be developed to fit an individual situation, but in the rest of this section certain general principles will be described. In order to make the example more meaningful, the figures are expressed in Swiss francs, as a representative international currency.

It should first be noted that salaries, when they include those of both professional and non-professional personnel, will normally represent somewhere in the neighbourhood of two-thirds of total operating expense for laboratory projects. When pilot-plant work is involved, depending on the method of charging for the larger-scale equipment being used, the salary ratio will usually be less. The salaries of the professional staff in conventional types of laboratory work will represent 40 to 60 per cent of the total budget. These figures will vary quite widely because of different ratios of professional to non-professional personnel encountered in different countries.

By total budget is meant, as stated earlier, the sum of all the costs involved in the operation of the industrial research institute. This includes not only salaries of all the professional and non-professional staff, but also the cost of supplies, equipment, services, utilities and administration. Sometimes a figure representing rental value for the space occupied is added, whether this is actual rental or an amortization charge for the building.

The most usual form of calculating the cost of a given piece of technical work is to base it on the salaries of the technical men involved. As a rough approximation, the total cost will normally amount to at least twice the salaries of technical staff when all overheads are assessed against the cost. To give a practical example, we will assume a project involving the full-time services of one technical man for one year. If his annual salary is Sw fr 20,000, this will be equivalent to a total cost of Sw fr 40,000 for a year of his time when the overheads are included. Procedures for calculating overheads vary; figures as high as 150 to 200 per cent of professional salaries on net time allocation can be considered realistic, depending on the methods of computation.

To calculate the cost of one day of his time, we must deduct time away from work. Allowing two days each for week-ends in the fifty-two

weeks, three weeks vacation of five working days each (totalling fifteen days), and an average allowance for illness of eleven days during the year and fifteen holidays. 145 days must be subtracted from 365, leaving net time available for work of 220 days on an annual basis.

If we use Sw fr 40,000 as the total cost of a year's time, including 100 per cent overhead, we reach a figure of Sw fr 180 per day. This represents over Sw fr 20 per hour if the institute operates on an eight-hour day.

This is only an example to illustrate the case in which the full time of a man is charged against the project. As has been mentioned earlier, projects are often carried out with part-time participation of several people. Moreover, experience has shown that the average amount of time devoted to project work by all professional technical personnel, if the allocation of their time is objectively analyzed, normally amounts to about two-thirds of that available. This may be defined as " the technical salary equivalent ". The rest of their activities, so far as the institute is concerned, will be devoted to administration, attendance at technical meetings, internal staff meetings, discussions and miscellaneous.

In considering the total income that the institute can derive from the services of its professional staff, a figure representing the average input in reimbursable work should be used. The overhead assessed against projects must realistically take into consideration the fact that only about two-thirds of the potentially useful time can be recovered through the cost assessed against clients.

In a later section procedures will be described for collecting time costs for professional personnel. This system will also provide a basis for calculating the cost of projects when multi-discipline task forces or project teams are used.

The management of the institute is almost certain to encounter resistance to making estimates of allocation of time and associated cost of work, particularly on the part of less experienced members of its technical staff. These men will insist that it is not feasible to forecast the progress of technical work and that therefore they cannot comply realistically with requests for preparing such estimates. As they become more experienced and learn from specific cases that they can make reasonable forecasts if they prepare systematic outlines of the work to be undertaken, with a projection of the amount of technical time required to complete each phase of the assignment, they will gain confidence in their ability to perform this task. As time goes on, this will become the accepted way of organizing the work.

Estimation of a one-man one-year project

To demonstrate the procedure involved in a relatively simple case, we may choose the example of a proposed investigation of the recovery of a useful constituent from an agricultural raw material. The client is

willing to support a one-year project, requiring the full-time services of one technical man. A programme is laid out jointly by the institute management and the staff member who has been appointed to undertake the work. This is reviewed with the client's representative to obtain his concurrence.

This programme is then evaluated in terms of the progress that can be expected in one year, because the client has expressed interest in rapid implementation of manufacturing and marketing the product if the results of the project justify this course of action. It is the aim of both the institute and the client to make enough progress to warrant continuation of the study for an additional year in the direction of development studies. If, however, critical review of the likelihood of a suitable degree of success from the one-year study is doubtful, the management would do well to explain its opinion frankly to the client and to decline acceptance of the assignment unless he is willing to support the work under these conditions.

The cost of this project is relatively easy to compute, since it represents the total expense of the professional man who will carry out the work for a period of one year, including not only his direct salary but other expenses and the overheads the institute has adopted as general accounting practice. To be concrete, if the man's salary is Sw fr 20,000 (the same figure that was used in an earlier illustration), and if the total of other expenses and overhead is estimated at 100 per cent of direct salary, the project will cost Sw fr 40,000 for a period of one year.

The first step is to select one of the senior technical men, preferably one who has previously carried out projects for development of new products of this general type. He should be chosen in time to permit him to participate actively in laying out the total programme, and he and the management of the institute should be in agreement that a reasonable rate of progress during the course of the one-year period will bring the study to a well-rounded stage for decision as to further steps.

Method of operation of a project team

In organizations which have developed skill in managing multi-discipline teams, the inputs of effort by the various technical specialists are not fixed throughout the life of the project, but fluctuate from week to week or month to month according to the judgement of the team leader as to their proper timing. All members of the team not fully engaged in a project devote the remainder of their time to other projects and duties under a similar flexible system of management.

The team leader and the director of the institute develop a schedule of technical manpower requirements such as the following. Most of the details of product development work will be conducted by a junior technologist, but it is believed that one-half the time of another technologist of the same qualifications will also be needed. Considerable analytical work

of a specialized nature will be required and it is estimated that one-third of the time of a chemist in the analytical department will be necessary during the year. Certain properties will require determination by specialized physical-chemical methods from time to time, and therefore the team leader foresees the need for one-tenth of a professional-man-year for this type of work. Examination of the suitability of the product in the proposed uses is also a specialized function and the institute has a staff competent in this area, one-half of this man's time will be required for a period of a year. Finally, the consultative services of a chemical engineer and of a specialist from the market research group will be advisable, and it is felt that one-tenth of a technical-man-year will be needed from each of these two areas. The team might also utilize the services of outside consultants, not included in this estimate.

In this example, the initial work will be concentrated in the hands of the two junior technologists in demonstrating the feasibility of process for making the required samples; the team leader also participates heavily at this stage and may be spending more than one-third of his time during this phase. The analytical chemist and the product evaluator are not yet involved in more than selecting or adapting methodology, and the other team members need only to keep themselves informed of progress.

At the end of four months, many samples have been prepared; the analytical chemist and the product evaluator begin an active programme. The other members of the team make a thorough study of the information that has been obtained from their special points of view, formulate their comments and suggestions for the course of further work and then reduce the extent of their involvement.

At the end of, say, eight months, the process has been defined, the most promising candidate products have been selected and the scene is set for more intense effort by the rest of the team in order that a well-rounded summary of all aspects of the work can be incorporated in a final report at the end of the year.

Estimation of cost of a project team

We arrive, therefore, at the following estimate of technical effort for this example :

Type of Man	*Technical-Man-Years*
Team leader	1/3
Junior technologist	1
Junior technologist	1/2
Analytical chemist	1/3
Physical chemist	1/10
Product evaluator	1/2
Chemical engineer	1/10
Market research expert	1/10

The total of technieal-man-years required from this tabulation is 2.97, which we will round out to 3.0. Assuming again that Sw fr 20,000 is the average salary of the professional staff of the institute, and using the same figure of 100 per cent of direct professional salary for other expenses and overhead, we reach an estimate of three times Sw fr 40,000 per technical-man-year, or a total of Sw fr 120,000 as the cost of this team effort for one year.

In praetiee, as the managerial techniques of the institute are refined, the estimating procedures used in developing costs for a projeet will reflect the pattern of actual salaries represented by the different team members.

CONTROL OF TECHNICAL EFFORT

Since, as already emphasized, the performance of an industrial research institute depends upon effeetive deployment of the technical skills of its staff, good managerial praetice dietates that use of this major asset should be measured and controlled. The procedures described below for distributing time of professional staff against projects and non-project activities are based on the systems in use in well-managed technical organizations in many parts of the world.

Reporting of professional time distribution

As an initial step, many organizations ask each professional member of the staff to report weekly the number of hours he has worked on each technical project assigned to him. The same procedure may be followed for non-professional employees, but it is often felt that these are likely to be used on various types of work in rough proportion to the professional effort on each.

This reporting of time distribution should not be considered a burden by scientists and engineers. They should be made to realize that it is of advantage for them to know how they are spending their time, as well as necessary for the management of the institute to have the information. If there seems to be considerable resistance to introduction of the procedure on an hourly basis, accounting for time even by whole days or half-days is a start in the right direction. It should be added that some organizations have practised this system for many years on the basis of fifteen-minute intervals. It must be recognized that the data obtained are not rigorously accurate, but the system is the best that has been devised for controlling the directions in which technical effort is applied.

The scheme of time reporting is often extended to in-house projects, and even to non-project activities and situations, such as administration, professional development activities, illness or other absences, contacts with potential sponsors and the like. The director and other senior staff

members would also do well to account for distribution of their own time as a means of analyzing the expenditure of effort on various administrative matters.

Translation of time distribution into costs

In comparing the expense of work on projects against the budgets established in the agreements with clients, the accounting department uses some form of cost per professional-man-hour as a factor. It is advantageous to refine these costs by having them calculated on the basis of the actual salaries of the professional men engaged, or, for convenience, there may be an average for certain groups of employees, for example, senior technical specialists, intermediates and juniors.

Cost control for multi-discipline project teams

Where use is made of the procedure of carrying out projects by means of a group of specialists with diversified backgrounds, many of them working on a part-time basis, keeping control of the input of professional effort becomes even more important. Unless there is a regular system by which the project-team leader can be informed, preferably on a weekly basis, of the amount of time spent by the various members of this team, obviously he can encounter severe difficulties in programming the work in such a way as to maintain the desired rate of progress and still keep within budgetary limitations.

Good practice is to collect the weekly time cards of all members of the professional staff, prepare listings for each project of the number of hours spent by each team member, translate these into costs and transmit them as rapidly as possible to the respective team leaders. The latter can then regulate the composite of activities by comparing the cost of the various segments of work with the projected progress.

Chapter 6

PERSONNEL ADMINISTRATION

General considerations

The success, reputation and acceptance of an industrial research institute will depend primarily on the quality and ability of its staff.

In an earlier chapter the qualities and characteristics of the director of the institute have been discussed. Now, the general requirements of the rest of the staff will be considered.

First comes the professional technical staff. They will carry out or direct the investigations of the institute under the general guidance of the director. They must be of sound technical background and must have high standards of ethical behaviour, because they will frequently be in contact with the people from whom the institute derives its funds and with those who will use the results of the institute's work. They should be personable in appearance and manner and have ability to get along with others. They should be alert, adaptable and flexible and should be prepared to tackle any problems within their professional competence.

Technologists, engineers and scientists are often individualists. Their work is profession-oriented rather than organization-oriented and they tend to regard as their superiors those who are their technical superiors rather than those who merely have organizational seniority. They need reasonable freedom in carrying out their work and are unused to, and may well resent, strict supervision. They should have freedom to consult colleagues and experts in their subject in and outside the institute and should in general be left to plan the details of their work themselves. They should be allowed to publish results of non-confidential work in the technical and scientific journals because their reputation will largely depend on such publication. Due to their technical training they will have a critical attitude to proposals and to solutions of problems and will be quick to detect weakness in general proposals. Having been trained to think in a logical fashion, they will not accept administrative dictates blindly and are therefore sometimes liable to resent administrative decisions when the reasons are not clear to them. Also, they are often impatient of systems which involve considerable paper and reporting work and feel that technical work should receive priority over such " office " activities.

Although we have discussed the general characteristics of the professional technical staff, it must not be overlooked that research institutes employ other types and grades of staff. These may be technical assistants, technicians, secretarial and clerical assistants, and those who deal with the administrative or maintenance side of the work.

Sound personnel policies must be established in regard to all types and grades of staff, but when the institute is young and small, these matters will be dealt with primarily by the director who will know each member of his staff personally. As the institute grows, an organizational system will grow with it and the general administration of staff matters will then rest with other officers but subject to over-all surveillance of the director. The director will, of course, report important personnel matters to the board of management, but the board will devolve on him the details of carrying out the personnel policies.

The ratio of professional staff to staff who assist the technical work is usually known as the support ratio, and this ratio varies with different types of technical work and in different countries. However, in general, it appears to vary between one and three non-professional staff to one professional staff. In some developing countries not only are professional staff scarce, but the support staff are also scarce — especially trained technicians, and it may therefore be necessary for the institute to set up training procedures for such staff.

The morale of a research institute is a very precious thing and it will be one of the main considerations of the director to maintain it on a high level. This will not be attained unless the personnel procedures are not only fair to, but are seen to be fair by, the staff. Remuneration must be adequate and there should be some means of giving special recognition for good work.

In the larger institutes some systematic procedures of staff evaluation will be required and this system will not only be of great assistance to the management of the institute, but will also assist greatly in enabling staff to see that salary advancements and promotions are based on merit and not on nepotism, favouritism or mere length of service.

In the larger institutes it is fairly common now for two ladders of advancement to be used. First, there is the normal organizational ladder. As a man mounts this ladder, he will become responsible for the work of a larger number of staff and will have greater administrative responsibilities. Secondly, there is the ladder of scientific or technical excellence where a man can be promoted for this reason alone without having his administrative responsibilities increased.

Professional staff should be as close as possible to the practical technical work and any tendency on their part to retire to an office chair should be discouraged.

Employment on the technical staff of an industrial research institute is excellent preparation for a mature career in many other types of work. It is therefore very important that the management of the institute recognize their responsibility for providing opportunities for development of younger staff members, either in the hope that they will expand into broader opportunities within the institute itself or that they will move into other outside positions in which, as alumni of the organization, they will join a circle of loyal friends who will be spokesmen for its value in the community or nation.

Because of its importance we repeat the statement made at the beginning of these general considerations — that the whole success of an institute depends upon the quality and ability of its staff. Quality must not be confused with the mere accumulation of academic diplomas or degrees, but must be regarded solely as describing the value of the work done.

Research is aimed at the production of new ideas. Organizational sophistication alone will not produce a single new idea. The success of the institute will depend on having on its staff people capable of producing new ideas and actually producing them.

Recruitment of staff

In a new industrial research institute the professional technical staff will be small in number — probably somewhere between six and ten people. It is possible that suitable qualified people will not be available in the country where the institute is being set up, and applications for appointment will therefore have to be sought over a larger area. The director will no doubt obtain advice about suitable people from local sources, universities, other research institutes and from international organizations, and in his initial appointments will attempt to obtain as wide a range of skills and abilities as possible.

A major question is the interest of an individual in working on projects that have defined objectives for practical application. Many younger men just leaving the academic atmosphere of universities, either local or foreign, after obtaining advanced training, are highly oriented toward "pure" research, that is, scientific investigations carried on without constraint in areas of the individual's own choosing. The nature of operations of the institute should be clearly explained to the candidates by emphasizing that in selecting goals and conducting the work the guiding principle is to make a direct contribution to technological advances in the operations of the clients. If they do not give evidence of comprehending and agreeing to this policy, the disillusionment on both sides which results when they begin their work may be traumatic.

A second major question is the matter of versatility. Again, younger men who have just completed academic training are strongly motivated to

continue work along the lines in which they prepared their theses or at least to keep on working in related areas in which they have developed experience and knowledge. The varying nature of problems that are likely to be assigned to them in an institute dictates that a man can rarely hope to keep on working in the original field of his choice to the exclusion of everything else. It may be that he will find himself fortunate enough to be engaged in projects related to his thesis work, if this happens to have been carried out in an area of rapidly developing technology pertinent to national development, but he cannot count on this as an enduring situation.

Along somewhat the same line, there is the additional requirement of the ability of the prospective employee to work on more than one subject at the same time. This becomes especially important where the task force or project-team scheme of operation is to be used, because he will frequently be a member of more than one team. Some scientists find that this is not a congenial manner in which to work, because their personal bents are to concentrate on a single subject for extended periods of time to the exclusion of other interests.

When apparently suitable staff have been located, they will no doubt be interviewed before appointment. In the interviews the director will probably be assisted by technical members of the board of management or by technical experts from other organizations by invitation.

Finally, the candidates should be interviewed also by the individuals who will be their direct supervisors if they are offered positions. It is demoralizing to have all discussions regarding employment conducted with senior members of the management of the organization, only to find that when the candidate begins work, he has to deal not with the executives whom he has met, but with other men at lower echelons.

Great care will need to be taken to see that the staff appointed have suitable technical abilities and that their activities are oriented towards industrial work. They will normally have academic qualifications and, generally speaking the higher the academic qualification, the better the individual. But this is not by any means always the case. A sound record of achievement should always be preferred to the mere possession of academic diplomas. In the new institute the initial staff will probably consist of an engineer, a chemist, a chemical engineer, a socio-economist and possibly one or two people skilled in the main industrial activities of the country. In making appointments, some form of contract will be required and this should cover the following points :

(*a*) The parties to the contract should be stated clearly. For instance, it should be clear whether the employee is a servant of the institute and whether he is engaged to work only at the institute or wherever else his duties may determine.

(*b*) There should be a very broad description of duties, and this should make it clear that the employee is expected to assist the work

of the institute in every way possible and not only in his particular discipline.

(*c*) The period of the contract should be stated, that is, whether the appointment is for a fixed number of years or for an indefinite term, and this clause should also state the length of notice required either for the institute to terminate the employee's contract or for the employee to terminate his appointment.

(*d*) The initial salary payable should be stated and also the frequency of payment, that is, whether weekly, fortnightly, monthly and so on.

(*e*) It should be stated whether the employee is expected to give his whole time to the post or whether he may undertake private work with the permission of the institute.

(*f*) The employee should be required to observe any reasonable working instructions given to him by the director.

(*g*) The employee should undertake to observe trade or other secrets of the institute or its clients.

(*h*) He should undertake, on leaving the employment of the institute, to return to it any property of the institute, including records of his work.

(*i*) The terms of engagement should provide that rights in inventions and discoveries made by the employee during the period of his employment and relating to matters which are the subject of his duties should belong to the employer. For this purpose he may be required to sign documents implementing this requirement.

(*j*) Some statement should be made about payment of salaries during illness.

(*k*) The length of holidays should be stated.

(*l*) If the employee is required to work away from the institute for any significant length of time, some statement should be made as to whether the institute will pay the expenses involved, such as, for instance, the expenses of the employee being accompanied by this wife and family and the possibility of needing to move his home.

(*m*) Some statements should be made about sickness, accident and fringe benefits and about superannuation provisions in which the employee can share.

In addition, contracts of service sometimes contain a restrictive clause which provides that the employee may not enter other employement in the area on any of the subjects on which he has worked at the institute without the approval of the management of the institute.

All the provisions set out above apply mainly to the professional staff of the institute, and it is good policy to have these matters clearly

understood before an employee joins the staff, rather than to have arguments on them afterwards.

In addition to the professional staff there will be supporting staff, many of whom will have lesser professional qualifications and experience. These staff will work under the direction of the professional staff and will assist generally in carrying out the investigational work. In many instances, the supporting staff can carry out a complete investigation within the guidelines set by the professional staff.

A small staff of maintenance and shop personnel will also be required to maintain the premises and equipment and perhaps operate a small workshop. Various types of abilities will be required in even a very small institute to use simple machine tools, wood-working and metal-working equipment, in addition to skill at glass-blowing and the laboratory arts.

Another general group of staff to be considered is the administrative or office staff. At first, one man with accounting experience can probably carry out the necessary functions, but as the institute grows it may be necessary to have an accountant, a steward who will supervise maintenance of buildings and grounds and someone — preferably with a scientific background — to deal with staff administrative matters. The librarian, a very necessary service to the institute, may also be associated with the administrative group.

As the library grows, a librarian will be required and a decision will need to be made whether this function should be allocated to a trained librarian or whether it should be performed by a technically trained person interested in information work. In the latter case the library can also deal with those minor technical inquiries which do not need to be referred to the professional staff.

In all the types of staff mentioned above and, especially with the professional staff, it is a sound policy to have a probationary period, the appointment of the individual being confirmed at the end of this period. For top professional staff, the probationary period is sometimes as long as two years, the period diminishing with the level of the staff, but perhaps it should never be less than six months. During the probationary period, the man's progress should be reviewed. It may be desirable to give him an opportunity to work with different groups or in different areas within the institute, as it is sometimes found that a move within the institute will convert a doubtful employee into an asset because his early difficulties may have been due to incompatibility of temperament, rather than lack of ability to carry out the duties assigned to him. If, however, after at least two tries an individual is found to be unsatisfactory, he should be asked to find other employment as soon as possible and the institute should assist him in doing this.

Handling of personnel separations

The existence of a misfit who is not carrying his weight is a deterrent to proper morale. Continuing such an employee indefinitely appears to his associates a sign of weakness in administration. The situation should be handled with kindness but firmness. It should also be viewed as unfair to the rest of the staff who are making a proportionate contribution to the success of the institute.

The management, by finding a position elsewhere into which the man will fit better, is doing a service to him, to the rest of the staff and to the success of the institute. His experience in the institute, in spite of the fact that he did not live up to expectations, will usually have been of real benefit in giving him professional background for other types of work.

Encouraging co-operation among professional staff

While the institute will not undertake to employ staff on particular types of work, they will, of course, take into consideration the natural abilities of the employees, because staff do the best work when they are engaged in problems to their liking. An outstanding characteristic of professional scientific and engineering work is the personal involvement of the investigator with his problem. This sometimes leads to a reluctance to consult other experts or to devolve those parts of the assignment which can be carried out by lower paid staff. The director must always be alert to this characteristic of professional staff. It is sometimes the case in larger institutes that one will find professional staff working on some aspect of a problem, the answer to which is already known in other parts of the institute.

It is essential that all administrative and secretarial staff shall regard themselves as providing a service to assist the technical work of the institute and should not regard themselves as controlling the institute. All administrative processes must therefore be designed from this point of view. In no circumstances should technical procedures be regarded as subservient to the administrative procedures.

It is highly important that all staff should take pride in the institute and its work and that they should feel that they are part of the institute and not just people doing a job for pay.

Remuneration and superannuation

Although it is often said that professional staff find their greatest satisfaction in the content of their work, such staff, like other members of the community, need to be freed from immediate preoccupation with the problems of maintaining themselves and their families. This position can best be achieved by the adoption of an adequate salary structure.

Salaries are the most tangible reward for individual performance, and on their adequacy will depend the stability of the staff. This is essential for good productive work. Fluctuations in level of technical employment should be kept to a minimum, and the salary structure should be flexible so that salaries can be related to individual effort.

In the smaller institutes the director himself can judge the value of the service of each member of the staff and he should have power to make adjustments so that productivity is recognized. In the somewhat larger institutes he will consult the senior members of his staff on these matters, and in the still larger institutes it will be necessary to set up a systematic evaluation process. This will be dealt with later in this chapter.

Salaries should be related to the general levels of salaries in other professions in the area, and in some institutes annual salary increments are granted within a predetermined limit. In other institutes no automatic advances are made but all additional payments are based on an appreciation of the work of the individual.

In addition to adequate remuneration some acceptable form of superannuation should be adopted. If the institute is supported by government, superannuation may be by the government system of the country and may not involve the employee in making any contribution; if the employee leaves the institute he may lose all benefits. On the other hand, the system may involve a contribution by the employee (often 5 per cent of salary) and a counterpart contribution by the institute (often 10 per cent of the salary). These sums are used to purchase a suitable superannuation policy from an insurance company. If the employee resigns he recovers his own contributions, but after a certain number of years' service he may be allowed to receive some or all of the institute's contributions as well.

Conditions throughout the world vary so greatly that no indication can be given here of actual salary scales; each institute will need to determine these in the light of local circumstances.

In some institutes the salary paid to individuals is regarded as confidential between the employee and the institute, but often in institutes which are supported by the government the salary scales are required to bear some relation to those in other branches of government and are known publicly.

Evaluation of staff

In the small institute, evaluation of staff is a matter for the director, but in the large institute there must be a periodic examination of the technical work and personal potentiality of each member of the professional and supporting staff. This operation is normally carried out annually, but sometimes twice annually. On the basis of the evaluation advancements of salary and promotions are determined. The system frequently adopted

is to have a staff evaluation form, at the head of which is entered the name of the employee together with other particulars such as age, qualifications and so on. It is important that any new qualifications or experience obtained by the employee during the period under review should be recorded here, and it is good practice for the employee himself to fill in this part of the form.

The form should then go to somebody more senior than the employee being evaluated and who is, if possible, in day-to-day contact with the employee. Those sections of the form to be filled out by the evaluator call for an assessment of the following characteristics of the employee :

(*a*) Scientific ability : This should be taken to include both the man's academic qualifications and his capacity to expand existing knowledge.

(*b*) Judgement and common sense : This is a personal quality rather than a matter of technical expertness and is largely a result of temperament modified by upbringing and experience.

(*c*) Initiative and drive : This should cover the energy put into his work together with a sustaining interest in the work.

(*d*) Speed, accuracy and method : This is particularly personal, but is also much influenced by the man's experience and knowledge. It therefore gives a closer measure of a man's potential than some of the preceding requirements.

(*e*) Power of expression : This is particularly important in senior staff. Some people have a natural gift for this and it is largely a matter of education. For those members of the staff who are poor in this connexion, the institute should make every effort to help them to develop the art of communication.

(*f*) Leadership and personal relations: Here we come to the qualities which above all mark out a man for promotion. It is essential to see that the description is treated as a whole and that it is not just a measure of geniality. These characteristics are due less to education and experience than any of the others. A bad mark under this head may indicate that a good man is for the time being a square peg in a round hole.

Some evaluation forms call for an adjudication of an employee under five heads, such as very good, good, normal, poor and bad, and these degrees are marked for each of the characteristics mentioned above.

When the form has been filled in by the immediate supervisor, it should then go to the division head in the large institute and ultimately to the director. At each stage comments should be added if the employee and his work are known to the more senior staff.

A characteristic of systematic evaluation procedure is that it throws as much light on the judges as it does on the judged. It is sometimes very easy to see that some supervisor is out of sympathy with some members

of his staff, whereas the judgement of the director may differ from that of supervisor. This will therefore tend to show up not only the qualities of the employees but incompatibilities of temperament.

When the periodical assessment has been completed, some senior member of the staff should discuss the results with those assessed. He should praise the good qualities before he deals with those which are not so good. This interview should be designed as a means of helping the employee and should not in any sense be merely a vehicle for criticism.

These evaluations will tend to show up the potential leaders in the institute. In the junior ranks it must be remembered that it is not always those who are most adept at manipulative work who have the qualities of a good leader. Sometimes those people who are technically most proficient may be so interested in detail that they are unable to take the broader view required of a leader.

As a result of the periodic evaluation, salary advances may be determined or it may be possible within the discretion of the board of management or director to make *ad hoc* financial awards for good work.

For supporting staff, the evaluation forms will be simpler because many of the characteristics required of more senior professional staff will not be shown or even expected of supporting staff. When technicians, for instance, are evaluated the form will be very simple indeed because here skill and productivity can more easily be assessed and these are the principal requirements of such staff.

The higher the staff member, the less easy it is to assess his productivity. With professional technical staff the final product of their effort is ideas and it is often almost impossible to assess the value of an idea until some considerable period has elapsed. However, in those institutes where publication of papers in journals is allowed, some measure of the productivity of the senior staff can be gained from the number and quality of publications. Even here, however, it must be remembered that some staff members may be engaged on projects regarding which publication is not possible, so this yardstick cannot be used to the exclusion of other considerations.

In large institutes one of the great values of a systematic evaluation system is that it shows the staff that they are receiving fair consideration. From the standpoint of management, it is valuable because it provides for a consideration of all aspects of an employee's character and work. Without such a system, judgements might be made on some recent but trivial activity of the employee.

A specimen evaluation report (form 3) for the professional and supporting staff of a large institute is illustrated below :

Form 3

SPECIMEN EVALUATION REPORT

Reporting officer's initials	

INDUSTRIAL RESEARCH INSTITUTE OF .....

ANNUAL CONFIDENTIAL REPORT

Year ending .....

(Professional and Supporting Staff)

Establishment :

Grade :

Section I

* The officer who is being reported upon should check the entries in paragraphs 1 to 5 below and complete paragraphs 6 to 11 before signing at the foot of the page.

1. Surname (in block capitals)
2. Other names
3. Age on ..... Years Months
4. Length of service at ..... (*a*) In grade Years Months (*b*) In I.R.I. Years Months (*c*) Other government service Years Months
5. Increments above minimum on .....
6. Degrees or other technical or educational qualifications (including membership or fellowship of learned societies, professional institutions, etc.).
7. Qualifications gained and publications and unpublished reports during the last twelve-month period (state if no opportunity).
8. Foreign languages

	Proficiency		
Language	Verbatim translation	Written without dictionary	Working knowledge

9. Further education in progress (if any).
10. Type(s) of duty in which the officer concerned has had experience, including the year under review.
11. Remarks by the officer, including type(s) of duty and work on which he wishes to gain more experience.

* Signature .....

Section II The reporting officer

1. WORK on which engaged during year

2. ASSESSMENT OF PERFORMANCE (in relation to age and grade).

Put a blue or black tick after the appropriate description of each quality *which you have reason to be able to judge.*

(*a*) Professional qualities

(i) Scientific and/or technical knowledge

Exceptionally wide, thorough and up to date ..... *a* — —
Considerable breadth or depth of knowledge ..... *b* .——
Sound within his field ..... *c* ..——
Rather narrow or out of date ..... *d* ...——
Inadequate ..... *e* ....——

(ii) Originality

Always full of good ideas ..... *a* ——
Makes contributions of unusual value ..... *b* .——
Usually able to see a way ..... *c* ..——
Seldom produces constructive ideas ..... *d* ...——
Fails to respond usefully to a new situation ..... *e* ....——

(iii) Interpretation of data or experimental results

Brilliant use of data and results ..... *a* ——
Reaches good conclusions with ease ..... *b* .——
Makes satisfactory use of his data ..... *c* ..——
Not good at interpreting results ..... *d* ...——
Fails to use data effectively ..... *e* ....——

(iv) Experimental ability

Exceptionally skilful ..... *a* ——
Very good ..... *b* .——
A sound practical man ..... *c* ..——
Not particularly good ..... *d* ...——
Unsuited to experimental work ..... *e* ....——

(v) Reliability

Distinguished for reliable and thorough work ..... *a* ——
Maintains a high standard ..... *b* .——
His work is generally sound ..... *c* ..——
His reliability leaves something to be desired ..... *d* ...——
Unreliable and/or careless in his work ..... *e* ....——

(vi) Output — quantity

Outstanding in the amount of work he does ..... *a* ——
Gets through a great deal of work ..... *b* .——
Output satisfactory ..... *c* ..——
Works rather slowly ..... *d* ...——
Output regularly insufficient ..... *e* ....——

(*b*) Personal qualities

(vii) Personal relations

Highly regarded and respected ..... *a* ——
Is well regarded ..... *b* .——
Gets on satisfactorily with others ..... *c* ..——
Not easy in his relationships ..... *d* ...——
A very difficult colleague ..... *e* ....——

(viii) Leadership

A born leader ..... *a* ——
Able to guide others well ..... *b* .——
Exercises adequate control ..... *c* ..——
Does not control others well ..... *d* ...——
Cannot control staff ..... *e* ....——

(ix) Organizing ability

An exceptionally effective organizer ..... *a* —
Shows considerable skill at organizing work ..... *b* —
Plans and controls work satisfactorily ..... *c* —
An indifferent organizer ..... *d* —
Without organizing ability ..... *e* —

(x) Judgement, common sense and discretion

Displays exceptional wisdom, foresight and discretion ..... *a* —
Sensible and discreet ..... *b* —
Handles most situations adequately ..... *c* —
Inclined to be erratic in judgement or indiscreet ..... *d* —
Judgement definitely faulty ..... *e* —

(xi) Self-reliance

Takes and carries responsibility at all times ..... *a* —
Very willing to carry responsibility ..... *b* —
Accepts responsibility when required of him ..... *c* —
Inclined to rely on others ..... *d* —
Seldom trusts his own judgement ..... *e* —

(xii) Quality of expression (oral)

A brilliant expositor ..... *a* —
Expresses himself clearly and convincingly ..... *b* —
Puts his point adequately ..... *c* —
Not an effective talker ..... *d* —
Obscure, diffuse or inarticulate ..... *e* —

(xiii) Quality of expression (written)

Exceptionally good ..... *a* —
Written work clear, concise and well arranged ..... *b* —
Expresses himself adequately ..... *c* —
Written work hardly good enough ..... *d* —
Cannot express himself on paper ..... *e* —

3. OFFICIAL CONDUCT

Satisfactory ..... *a/c* —
If less than satisfactory explain why in item 4 below.

4. GENERAL REMARKS (including the noting of any special qualities of performance, under normal or special conditions, which cannot properly be recorded in any previous section).

5. OVER-ALL ASSESSMENT FOR DUTIES OF GRADE IN PAST YEAR
(Marking should be made in the light of the individual's age and incremental position in the grade.)

An exceptional officer outstanding in all respects ..... *a* —
A very able and effective officer ..... *b* —
A competent officer ..... *c* —
Fair ..... *d* —
Indifferent ..... *e* —
Unsatisfactory ..... *f* —

6. DEGREE OF FITNESS FOR PROMOTION
(Including class-to-class promotion) (See notes)

Delete one of the following :
1. Fitted } for immediate promotion
2. Not fitted }
Remarks (if any) :

7. CERTIFICATE

In my opinion the conduct and standard of efficiency of this officer are as stated above.

Reporting Officer's Signature : .....

Grade : Date :

Section III The countersigning officer

1. Do you agree entirely with the above report?
   Yes / No (Delete whichever does not apply.)
2. If not, what adjustment do you propose? (Revised markings can be indicated by blue or black crosses following the appropriate items.)

3. Have you any other observations?

4. CHANGE OF WORK : If you regard this officer as better fitted for other duties, state what you think he should do.

5. DEGREE OF FITNESS FOR PROMOTION
   (Including class-to-class promotion) (See notes)
   Delete all but one of the following :
   1. Highly fitted
   2. Fitted — for immediate promotion
   3. Not fitted

Remarks (if any) :

Signature : ..... Date : .....

Section IV

Remarks by Director :

Signature : ..... Date : .....

(Before this form is handed to the officer concerned, the reporting officer should initial it in the box provided on the front of the form.)

NOTES

The report is divided into four sections, the first of which contains factual information relating to the officer reported upon, who should check the entries and complete paragraphs 6 to 11, signing at the foot of the page before any entries are made on the remainder of the form.

The second section is the responsibility of the reporting officer, the third that of the countersigning officer and the fourth that of the director.

The opinions expressed in each section of the report should be genuine personal opinions of the officer concerned. Such opinions may differ as between the reporting officer, the countersigning officer and the director. Where this is so, it is essential for the success of the reporting scheme that the difference should not be concealed or glossed over.

Section II : The reporting officer. This section should be completed by an officer, designated by the director, who is in close contact with the person reported upon and

who is at least one grade senior to him. The report should refer strictly to the period specified at the head of the form and should not be based on earlier observations. Normally it is intended that one officer should complete this section of the report, but in cases where there has been a change of reporting officer during the year, the director should obtain a report from the reporting officer with the greater experience of the reportee during the year, or when appropriate, a joint report from both. Although it is expected that officers will exchange views in order to assist in the development of uniform standards, it is intended that a reporting officer should record his own judgement and not consult others about reporting upon individual cases. The report should therefore be based on the reporting officer's own observations of the officer under report, though occasionally where the officer being reported upon is engaged on two or more distinct jobs, the collaboration of two reporting officers is desirable. The " General Remarks " section offers an opportunity for any apparent inconsistency in markings to be explained or for disagreement between two reporting officers in the case noted above to be recorded and commented on.

Ticks should be inserted in the appropriate boxes, but all such markings should represent a definite assessment by the reporting officer. If the reporting officer is not in a position to pass judgement on any particular matter, the relevant boxes should be left blank and he should write before them in the margin NA (not applicable). Any characteristics not provided for elsewhere should be noted under " General Remarks ". The " Over-all Assessment " should be a general assessment and not an attempt to strike an average of the ticks in section II.

In marking fitness for promotion, the reporting officer is required to give his personal assessment of the suitability of the officer under report for a higher appointment at the present time. In the absence of other explanation under " Remarks ", this will be interpreted in relation to fitness for promotion to the next higher grade in the officer's present class. The marking should be based on the officer's qualities irrespective of age or length of service in his grade and be completely independent of the existence or otherwise of vacancies in the higher grade.

Section III : The countersigning officer. The countersigning officer should be a senior officer, designated by the director, who is normally responsible for the work of the reporting officer and the officer reported on. He should record any matters relating to the officer under report which are not brought out adequately in section II, or any instance in which he disagrees with the section II assessment. An absence of comment will be taken as implying agreement with the section II assessment.

Note 6 above concerning the assessment of fitness for promotion applies also to the countersigning officer.

Section IV : The director. The director is asked to try to ensure that there is reasonable uniformity of standards between the reports on the various grades within his station. This section provides an opportunity for adjusting standards between reporting officers and also for adding any special comments on the work of the officer reported upon.

General. Copies of reports may not be kept except by Heads of Establishments and in NO circumstances may reporting officers refer to previous reports when completing this form. The value of these reports is largely dependent upon strict observance of this rule.

Communication of Adverse Markings. The following procedure for notifying officers of certain low markings will be followed except in the circumstances noted in paragraph 12.

A marking under (*e*) of any heading of section II supported by the countersigning officer will be communicated to the officer informally in such a manner as the director may deem appropriate.

An over-all "unsatisfactory" marking supported by the director will be communicated by him to the officer in writing in duplicate. The officer will be required to sign and return one copy within four weeks with his written observations, if any. This copy together with the officer's observations, will be attached to the report before the report is sent to headquarters.

Adverse markings need not be communicated to the officer if : (i) in the opinion of the director communication is considered likely to affect adversely the officer's health; (ii) the marking is due to inexperience owing to less than one year's service in the grade (except in cases of unsatisfactory conduct, laziness and so on), or (iii) the weakness has already been notified, and it is clear that no useful purpose can be served by repeated notifications.

(In such cases the officer should be advised of the proposal to discontinue future notifications to the same effect as those he has previously received. Any change for better or worse should be notified to the officer.)

TRAINING

It is often the case that the formal education and training of staff are not quite adequate to meet the requirements of the institute. Even with people of high academic qualifications some specialized training may be required. Professional staff should be encouraged to welcome training rather than to regard it as a slight on their professional status.

For professional staff, training may well take the form of leave of absence at universities or at other research institutes designed to bring them up to date with new ideas and techniques. For the junior staff, some or all of whom may already have undergone a programme of technical training in a technical college or similar institute, additional training can often be provided on the job through suitable apprenticeship arrangements designed to produce the well-rounded types of technicians required by the institute. Where necessary, institute technicians may receive further training at appropriate technical colleges or universities in the country or abroad and in some instances may thus acquire professional qualifications.

In large institutes, some senior member of the staff is allocated the responsibility of supervising training programmes and of advising junior members of the staff on the types of training they should take. If it is possible to recognize successful training by suitable increments of pay, so much the better.

For senior staff members, training may be given in such topics as management, communications, human relations and how to deal with clients' representatives. In particular, training in management is required for those members of the staff who are being promoted from purely technical activities to those which require the exercise of managerial functions. Many institutes in the developed countries offer training facilities and, in some cases, these institutes are prepared to send members of their staff, to institutes in developing countries so as to train local staff in special techniques. Many international programmes are also designed for the train-

ing of professional staff. Whether training is to be in-house or whether it must take place outside the institute will depend on, among other things, the availability of suitable experts within the institute to undertake the training functions. It also depends on the availability of suitable training facilities and programmes outside the institute.

Within the institute, the holding of staff meetings, seminars, and the like can do much to expand the professional horizons of the technical personnel. Arrangements should be made to have all staff members participate actively by assigning them topics to prepare in advance for presentation and by occasionally holding programmes in which individuals are required to take part without preparation. This will improve the ability of individuals to organize their thoughts and to present them in an orderly and forceful manner.

The institute can also, by the diversity of its fields of activity, systematically expose individual members to various types of work by arranging for them to participate in a consulting capacity or as team members on projects in areas other than their main lines of activity.

It should be the policy of the institute to encourage the technical staff to participate in the organizational and technical activities of professional groups. Sometimes a pattern develops of representation in such affairs only by senior men. A plan should be worked out which provides for a reasonable amount of participation by junior members.

It is warranted to emphasize again one of the most important contributions that an industrial research institute can make to the national welfare in a developing country. By providing technical personnel with good training and opportunity to develop their ability to carry out research and development activities and by giving them experience in managerial aspects of technical programming, execution and implementation, the institute is aiding them in acquiring skills that make them particularly well fitted for taking senior posts in industrial establishments, industry associations and government agencies.

Motivation

While staff should be selected on the basis of having appropriate qualifications, the climate created by the management philosophy within the institute must be such that these attributes are encouraged by the internal administration. There should be throughout the organization a feeling of purpose, and procedures should be aimed at fostering this attitude. This requires that the senior members of the organization should set an example of effectiveness in carrying out their responsibilities.

The conditions of employment should be appropriate for the satisfaction of professional men of high calibre; even though they may not be ideal, they should at least be as good as can be achieved under existing

conditions. The scale of salaries and other benefits should correspond to these advantages for professional men in other types of occupations. Policies should be formulated and carried out for recognition of the self-respect of the individual. He should be made to feel that he is a vital part of the organization, not just another employee.

The management must set a pattern of constructive efforts to obtain interesting and rewarding technical assignments. Individual staff members should be made to feel that they are a part of this effort.

There must be recognition that there are two major facets involved in the handling of professional employees. The first may be called the organizational climate : this involves establishment of administrative channels which will define the relationship of the individual with respect to such matters as assignments of responsibility and authority in the chain of command, remuneration and other benefits, and guidance and assistance in personal development. The second aspect is the climate for professional work : this includes the method of defining assignments, establishment of a creative spirit, provision of opportunity for bringing into play individual technical abilities and recognition of accomplishment.

In older theories of management these two aspects of administration of technical personnel were treated as one and the same; in other words, the administrative superior not only was responsible for formal relationship in the organization, but also directed work assignment and performance. More recent managerial practices, particularly when a multi-discipline team approach is used on projects, treats these two channels of responsibility and authority in a different fashion by according to the individual much greater freedom in planning and using his abilities for reaching defined end results through collaboration with his colleagues.

Chapter 7

RELATIONSHIPS BETWEEN THE INDUSTRIAL RESEARCH INSTITUTE AND ITS CLIENTS

General considerations

If the *raison d'être* of an industrial research institute is that its help is needed by government, local enterprises and industrial development agencies, then its effectiveness must be measured by the extent to which these various undertakings really make use of its services. This will not take place automatically, nor can it be brought about just by offering services at subsidized rates or even free; the provision of research and technical services involves more than merely making them available. An industrial research institute anywhere — especially a new one — must successfully "sell" its services to the community if its value is to be felt where it is most needed.

Before discussing relevant techniques, it will not be out of place here to stress once more that the institute must first have something sufficiently valuable to sell. By this it is meant that, irrespective of promotional technique, what basically must be relied upon to sell technical services is the actual ability of the institute to return more than the investment in it — in other words, its ability to bring substantial gains to the user. Practical demonstration of this ability has to be the chief promotional tool. Thus, as already discussed elsewhere, the institute must have real competence; its staff, for instance, cannot afford to be in any sense of lower calibre than that of the organizations it hopes to advise, or the demonstration will inevitably fail. Likewise the institute's own position must be such as to assure clients of its capacity for impartiality and, where necessary, truly confidential treatment of information.

Starting and developing a clientele

Given these prerequisites, the successful development of a clientele is in itself a marketing research project. It involves an analysis of the types of services for which a demand may be created and a characterization of the industrial establishments, industry associations and government agencies considered likely candidates for sponsoring institute work. One of the early steps in organizing an industrial research institute is to decide what

technical areas the institute will endeavour to cover initially and what types of client are likely to be interested in the services to be offered. The decisions reached in this initial planning may eventually be modified and should not exclude the possibility of exploring other types of clients or other professional fields of work.

Criteria should be formulated for a systematic review of the range of operations, sizes, managerial attitudes and economic statuses of the potential clients to determine those that are likely to be most susceptible to the institute's appeal for sponsored work. Lists of proposed contacts may be assigned priorities and the original assumptions as to the most promising candidates tested against the results of trial calls on carefully selected representatives of major classifications. The reactions of the executives to the type of presentation made should be objectively analysed to improve the method of approach. The institute's management should continually be comparing its success in attracting projects in various lines, and accordingly seeking to adjust the scope of its professional proficiency in relation to the total community it seeks to serve.

It should be borne in mind that time and repeated contacts will be required to convince many executives of the value of the institute's services to their organizations. But intuition must be used in deciding which of the prospects warrant additional attention and which are unlikely to be convinced no matter how frequently they are approached.

In order to carry out successfully these explorations of types and areas of service, the senior executives of the institute should be acknowledged figures in the world of applied science, so that they can obtain entry into the managerial circles in which decisions will be reached on the need for outside help on technical or economic problems. They must be spokesmen for the broad aspects of the need of the industrial establishments, agencies and departments in their countries or communities for self-generated technology as the spearhead for future development and expansion of industry — indeed, even for its survival in the face of increasing competition throughout the world.

The board of management of an industrial research institute can be of great assistance to the institute in facilitating direct contacts with key persons in potential client organizations. From this aspect the members should be leading figures in industrial and public affairs, and their selection should be influenced by the types of clients and areas of work that are being sought. If they are suitably briefed on the objectives, method of operation and general capability of the institute staff, they can contribute greatly to the prestige of the organization and to its acceptance as a useful institution by appropriate echelons in government, industry associations and industrial establishments.

It is often advantageous to make contacts in the organizations of potential clients at more than one level. This may be done, for example, at the

level of the managing director, and also with some of the technical personnel. In this way both levels will become aware of the services the institute is prepared to offer, so that when the question of authorizing a project comes up for decision, the ground will have been prepared at both levels.

A word of caution should be expressed on the size of establishment which may make use of industrial research institutes. Often institutes have been thought to be most useful to small industrial undertakings which cannot afford to have their own technical staff. Experience has shown, however, that the major sources of institute support are actually the establishments of medium and large size. The smaller industrial units, even though they might be able to afford the expense of a project, often will not feel that by themselves they have the resources to make sufficient use of the results of research and development to justify the cost. In many lines, rather than try to provide major research services to individual small enterprises, the institute management will do well to seek instead some means of handling common problems of a group of such units in the same industry. Less costly services, however, such as routine testing and trouble-shooting, can still be provided to the small individual enterprises. These observations about small industrial establishments do not necessarily apply to government agencies, for it is conceivable that small agencies may need to arrange for outside technical assistance and will be well able to justify the cost.

These considerations emphasize the fact that the management of an industrial research institute must plan carefully the types of contacts which it wishes to carry out with potential clients. It should develop flexibility and patience in seeking support, until experience shows the sources and procedures that yield best results.

Remembering, too, that the continued growth of an industrial research institute cannot be based on words, but only on inspired confidence and demonstrated successes, it is wise policy to discourage proposed sponsored projects — indeed any projects — which seem to have poor odds for success. This is especially advisable in the early years, no matter how urgently new clients may be desired. In such instances it is better to suggest to the prospective client a modest exploratory programme or some simple initial tests, emphasizing that the institute is not in business to make a profit but only to be of genuine service, and does not want to take the client's money unnecessarily. Not only may the institute thus be spared the likelihood of an unsuccessful project on its record, but the goodwill engendered by this tactic will in due course bring in many times the volume of work so rejected.

Promotional literature

One of the first requirements of an industrial research institute is suitable literature. This need not be elaborate, but its content and quality of reproduction should be first class to reflect an institutional tone of care and competence. It is often in the form of a brochure setting forth concisely the objectives, areas of operation, outline of provisions for project contracts or agreements, a brief description of facilities and summary of the backgrounds of the professional staff. As time passes there will be additional literature to go along with the general brochure, such as illustrated annual reports describing the institute's achievements, copies of speeches on the general subject of institutional research, socio-economic development procedures and the like, all of which can be an effective means of attracting attention to the merits of placing projects with the organization.

Personal calls by institute staff

Visits to potential clients should be arranged in accordance with the customs of the country or community, usually by an introductory letter requesting an appointment, stating the purpose of the discussion and enclosing whatever literature may be available to pave the way for an appropriate reception. After the meeting, the institute executive may profitably write a letter expressing appreciation for the opportunity of having the discussion and, if possible, commenting upon some of the topics which appeared to be of most interest. Often some questions will have been raised during the discussions which will afford an opportunity for enclosing some preliminary information or for suggesting approaches to the problems.

The importance of having the names of the institute and its representatives well known throughout the community cannot be overemphasized. It has been the experience of nearly all organizations of this type that appreciable periods of time may elapse before the results of their initial promotional contacts bear fruit in the form of projects. But by diligent and courteous cultivation of a wide range of such contacts, the name of the institute will keep arising whenever an organization feels the need for external technical assistance.

Presentation of addresses and attendance at meetings

The executives of industrial research institutes who have primary responsibility for developing requests for service must devote major efforts to public appearances. They must accept invitations to present addresses before various types of industrial, government, technical and other organizations. These addresses should be carefully prepared, and while it is suitable that in many cases the subject should be the need for technological develop-

ment of the country, the material should not be too general and high flown, but should deal with illustrative practical cases to excite interest, with tactful presentation of the services that the institute is prepared to offer for this worthy cause. The accomplishments of the institute should be touched upon. When possible, the talks should be prepared in written form and published or reproduced for distribution to potential clients. At the least, there should be copies available for the daily press at the time of presentation, or summary releases or abstracts suitable for publication in the newspapers or in other general periodicals. If the director of the institute is not particularly adept in writing such material, one of his first needs to promote the welfare of the organization may be to engage a public relations assistant to aid him in doing this.

As the staff of the institute increases and the number of requests for representatives to deliver talks before various bodies grows, other senior men in the organization should develop their ability to help carry this load. As this type of activity expands, the usefulness of a public relations specialist will become more and more apparent.

The senior staff of the institute should also be ready to serve on appropriate public committees of a non-political nature and should be assiduous in attending meetings of industrial, government and social groups in which they will come in contact with prominent executives in the organizations from which they hope to obtain support for projects. This they must do even when they are not called upon to be speakers. Often there is opportunity for making comments from the floor after an address by someone else.

It is perhaps as well to add that, in activities of this kind, the tone of speeches and participation in discussions should be carefully framed with respect to what is fitting in carrying out a programme of dignified public relations. Overdoing the attempts to be in the public eye or adopting an approach that is not quite acceptable may do more harm than good. Thus a director experienced in the techniques of public relations is most desirable and, failing this, a staff assistant so experienced is an especially valuable member of the staff of an industrial research institute.

Institute periodical publications or bulletins

As an additional way of maintaining continuing contact with potential clients, some sort of regular mailing to a selected list of addressees is very helpful. Many industrial research institutes have printed bulletins issued monthly, quarterly or occasionally. These are often reproduced in an attractive printed form; for a smaller organization, however, a one- or two- page bulletin carefully prepared from time to time and duplicated on an office machine will serve the same purpose effectively. The contents may be essays on some timely topic, research news of local interest or abstracts of pertinent literature on technical or economic subjects culled

from the national literature and from international publications. Whatever their nature, the main point is that they cross the desks of potential clients with sufficient frequency to insure that the name and activities of the institute are not forgotten.

Symposia and special meetings

Industrial research institutes can fulfill a useful function in their countries or communities by organizing symposia or meetings at which papers on important topics may be presented. Naturally, some members of the institute staff may be included among the list of speakers, but it frequently creates a better impression if others are invited from outside the organization to participate. The assemblage of an important group in a symposium affords an excellent opportunity for expanding personal contacts, but this does not take the place of personal calls upon selected individuals. Also, if manuscripts of the adresses delivered at the meeting are collected, these can be reproduced and distributed among the participants or circulated to a wider readership.

An inviting public image

Finally, an industrial research institute must keep in mind that its clients often have to base important decisions and large financial outlays on its technical advice. They will not do this unless they feel that the institute is not only competent but critically careful in every respect.

Accordingly, such an institute must strive to set a quality of excellence in everything it does. The typing of reports should be of first-class workmanship, the receptionist should be pleasant and well informed, the front lawn should be well kept and everything else likewise should suggest that the institute has high standards and can be trusted with an important piece of work. To be sure, such a policy helps any business; but for a research institute to let so much as a carelessly typed letter leave the premises can give the impression that a table of research data might be similarly full of inaccuracies and capable of causing the client's factory serious financial loss. In short, to develop a clientele an institute must not only be competent but must appear to be competent.

CONTRACTUAL RELATIONSHIPS

Before the industrial research institute undertakes a project for a client, a proposal of the projected investigation is prepared and submitted to the client for his consideration. When the project proposal meets the satisfaction of the client, an agreement is entered into by the institute and the client. In general, if the project is small, the agreement may take the form of an exchange of letters; if it is large, it is customary either to use a standard agreement form or to prepare a detailed agreement for the specific project.

The following paragraphs illustrate the provisions that are generally included in contracts or agreements. Typical wording is underlined, followed by comments and various modifications that might be preferred by an individual institute.

SUBJECT : *This agreement confirms the mutual understandings between ABC Industrial Research Institute (hereafter called the Institute) and DEF Establishment (hereafter called the Client) covering a programme of research and development on (subject)*

It is usual to employ a short identifying subject which facilitates reference in correspondence or other communication.

Obligations of the Institute

PROGRAMME OUTLINE : *The Institute agrees to undertake on behalf of the Client a research and development programme to produce a product having the following characteristics...*

Sometimes it is preferable to attach a more detailed programme as a supplement to the agreement, in which case reference is made to it by including in the above statement the wording : " agrees to undertake the research and development programme described in detail in the supplement to this contract, which is acknowledged by both parties as a part thereof. "

CONTACT RESPONSIBILITY : *The Institute designates (individual's name) as having over-all responsibility for the conduct of this work.*

It has been found very desirable that both the Institute and the Client shall each designate a key individual who will make policy and day-to-day decisions on behalf of his party to the agreement.

PERSONNEL RESPONSIBILITY : *The Institute agrees to provide a qualified staff of professional personnel to carry out this assignment.*

In some cases the names of one or more professional people who are to take part in the work are specifically mentioned. It may also be advantageous to describe the qualifications of these men in an appendix to the contract.

FACILITIES RESPONSIBILITY : *The Institute agrees to provide laboratory (and/or pilot plant) space and general equipment needed for the carrying out of this investigation.*

Sometimes expensive specialized equipment or supplies beyond the normal type at the institute will be required. This possibility should be allowed for by indicating the estimated cost of these additional items, how they are to be paid for and the disposition to be made of used equipment or balance of supplies at the conclusion of the investigation. For example, the items may be retained by the Institute, they may be turned

over to the Client for his own use or they may be purchased by the Institute at some fair price.

REPORTING RESPONSIBILITY : *The Institute agrees to submit to the Client monthly reports describing the progress on the project. It will also maintain careful records in the laboratory of details of all work carried out. At the conclusion of the project a final written summary of all work will be prepared.*

Reporting may, of course, be carried out on some other schedule, such as quarterly, semi-annually or annually, as mutually agreed. The character of the reports should be such that they are useful to the individuals in the Client's organization who will receive them; in other words, if the reports go to a nontechnical executive, the language should be as simple and nontechnical as feasible, with due regard to giving all the necessary information and conclusions.

To maintain the Client's interest in the work, it is advisable to have reasonably frequent contacts by means of reports, letters, personal meetings or telephone discussions. Experienced managers of industrial research institutes often find that there should be a general policy of at least one contact of an appropriate character per month with each Client.

CONFIDENTIAL TREATMENT OF INFORMATION : *The Institute agrees that it will keep confidential any proprietary information supplied by the Client, and that it will not disclose information obtained during the course of the work to outside parties except in accordance with policies agreed to by the Client as follows : (Concise definition of policy.)*

The necessity for a stipulation of this sort will of course depend upon the situation within the given country. Where active competitive situations exist, either within the country or in the international field, it is likely that some agreement of this type will be required. The nature of the policy can, of course, be varied considerably.

RIGHT OF PUBLICATION : *The Institute is given the right for free publication of all results in the technical literature two years after the termination of this agreement.*

This type of arrangement varies much in various organizations, depending upon the situation in the economy, the policies of the Client, and the charter of the Institute.

PATENTS : *All patentable inventions made during the course of this investigation are the property of the Client. The Institute agrees to prepare the necessary memoranda and documents, at the Client's expense, for filing and prosecuting patent applications.*

Here again the stipulations in different countries and in different types of Institutes will vary widely. In a given country, while internal patents may not have value, it may be felt that patents should be taken out in other countries.

Sometimes in industrial research institutes, the policy is for the Institute to take out the patents, and to negotiate with the Client either a royalty arrangement for an exclusive license, or for a non-exclusive license; in the latter case the provision is often made that no other non-exclusive licenses will be granted to competitors until a period of, say, three years has elapsed, in order to give the Client lead time in commercializing the invention.

The stipulation "at the Client's expense" is included in the second sentence of the typical wording so that the Institute can recover the cost of preparing material for the patent application, which may not be requested until after the original project has been completed and the agreement terminated.

Obligations of the Client

FINANCIAL RESPONSIBILITY : *The Client agrees to make available to the Institute for this work the sum of* ..... *to be paid in accordance with the terms set forth in a later section.*

CONTACT RESPONSIBILITY : *The Client designates (name of individual) as responsible for policy decisions and day-to-day contacts with the project.*

Just as in the case of the similar clause under Obligations of the Institute, it is highly advisable to have one specific person mentioned in the agreement as the point of contact between the Client and the Institute.

ACCESSIBILITY FOR DISCUSSION : *The Client agrees to make its representative (or representatives) available with reasonable frequency for discussion either at the Client's place of business or at the Institute.*

This might be considered a superfluous provision, but it will be advisable to include it if there is any doubt on the part of the Institute regarding opportunities for reviewing the work with the Client.

PROVISION OF INFORMATION : *The Client agrees to make available to the Institute pertinent information necessary for the success of the project.*

Where it is known that the Client has information, obtained through its own efforts or from other sources, which would be helpful in carrying out the investigation, it is well to have a provision that this information be made available to the investigation. For example, the cost and availability of alternative raw materials, the type and cost of equipment and operations the Client is already using or market data and information on existing product lines may all be pertinent to determining the economic feasibility of the project.

DURATION : *This agreement shall take effect within (days, weeks, months) after the Client has authorized the project and shall remain in effect for (months, years).*

COST : *The Client authorizes the Institute to use a budget of (sum of money) in carrying out this work during the period of the agreement.*

The stipulation of the cost can take many different forms. It may be a budget for the entire length of the project. It may be a monthly or other periodic rate of expenditure. It may be based on a more detailed budget, specifying the limits of expenditures for salaries, supplies and equipment, overhead and travel of the personnel engaged in the work.

METHOD OF PAYMENT : *The Institute will submit monthly statements which the Client agrees to pay (stipulation of time period allowed before payment, for example, thirty days).*

Depending on the discretion of the institute with respect to the credit rating of the client, it may request part or full payment of investigatory costs in advance. In any event, it is highly undesirable to permit the accruing of large unpaid charges (for the method of estimating project costs, see chapter 5).

CANCELLATION : *Both parties to this agreement stipulate willingness to have it cancelled by either party on written notice of thirty days.*

It is well to include such a statement in the event that the Institute feels dissatisfied with the course of the work and wishes to terminate the investigation, or that the Client, for any reason, feels obliged to cancel it. Most Institutes find that cases of cancellations by either party are infrequent, but inclusion of the provision makes a good impression on Clients. The period of time before the cancellation becomes effective, after notice has been received, is optional.

RENEWAL : *This agreement may be extended for (a stated period) under the same conditions by mutual exchange of letters between the Institute and the Client.*

USE OF NAME : *Both the Institute and the Client agree that they will not use the name of the other party in connexion with this work without the written permission of the other.*

This provision is a mutual protection that publicity or promotional activities regarding the project and its results will not be carried out without written permission.

Other stipulations may be included in the contract, such as a provision for indemnity for personal injury or property damage, avoidance of conflict of interest with respect to other projects, and the rendering of the institute's co-operation to the Client's staff.

Authorization

Authorization is usually accomplished through appending signatures of duly authorized representative/s of the Institute and of the Client at the end of the document.

Assuming that the agreement has been prepared by the Institute, it is signed and dated by its contracting officer with a notation of his title. Authorization by the Client is frequently accomplished by typing in the letter or Agreement the words " Approved by " followed by the authorized representative's signature, title, and the date of signing.

Form 4 gives an example of a contract agreement used by a research organization in a developed country. The information relating to the specific project is entered on one side and the conditions covering the agreement are on the reverse side. Two copies of the form, signed by the institute, are submitted to the client for his signature and one copy is retained by each interested party.

Form 4

SAMPLE AGREEMENT

.....
(Name of Client)
of .....
.....
(hereinafter called " the Client ")

hereby appoints

A.B.C. INDUSTRIAL RESEARCH INSTITUTE
(hereinafter called " the Institute ")

to perform the following services :

(hereinafter called " the project ")

The Client agrees to appropriate a total sum not to exceed $——— for the project, and the Institute shall not expend more than this sum without first securing the specific written approval of the Client to do so.

The Client agrees to pay $_____ in advance, and thereafter as invoiced, all charges for the services specified above.

The Institute is authorized to commence the project forthwith upon the terms and conditions stated overleaf.

Signed by :	Signed by :
The A.B.C. INDUSTRIAL RESEARCH INSTITUTE	
This day of 19	This day of 19
Per	Per .....
.....	.....

Please sign and return one copy of this Agreement together with your Purchase Order if one is required for your administration.

Conditions of Contract

1. Invoices shall be rendered by the Institute on or about the 1st day of each month for the charges and expenses incurred on behalf of the Client prior to the date of the invoices, and the Client will pay such invoices at the Institute's office within thirty (30) days after receipt thereof. Unpaid invoices bear interest at eight per cent (8 %) per annum after sixty (60) days from their date.

2. In the event that the project sum is expended prior to the completion of the project, then the project shall terminate unless the Client authorizes the Institute to continue the project.

3. Any and all patentable inventions, applications for patents and patterns thereon relating to the subject matter of the project which may hereafter be made by staff members employed by the Institute on this project during the term of this project and as a result thereof, shall become the property of the Client, subject to the terms and conditions of this agreement. The Institute shall be entitled to the royalty-free use of any such inventions during the life of any patents thereon and the Client will pay to the Institute ten per cent (10 %) of all gross royalties, income or consideration derived from any dealing by the Client with such patents. In the event that the Client fails to apply for patents within six (6) months of being notified of such invention, the invention shall become the property of the Institute, which may apply for patents thereon free of any claim by the Client other than the right to the royalty-free use of such patents during the life thereof.

4. The Institute shall keep records of its experimental work and research during the project and shall from time to time deliver progress reports to the Client. In the event that the Client desires to keep secret any matter relating to the project, including matters pertaining to the business of the Client disclosed to the Institute for the purposes of the project, the Institute will use its best efforts to maintain the same secret.

5. The Institute will not during the term of this project conduct investigations for others which would in its opinion conflict with this project.

6. Until payment in full of all invoices rendered by the Institute during the currency of this agreement, title to all models, equipment, reports, data, diagrams, inventions and results, whether or not delivered to the Client, shall be and remain in the Institute, who shall also have a lien upon all property of the Client in the Institute's possession.

7. The Client shall not directly or indirectly associate the Institute with any advertising or promotional material or publicity releases relating to the project or the results thereof without the prior written consent of the Director of the Institute.

8. Special equipment required for the conduct of the project shall with the Client's consent be charged against the project. Such equipment is to become the property of the Institute unless otherwise agreed.

9. The Institute shall be liable for and shall indemnify the Client only in respect of personal injury or property damage occasioned by the negligent or wilful act or omission of the Institute or its servants in the course of services performed for the project, but not otherwise.

Basic principles and considerations in institute-client relationships

Paramountcy of client's interests

Successful liaison between the staff of an industrial research institute and its clients hinges upon realization by institute members that they are really functioning as an extension of the client's organization. If they adopt this attitude they will obtain a more effective discussion of project

work with client's representatives because they will be treated as colleagues carrying out a collaborative programme rather than as outsiders.

The institute's executives and the professional personnel engaged on projects must endeavour to develop full understanding of the objectives of their assignment as interpreted by the client. They must continually weigh their plans for work against the mutually agreed goals. If they feel that the objective should be modified, the situation should be explored in good faith with the client in an attempt to work out a suitable alteration or change in direction. If the difference of opinion suggests a lack of confidence in the institute's ability to attain goals, or if the institute believes that even though the results turn out as planned the client would not be able to use them, the best policy to maintain the reputation of the organization for integrity and sincerity — an extremely valuable asset — is to terminate the project.

Whereas this attitude may come more easily to the executives of the institute than to the professional staff at the working level, one of the functions of the management should be a systematic endeavour to instil this philosophy thoughout the staff. In practice, therefore, the work should be guided and planned with a view to how well it conforms to the client's objectives and interests and not be permitted to follow purely the path of scientific interest.

Recognition of the reasons for sponsorship of projects

Communications between institute staff and the client are improved if the former appreciates the basic reason for the project. This permits them to work more effectively on the programme. The four chief reasons for assigning projects to an industrial research institute are presented and discussed briefly below :

Acquiring skills that do not exist in the client's organization

Supplementing the resources of the client's internal staff when it becomes overloaded with work

Obtaining an approach to the solution of a problem different from that used internally

Obtaining confirmation of results obtained internally through the appraisal of an independent group

Acquiring new skills from an external source

This reason for using an industrial research institute is especially important in developing countries, because many of the establishments will not have their own research and development facilities. As they feel the need for new or improved technology, they will turn to an existing organization which has the background, experience and skills for conducting

the necessary investigations. It is therefore incumbent upon the institute to conduct its work so that the client becomes convinced of the need for his own research department. Also, the experience that he gains while working with the technical personnel of the institute will assist him in organizing and using internal research later.

The institute staff, therefore, has a responsibility for the national welfare of the country to demonstrate how technical resources can best be expanded for the solution of industrial problems. Their success or failure will have a strong influence on the attitude of industrial establishment managers toward the use of research and development. If they show standards of performance, it is probable that many members of the institute staff will enjoy important new job opportunities by joining industrial organizations as technical directors.

Supplementing client's internal staff

Frequently an establishment will have more work than it can successfully carry out with its own technical personnel. Sometimes additional technical men can be rapidly recruited, but very often the overload of work is of limited duration and recruitment for a short time is uneconomic. An organization which can make personnel with the necessary skills available on short notice is the practical answer. This course is customarily practised in large engineering projects for which it is too costly for an establishment to maintain large engineering design and drafting staffs to handle the peak loads.

When an industrial research institute is requested to assist a sponsor in this way — and the range of projects may vary from exploratory research to assistance in helping to design and install a large plant — duplication of work may occur in the client's and institute's programmes. Both sides must endeavour to avoid this. Initially they must clearly define the assignment to the institute, with a careful explanation of how the assignment fits into the client's master plan. The two parties should hold frequent meetings and consider any apparent inconsistencies, so that parts of the programme do not diverge. From the institute's point of view, it should be given a major section of the project, which it can carry forward as a whole, rather than small sections which require very close co-ordination with the internal work of the client.

Obtaining a different approach

Managers of establishments frequently feel that their own personnel are too much influenced by time-honoured practices of their industries to see new, more advantageous solutions. In any case engaging a group of researchers with a fresh outlook is often a wise practice, to confirm that the proposed operation is the best that can be found within the framework of available technology.

When an industrial research institute is requested to undertake a project of this kind, the staff should make an imaginative and systematic exploration of ways for accomplishing the same general objective. Sometimes, when they have been asked to do this without detailed knowledge of the nature of the client's own solution, they may come up with an identical solution; this does not mean that their effort has been wasted. They have given additional confidence to the one available solution.

This type of study is best achieved by making a systematic analysis of the objective in general terms and listing all potential methods for solving each major step. Whether or not these appear economic is not important at the time, but all reasonable routes should be included. These should then be systematically evaluated by consideration of how available raw materials or intermediate products produced in earlier steps fit into the goals in each case, what the technical feasibility of various operating procedures may be and what economic justification can be provided. From this examination, criteria should be established for the most effective methods for the process. When the unacceptable steps have been eliminated, a still more critical evaluation of the remaining ones should be made. The component transformations should be considered in relation to preceding and succeeding steps and not merely on their own individual merits. Acceptance of a step without considering its bearing on other steps might, for example, prove faulty if it involved a change in the specifications for raw materials at the start of the process.

Independent confirmation of internal work

Sponsoring establishments may decide that additional confirmation is needed for decisions based on work done by its internal staff. The size of commitments for new process equipment or plant may warrant having the data and information re-checked by an outside group. When an industrial research institute undertakes a project of this type, which bears considerable relationship to that described in the preceding section, it should obtain policy guidance as to whether it is merely to give an independent evaluation of the information supplied to it, or whether it should undertake a more critical examination of alternatives and, if so, in what depth to investigate them.

The character of the study should be defined as explicitly as possible in the agreement or contract covering the assignment. Even so, very frequent contact with the proper individuals in the client's organization is necessary to make sure that this independent investigation is following the proper course.

This type of work calls for objective and analytical review, making sure that minor differences of opinion of the experts on the institute's staff do not overweigh the judicial nature of the assignment. Several possibilities for carrying out a series of operations always exist and, unless there

is very good reason to suggest alteration in the process, with the additional time and expense involved in production start-up, they should be looked at impartially, from both a technical and an economic standpoint.

Frequency of contact with clients

To maintain successful relationships in carrying out a project for a client, an appropriate level of communications must be followed. Many industrial research institutes have found by experience that it is advisable to see the client's representative personally once a month, to report the status of findings and to discuss the future programme. If this frequency of personal or written contact seems to be excessive, the institute should at least communicate either by letter or by telephone to assure the client that the proper attention is being given to the assignment.

It is often the case that more than one individual in the institute will be carrying on contacts with members of the client's organization. These individuals may be at different levels of authority and the contacts made at the same or different times. For example, the director of the institute may have reason to call on or write to the manager of the establishment, while the project leader in the institute may be making separate contacts with a different member of the client's technical staff. When this situation arises, determined effort should be made to have each level of contact in the institute keep the other informed of the communications or discussions. Nothing is more disconcerting to good relationships than to have the top level of both organizations feel that excellent progress is being made, while at the lower level there have been discouraging results or upsetting differences in points of view between the client's representative and the project team.

Unsuccessful projects

There are inevitably cases in which the results of a project lead to disappointing conclusions. These can, however, be valuable to the client. This paradox is explained by the fact that a thorough study which fails to indicate promise of a commercial potential can prevent the client from undertaking additional work in his own organization or in some other outside group along directions which should be discouraged.

In the final report of such unsuccessful undertakings, the broad implications of the conclusions should be stressed. If, for example, the findings are unfavourable because certain raw materials are too costly, it should be noted that if the cost drops, the merits of the project should be re-evaluated. Or, feasibility may be unlikely because certain types of equipment cannot be had, but if these can be purchased at a later date, a reconsideration should be given. In other words, a careful analysis of the major causes of failure should be clearly pointed out, so that a change respecting any one of them can justify a re-examination of the entire subject.

General information not directly related to the project

An industrial research institute, because of its diversity of skills and information, can cement its relationships with clients by continually providing them with information of value to their other operations. Supplying the client with copies of a regular publication of the institute is a partial answer. Such copies should be sent to more than one individual in the client's organization, so that it may reach all the appropriate levels. There should be alertness on the part of the institute management and the project workers to provide other kinds of information that have a bearing on any of the client's activities or plans.

These observations emphasize the fact that the industrial research institute should consider itself a part of the client's organization, not only for the purpose of the specific project, but in the general interest of his operations.

Successful commercial applications as an asset to an institute

Since, as already pointed out, the success of an institute hinges on its reputation for carrying out projects successfully, its management should welcome opportunities for participation in the application of the results to industrial production, or at least of maintaining information to the client on the usefulness of some of its experiments. This continuing interest on the part of the institute may be a stimulus to better use of its findings. Commercial application of results should, whenever permissible, be described in institute literature.

Successful application also has a distinctly beneficial effect on the morale of the institute staff. Those dedicated to a career in applied research find their real professional satisfaction in seeing the studies they have conducted put into practice.

Institute-client relationship with respect to type of problem

The institute's ability to take a continuing interest in the use of its research results by the client may hinge on the attitude of the client's management and on the client's technical personnel strength. For example, the solution worked out in the institute may be passed on to a highly qualified technical staff in the client's organization, who may thus feel that they have all the information they need to carry the project forward internally and without further outside participation. Sometimes there is a resistance on the part of the client's management to disclosing to outside sources, even those that like the institute have been helpful, the exact use to which they propose to put research results.

There is also the question of the type of information provided by the project. If this is only confirmatory, probably this is all that the client needs

to prepare the way for utilization. If the project is quite limited in scope, again it is only a part of the total of information that is fed into the commercial enterprise.

Value of continued participation by both sides

A consideration that should influence a client in encouraging continuing interest by the institute is the fact that it is always advantageous to maintain adequate involvement of previous participants at various stages in the project, because new information obtained within the organization or from outside sources may have an important bearing on the success of the commercial undertaking. This point may be lost sight of inside the organization because of faulty communication.

A scientist in the institute might, however, read in the literature or find out through continuing work of his own in some field, a new phenomenon or fact that is related to the investigation in which he was involved a considerable period of time previously. A technologist who was engaged in the product development phase may learn of a new evaluation procedure, a new competitive product or a new use for materials of the general characteristics of the product, any one of which could have an important influence on plans for the new commercial operation. A market research expert may learn of changes in the market-place which warrant attention to some particular facet of the product's pricing, manner of distribution or extension into other markets.

All these points are particularly important during the state of commercial introduction and shortly thereafter because they can have a bearing on the manner of handling the start-up of manufacturing or the marketing plans. It is advantageous for industrial organizations to set up a final review of a project before commercialization, in which all departments or groups involved throughout the various stages are assembled for final comment. Where an industrial research institute has been involved in one or more phases, it should be valuable to have the project participants take part in any review of this character carried out by the client.

Advantages of continuing follow-up by the institute

To conclude, an industrial research institute should have a policy of endeavouring to maintain continuing contact with the client as the project moves forward into commercial scale. This not only provides evidence of interest in the welfare of the establishment, industry group or government agency which placed the assignment, but can be a very valuable adjunct to the client for a considerable period after work at the institute has terminated. It can at times be a means of obtaining additional projects for later phases or for review of previous work which may need to undergo some alteration as a result of additional experience.

Discretion in the use of proprietary information

During its contacts with a client the staff of an industrial research institute is likely to acquire considerable information of a proprietary nature. Disclosure to other parties can be the source of unfortunate repercussions. Any use made of data and information should therefore be in accordance with policies established by the institute management with the executives of the client.

Explanation of programmes, costs and time factor to potential sponsors

The staff of an industrial research institute in a country in which very few managers of industrial establishments or government agencies have had contact with technical programmes often has to explain why projects take so long and cost so much. Many executives who have not been involved in such matters — and this is true even in highly industrialized economies — think that a new product is developed by a technologist in a few days by making some tests in the laboratory or by sketching a design at his desk.

The institute staff, in approaching client executives whose difficulties arise from lack of exposure to the lengthy process of generating new technology, have to make use of case histories. Often managers of establishments or agencies which have already made use of the institute's services can be of invaluable aid in this educational undertaking, if they will consent to serve as references.

In most instances a description of the steps involved in the project is a good starting point. The material in chapter 4 on the sequence of work needed to confirm technical, economic and marketing feasibility at successive steps may be useful as background. After the executive of the potential client realizes the amount of effort required, he will more readily appreciate the cost.

The literature has much information on the time factors in research programmes. These discussions relate largely to experience in highly industrialized countries. They will therefore be less convincing in local situations than case histories of projects in developing countries. Institute directors will be well advised to collect as much data as possible on research time requirements in their own and other laboratories within the country or in other similar economies.

There is also much information in the literature on costs of research and development. Again, this centers largely on the expense per technical-man-year in industrialized countries. Within the next few years much better information relating to developing countries will undoubtedly become available on this subject.

As a basic principle, however, the cost in a given country per technical-man-year will tend to reach a norm applicable to industry, as well as to

industrial research institutes, provided that the figures are based on all expenses incidental to the work and provided that professional salaries have reached a common level proportionate to qualifications and experience.

Therefore, the management of the institute can state truthfully that the cost of carrying out a project by its staff is roughly the same as it would be in the client's organization.

The management of an institute should collect as much information as it can on the cost of technical activities throughout the country. A useful procedure is to organize a survey covering the experience of industry and other institutions. Available patterns which have been carried out in other countries can be used as guidelines.

A SELECT BIBLIOGRAPHY

This bibliography includes material pertaining to the administration of industrial research programmes and institutions, as well as general works on administration, personnel, financing, office management, patents, public relations and report writing. Its purpose is to assist the research administrator in the quest for literature pertinent to the varied and complex activities of his establishment. The bibliography is not by any means exhaustive and is offered as a guideline only.

CONTENTS

General works

1. ALHERS, Henry H. *Organized executive action : decision-making, communication and leadership.* New York, Wiley, 1961. 604 pages.
2. BARNARD, Chester Irwin. *The functions of the executive.* Cambridge, Mass., Harvard University Press, 1958. 334 pages.
3. BROSS, Bertram M. *The managing of organizations; the administrative struggle.* Glencoe, Ill., Free Press, 1964. 2 vols.
4. BROWNRIGG, William. *The human enterprise process and its administration.* Alabama, Alabama University Press, 1954. 232 pages.
5. DALTON, Melville. *Men who manage; fusions of feeling, and theory of administration.* New York, Wiley, 1959. 318 pages.
6. DIMOCK, Marshall Edward. *Administrative vitality; the conflict with bureaucracy.* New York, Harper, 1959. 298 pages.
7. ————. *A philosophy of administration; toward creative growth.* New York, Harper, 1958. 176 pages.
8. DRUCKER, Peter. *Landmarks of tomorrow.* New York, Harper, 1959. 270 pages.
9. GROSSMAN, Richard M. *Master standard data; the economic approach to work measurements.* New York, McGraw-Hill, 1962. 257 pages.
10. HAIRE, Mason, *ed. Modern organization theory; a symposium.* Berkeley, University of California Press, 1959. 342 pages.
11. HOUGHTON, P. S. *Work management and organization.* London, Spon, 1950. 269 pages.
12. KAHN, Robert Louis. *The dynamics of interviewing; theory, technique and cases.* New York, Wiley, 1957. 368 pages.
13. LEPAWSKY, Albert. *Administration; the art and science of organization and management.* New York, Knopf, 1949. 669 pages.
14. MARCH, James Gardner *and* SIMON, Herbert. *Organization.* New York, Wiley, 1958. 262 pages.
15. PFIFFNER, John McDonald *and* SHERWOOD, F. *Administrative organization.* New York, Prentice-Hall, 1960. 481 pages.
16. Pittsburgh University. Administrative Science Center. *Comparative studies in administration, ed.* by J. D. THOMPSON *and others.* Pittsburgh, Pittsburgh University Press, 1959. 224 pages. (Pittsburgh University. Series in comparative administration, 1).
17. ROY, Robert H. *The administrative process.* Baltimore, Johns Hopkins Press, 1958. 236 pages.
18. SELZNICK, Philip. *Leadership in administration,* Evanston, Ill., Row, 1957. 162 pages.
19. SIMON, Herbert A. *Administrative behavior; a study of decision-making processes in administrative organization.* 2nd ed. New York, Macmillan, 1957. 259 pages.
20. SMYTH, Bruce L. *Problemas administrativos de un departamanto de organizaciôn.* Mexico, 1958. 216 pages. (Centro de Estudios Monetarios Latinoamericanos, Mexico. Estudios.)
21. SOFER, Cyril. *The organization from within.* London, Tavistock, 1961. 128 pages.
22. STANLEY, Alexander J. *Organizing for international operations.* New York, 1960. 318 pages. (AMA Research study, 41.)

23. TEAD, Ordway. *Administration; its purpose and performance*. New York, Harper, 1959. 79 pages. (New York University, School of Commerce, Accounts and Finance. Ford distinguished lecture, 2.)

24. WALTERS, J. E. *Basic administration; the process of planning, organizing, managing, appraising and controlling*. Patterson, N.J., Littlefield, 1959. 399 pages.

Research programmes and institutions

25. ACKOFF, Russell Lincoln. *Scientific method; optimizing applied research decisions*. New York, Wiley, 1962. 464 pages.

26. ACKOFF, Russell Lincoln *and* RIVETT, Patrick. *A manager's guide to operations research*. New York, Wiley, 1963. 107 pages.

27. American Management Association. *The commercialization of research results, ed.* by Elizabeth MARTING. New York, 1957. 99 pages. (Special Report No. 20.)

28. ————. *Making effective use of research and development*. New York, 1956. 55 pages. (General management series, No. 180.)

29. ————. *New solutions to production problems*. New York, 1952. 28 pages. (Manufacturing management series, No. 200.)

30. ————. *Operations research : explained and applied*. (Conference handbook, published for distribution at the AMA special finance conference, 3-5 October 1956, Hotel Roosevelt, New York.) New York, 1956. 189 pages.

31. ————. *Organizing research and engineering for profit*. (Conference handbook published for distribution at the AMA special conference, 18-19 October 1956, Hotel Statler, New York.) New York, 1956. 144 pages.

32. ————. *Organizing the research function for profit, ed.* by Elizabeth MARTING. New York, 1956. 50 pages. (Research and development series, No. 1.)

33. ————. *Product development in medium- and smaller-sized companies*. (Conference handbook published for distribution at the AMA Special Conference, 25-27 March 1957, Chicago.) *Ed.* by Elizabeth MARTING. New York, 1957. 146 pages.

34. ————. Research and Development Division. *Achieving full value from R and D dollars*. New York, 1962. 108 pages. (AMA management report No. 69.)

35. ————. Research and Development Division. *Maintaining the product portfolio; the commercial development concept*. New York, 1960. 87 pages. (AMA management report No. 42.)

36. ————. Research and Development Division. *Trade secrets; a management overview*. New York, 1965. 24 pages. (Management bulletin, 64.)

37. ANDREASEN, Sv. V. *and* Bo Kristen. *Liaison between industry and research; a report on the ATV Liaison Service, 1st September 1958-31st August 1961*. Danish Academy for Technical Sciences, Copenhagen, 1961. 43 pages.

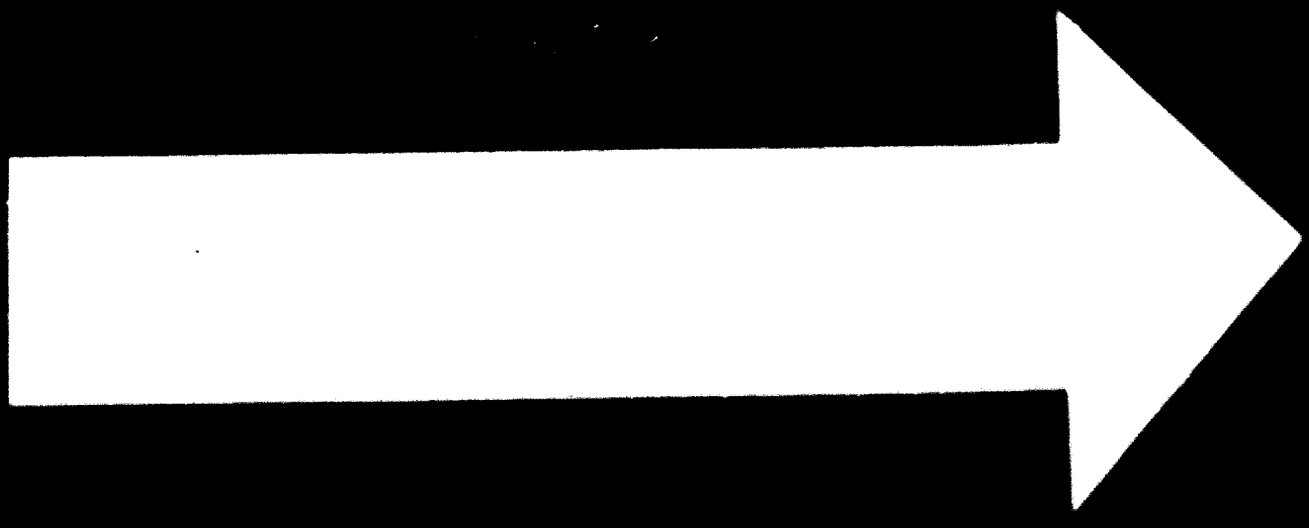
38. ANTHONY, Robert Newton. *Management controls in industrial research organizations*. Boston, Harvard University, Graduate School of Business Administration, Division of Research, 1952. 537 pages.

39. ————. *Selected operating data for industrial research laboratories*. Boston, Harvard Business School, Division of Research, 1951. 41 pages.

40. Arbeitsgemeinschaft Industrieller Forschungsvereinigungen. *Handbuch der industriellen Gemeinschaftsforschung*. Köln, 1958. 270 pages. (Handbook of industrial co-operative research.)

41. ————. *Handbuch der industriellen Gemeinschaftsforschung* (Nachtrag). Köln, 1958. 57 pages. (Handbook of industrial co-operative research (Supplement).)

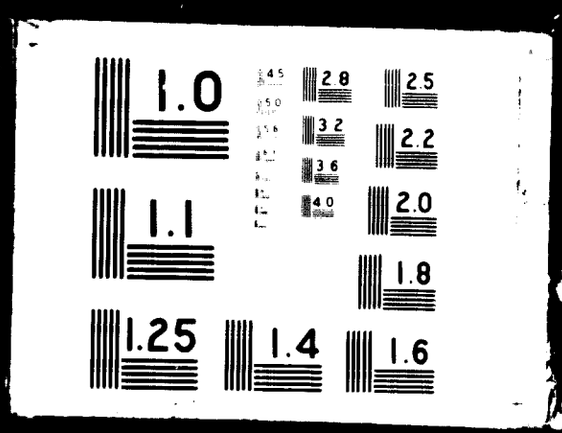
42. BARISH, Norman N. *Economic analysis for engineering and managerial decision-making*. New York, McGraw-Hill, 1962. 729 pages.



4.9.74

3 OF 3

03790



43. BARNES, Louis Byington. *Organizational systems and engineering groups; a comparative study of two technical groups in industry.* Boston, Graduate School of Business Administration, Harvard University Press, 1960. 190 pages.

44. BAUMGARTNER, John Stanley. *Project management.* Homewood, Ill., Irwin, 1963. 185 pages.

45. BASS, Lawrence W. *The management of technical programs, with special reference to the needs of developing countries.* New York, Praeger for Arthur D. Little, Inc., 1965. 138 pages. (Praeger special studies in international economics and development.)

46. BENTON, W. E. *The functions of a research department in a small firm.* London, British Institute of Management, 1951. 23 pages. (Production management series, No. 3.)

47. BERENSON, Conrad *and others, eds. Administration of chemical enterprises.* New York, Interscience, 1963. 414 pages.

48. BEVERIDGE, William Ian Beardmore. *The art of scientific investigation.* London, Heinemann, 1950, 171 pages.

49. BIXLER, Harley H. *The manufacturing research function.* New York, American Management Association, 1963. 80 pages. (AMA research study, 60.)

50. BOORE, William F. *Contract research and the small manufacturer.* Pullman, Washington, Washington State University, Division of Industrial Research, 1963. 93 pages, mimeographed.

51. BOOZ, Allen *and* Hamilton. Management Research Department. *The management of research and development; key to enhanced research effectiveness.* New York, 1958, 23 pages.

52. BRIGHT, James Rieser, *ed. Technological planning on the corporate level; proceeding of a conference sponsored by the Associates of the Harvard Business School, Sept. 8 and 9, 1961.* Boston, Harvard University, Graduate School of Business Administration, 1962. 253 pages.

53. BRILLOUN, Leon. *Scientific uncertainty and information.* New York, Academic Press, 1964. 161 pages.

54. BRUGGMANN, Max. *Betriebswirtschaftliche Probleme der industriellen Forschung.* Winterthuer, P. G. Keller, 1957. 212 pages. (Management and economic problems in industrial research.)

55. BUSH, G. P. *and* HATTERY, L. H., *eds. Scientific research; its administration and organization.* Washington, American University Press, 1950. 190 pages.

56. ————. *Teamwork in research.* Washington, American University Press, 1953. 191 pages.

57. BYLEVELD, Herbert. *Scientific research in Canadian industry.* Montreal, National Industrial Conference Board, Canadian Office, 1963. 40 pages. (Survey of executive opinion and experience, No. 6.)

58. CARTER, Charles Frederick *and* WILLIAMS, Bruce Rodda. *Industry and technical progress; factors governing the speed of application of science.* London, Oxford University Press, 1957. 244 pages.

59. ————. *Science in industry; policy for progress.* London, Oxford University Press, 1959. 186 pages.

60. CHAPANIS, Alphonse Robert Everysta. *Research techniques in human engineering.* Baltimore, Johns Hopkins Press, 1959. 316 pages.

61. CHORAFAS, Dimitris N. *Operations research for industrial management.* New York, Reinhold, 1958. 303 pages.

62. Clark, Wallace and Co. *Planning of research and development work; a statement of our experience*, by D. L. WILLIAMS. New York, 1946. 27 pages.

63. Conference for the Management of Materials Research. 1st, Arden House, 1961. *Report... Management of materials research.* New York, Interscience, 1962. 171 pages. (Metallurgical Society conferences, vol. 14.)

64. Conference of Industrial Research Directors and Managers. Warwickshire, England 1949. *Report...* London, Federation of British Industries, 1949. 123 pages.

65. ————. Warwickshire, England 1953. *Report... The commercial utilization of research results.* London, Federation of British Industries, 1953. 70 pages.

66. Conference on Administration of Research. 1st, Pennsylvania State College, 1947. *Proceedings.* 6-7 October 1947. State College, Pennsylvania State College, School of Engineering, 1948. 124 pages. (Pennsylvania State College, School of Engineering. Technical Bulletin, No. 29.)

67. ————. 2nd, Pennsylvania State College, 1948. *Proceedings.* 13-15 October 1948. State College, Pennsylvania State College, School of Engineering, 1949. 77 pages. (Pennsylvania State College. School of Engineering Technical Bulletin, No. 30.)

68. ————. 3rd, Pennsylvania State College, 1959. *Proceedings.* 12-14 October 1949. State College, School of Engineering, 1950. 78 pages. (Pennsylvania State College. School of Engineering Technical Bulletin, No. 31.)

69. ————. 4th, University of Michigan, 1950. *Proceedings.* 11-13 September 1950. Ann Arbor, University of Michigan, Engineering Research Institute, 1951. 86 pages.

70. ————. 5th, University of Michigan, 1951. *Proceedings.* 24-26 September 1951. Ann Arbor, University of Michigan, Engineering Research Institute, 1952. 78 pages.

71. ————. 6th, Georgia Institute of Technology, 1952. *Proceedings.* 8-10 September 1952. Atlanta, Georgia Institute of Technology, Engineering Experiment Station, 1953. 94 pages.

72. ————. 7th, University of California, 1953. *Proceedings.* 31 August-3 September 1953. Berkeley, University of California, 1953. 78 pages.

73. ————. 8th, New York University, 1954. *Proceedings.* 8-10 September 1954. New York, New York University Press, 1955. 108 pages. (University series.)

74. Conference on the Administration of Research (superseded by National Conference on the Administration of Research). 9th, Northwestern University, 1955. *Proceedings.* 7-9 September 1955. New York, New York University Press, 1956. 102 pages. (University series.)

75. Conference on Industrial Research. 3rd, Columbia University, 1952. *Proceedings. Research operations in industry; papers delivered at the third annual conference on industrial research, June, 1952, with selected papers from the first and second conferences, ed.* by David B. HERTZ *and* Albert H. RUBENSTEIN. New York, King's Crown Press, 1953. 453 pages.

76. Conference on Research and Development and its Impact on the Economy. Washington, D.C., 1958. *Proceedings.* Washington, National Science Foundation, 1958. 223 pages.

77. CONNELL, Vera, *ed. The application of results of research.* London, Butterworths Scientific Publications, 1954. 212 pages.

78. COOPER, William Wager *and others. New perspectives in organization research.* New York, Wiley, 1964. 606 pages.

79. COSSLETT, Vernon Ellis, *ed. The relations between scientific research in the universities and industrial research; a report on conditions in Great Britain* ... London, International Association of University Professors and Lecturers, 1955. 187 pages.

80. DEAN, Burton Victor, *ed. Operations research in research and development; proceedings of a conference at Case Institute of Technology*. New York, Wiley, 1963. 289 pages.

81. DUCKWORTH, W. E. *A guide to operational research*. London, Methuen, 1962. 145 pages.

82. DUNSHEATH, Percy. *Industrial research, 1956-1957*. (3rd ed.) London, Harrap, 1956. 444 pages.

83. EDWARDS, Ronald Stanley. *Co-operative industrial research; a study of the economic aspects of the research associations grant-aided by the Department of Scientific and Industrial Research*. London, Pitman, 1950. 285 pages.

84. EDWARDS, Ronald Stanley *and* LA ROCHE, Charles. *Industrial research in Switzerland; its institutional and economic background*. London, Pitman, 1951. 111 pages.

85. EDWARDS, John Alfred. *Laboratory management and techniques*. London, Butterworth, 1960. 207 pages.

86. ELLIOTT, A. *and* DICKSON, J. H. *Laboratory instruments; their design and application*. New York, Chemical Publishing, 1953. 414 pages.

87. Federation of British Industries. *Industrial research in manufacturing industry : 1959-60; results of a survey including commentaries and a statistical report*. London, 1961. 129 pages.

88. FENN, Dan Huntington, *ed. Management of materials research*. New York, Interscience, 1962. 171 pages. (Metallurgical Society conferences, vol. 14.)

89. FURNAS, Clifford Cook, *ed. Research in industry, its organization and management*. New York, Van Nostrand, 1948. 574 pages.

90. GILPIN, Robert George, *ed. Scientists and national policy making*. New York, Columbia University Press, 1964. 307 pages.

91. GUY, K. *Laboratory organization and administration*. London, Macmillan, 1962. 386 pages.

92. HAJEK, V. *Product engineering; profitable technical programme management*. New York, McGraw-Hill, 1965. 192 pages.

93. HARPER, James Ingram, *ed. Chemical engineering in practice*. New York, Reinhold, 1954. 140 pages.

94. HENKE, Russell W. *Effective research and development for the smaller company*. Houston, Tex., Gulf, 1963. 204 pages.

95. Herner, Meyer and Co. *Research, problem-solving, and the use of technical information in small and medium sized manufacturing firms; a report to the United States Department of Commerce, Office of Technical Services*. Washington, 1958. 26 pages. (PB131578.)

96. HERRING, PENDLETON *and others. Research for public policy*. Washington, Brookings Institution, 1961. 126 pages.

97. HERTZ, David Bendel *and* RUBENSTEIN, Albert H. *Team research*. Boston, Eastern Technical Publications, 1943. 103 pages.

98. HEYEL, Carl, *ed. Handbook of industrial research management*. New York, Reinhold, 1959. 513 pages.

99. HISCOCKS, Edward Stanley. *Laboratory administration*. London, Macmillan, 1957. 392 pages.

100. HOROWITZ, Ira *and* ALCOTT, James A. *Small business and government research and development*. Washington, Small Business Administration, 1962. 42 pages. (Small business management series, No. 28.)

101. HOWARD, George Wilberforce. *Common sense in research and development management*. New York, Vantage Press, 1955. 104 pages.

102. Industrial Research Institute, New York. *Organization of technical research in industry*, a monograph. New York, 1945. 15 pages.

103. Johns Hopkins University. Operations Research Office. *Organization for operations research*, by Foster L. WELDON. *Training for operations research groups*, by Thornton PAGE. Speeches delivered at the National Convention Institute of Radio Engineers, New York City, 23 March 1954. Chevy Chase, Md., 1954. 18 pages.

104. International Conference on Operational Research. 1st, Oxford, 1957. *Proceedings*. Baltimore, Operations Research Society of America, 1957. 526 pages.

105. ———————. 2nd, Aix-en-Provence, 1960. *Proceedings*. New York, Wiley, 1961. 810 pages.

106. International Symposium on the Organization of Applied Research in Europe. 2nd, Nancy, 1954. *Proceedings*. 11-13 October 1954. Project No. 191. Paris, Organisation for European Economic Cooperation, 1955. 258 pages.

107. ———————. 3rd, Vienna, 1956. Delegation from the United States. Report (n.p.), 1956. 1 vol. (various pagings).

108. ———————. 4th, Milan, 1959. Papers presented by France, Switzerland, United Kingdom, and United States. Paris, Organisation for European Economic Cooperation, European Productivity Agency (1959?). 9 vols.

109. International Symposium on the Organization of Scientific and Industrial Research. *Proceedings*. (November 12-October 10, 1951, London.) Washington, U.S. Department of Commerce, Office of Technical Service (1951?). 1 vol. (various pagings).

110. KARGER, Delmar W. *and* MURDICK, Robert G. *Managing engineering and research; the principles and problems of managing the planning, development and execution of engineering and research activities*. New York, Industrial Press, 1963. 693 pages.

111. ———————. *The new product; how to find, test, develop, cost, price, protect, advertise and sell new products*. New York, Industrial Press, 1960. 234 pages.

112. LISTON, Joseph *and* STANLEY, P. E. *Creative product evolvement*. West Lafayette, Ind., Balt, 1964, 1 vol. (various pagings).

113. LOTHROP, W. *Management uses of research and development*. New York, Harper, 1964. 148 pages.

114. LOTHROP, Warren C. *Paradoxes in research administration. East Lansing, Michigan State University, 1959*. 18 pages. (Bureau of Business and Economic Research, Michigan State University. Marketing and transportation paper, No. 4.)

115. MCCONNELL, Campbell R. *and* PETERSON, Wallace C. *Research activity, product diversification and product differentiation in small manufacturers in Nebraska*. Lincoln, University of Nebraska, College of Business Administration, 1963. 92 pages. (U.S. Small Business Administration. Small business management research reports.)

116. Management Conference. *Managing the search : a symposium on the effective administration of research programs*. 18-19 April 1958. Ithaca, New York, Cornell University. Graduate School of Business and Public Administration, 1958. 84 pages.

117. *Management's stake in research*, by Maurice HOLLAND *and others*. New York, Harper, 1959. 143 pages.

118. MARTIN, Henry A. *Management engineering in industrial research laboratories; from a panel discussion*. Industrial Research Institute Inc., Swampscott, June 1947. New York, Wallace Clark, 1947. 15 pages.

119. Mees, C. E. Kenneth *and* Leermakrs, John A. *The organization of industrial scientific research.* 2nd ed. New York, McGraw-Hill, 1950. 383 pages.

120. National Conference on the Administration of Research (supersedes Conference on Administration of Research). 10th, Pennsylvania State College, 1956. *Proceedings.* 5-7 September 1956. University Park, Pa., Pennsylvania State University Press, 1957. 133 pages.

121. ————————. 11th, Johns Hopkins University, 1957. *Proceedings.* 4-6 September 1957. University Park, Pa., Pennsylvania State University Press, 1958. 155 pages.

122. ————————. 12th, University of Denver, 1958. *Proceedings.* 10-12 September 1958. University Park, Pa., Pennsylvania State University Press, 1959. 131 pages.

123. ————————. 13th, Rensselaer Polytechnic Institute, 1959. *Proceedings.* 27-30 September 1959. University Park, Pa., Pennsylvania State University Press, 1960. 57 pages.

124. ————————. 14th, University of Michigan, 1960. *Proceedings.* 19-21 September 1960. University Park, Pa., Pennsylvania State University Press, 1961. 97 pages.

125. ————————. 15th, University of Puerto Rico, 1961. *Proceedings.* 10-13 October 1961. University Park, University of Denver, Denver Research Institute, 1962. 132 pages.

126. ————————. 16th, French Lick, Indiana, 1962. *Proceedings.* 16-19 September 1962. Denver, Colo., Denver Research Institute, University of Denver, 1963. 102 pages.

127. ————————. 17th, Estes Park, Colo., 1963. *Proceedings.* 11-13 September 1963. Denver, Colo., Denver Research Institute, University of Denver, 1964. 132 pages.

128. National Physical Laboratory, Teddington, England. *The direction of research establishments.* London, HMSO, 1957. 1 vol. (various pagings).

129. National Science Foundation. *A case study of support of scientific and engineering research proposals.* Washington, 1963. 123 pages. (NSF. 63-22.)

130. ————————. *Conference on research and development and its impact on the economy. Proceedings.* 20 May 1958. Washington, Government Printing Office, 1958. 223 pages. (NSF 58-36.)

131. ————————. *Current projects on economic and social implications of science and technology, 1963.* Washington, 1964. 158 pages. (NSF 64-10.)

132. NATO Conference on Operational Research, Paris, 1957. *Operations research in practice; report of a NATO conference.* New York, Pergamon Press, 1958. 201 pages. (Published also in French.)

133. Organization for Economic Cooperation and Development, *Technical information and the smaller firm; facts and figures on practices in European and American industry.* Paris, 1964. 69 pages.

134. ————————. *Technical services to the smaller firm by basic suppliers; case studies of European and American industry.* Paris, 1964. 40 pages.

135. Organization for European Economic Cooperation. *The organization of applied research in Europe, the United States and Canada.* Report of Technical Assistance Missions Nos. 81, 82, 83. Paris, 1954. 3 vols. in 1.

136. Paris. Université. Institut d'Administration des Entreprises. *Aspects économiques et sociaux du progrès technique et de la recherche scientifique; cycle de conférences organisé par l'Institut d'Administration des Entreprises de l'Université de Paris avec le concours de la Délégation Générale à la Recherche Scientifique,* par P. Auger *et les autres.* Paris, Dunod, 1964. 101 pages.

137. President's Conference on Technical and Distribution Research for the Benefit of Small Business, Washington, D.C., 1957. *Proceedings.* 23-25 September 1957. Washington, United States Department of Commerce, 1957. 287 pages.

138. QUINN, James Brian. *Yardsticks for industrial research; the evaluation of research and development output.* New York, Ronald, 1959. 224 pages.

139. ROBERTS, Edward Baer. *The dynamics of research and development.* New York, Harper, 1964. 352 pages. (Executive and leadership series.)

140. ROETHLISBERGER, Fritz Jules. *Management and the worker.* An account of a research program conducted by the Western Electric Co., Hawthorne Works, Chicago, with the assistance and collaboration of Harold A. WRIGHT. New York, Wiley, 1964. 615 pages.

141. RUSSELL, Robert Price. *The organization of industrial research.* London, Federation of British Industries, Industrial Research Committee, 1947. 15 pages.

142. SCOTT, Raymond H. *Industrial research activities of manufacturers in the Northwest.* Pullman, Washington, 1964. 285 pages. (Washington State University. Institute of Technology. Bulletin 285.)

143. SILK, Leonard Solomon. *The research revolution.* New York, McGraw-Hill, 1960. 244 pages.

144. SINGER, Tibor Eric Robert, *ed. Information and communication practice in industry.* New York, Reinhold, 1958. 304 pages.

145. STALEY, Eugene *and* FULTON, D. C., *eds. Scientific research and progress in newly developing countries; an exploration of ways in which basic and applied research can be used more effectively to speed socio-economic development in Africa, Asia and Latin America.* Menlo Park, California, 1961. 48 pages. (Stanford Research Institute. International Industrial Development Center. Staff paper.)

146. TERLECKYJ, Nestor E. *Research and development; its growth and composition.* New York, Halper, 1963. 115 pages. (National Industrial Conference Board. Studies in Business Economics, 82.)

147. THOMPSON, Victor Alexander. *Modern organization.* New York, Knopf, 1961. 197 pages.

148. THRING, Meredith Wooldridge, *ed. The principles of applied science.* New York, Macmillan, 1964. 226 pages.

149. Union of South Africa. *Act to promote scientific and industrial research, for that purpose to establish a South African Council for Scientific and Industrial Research, to define the objects for which it is established, to prescribe the manner in which it shall be managed and controlled and to provide for other incidental matters.* Pretoria, Government Printer, 1945. (No. 33, Statutes.) Text in English and Afrikaans.

150. United Nations Conference on the Application of Science and Technology for the Benefit of the Less Developed Areas. *Scientific and technological policy, planning, and organization. Science, technology, and development,* United States papers. Washington, Government Printing Office, 1963. 60 pages. (*Proceedings*, vol. 9.)

151. United Nations. *The question of establishing United Nations research laboratories.* Sales No. : 49.IV.1.

152. United States Bureau of Labor Statistics. *Science and engineering in American industry; report on a 1956 survey.* Washington, 1959. 117 pages. (NSF-59-50.)

153. United States Economic Cooperation Administration. *Report on the organization of industrial research in France; findings and recommendations of Mission O.E.E.C.-84 to France, organized by the Economic Cooperation Administration in co-operation with the Organization for European Economic Cooperation, the Ministry of Industry and Energy and the Ministry of Economic Affairs of the Fourth Republic, November-December 1951.* Washington, U.S. Department of Commerce, Office of Technical Services (1952?). 89 pages.

154. United States Small Business Administration. *Research relations between engineering educational institutions and industrial organizations.* A report of the Engineering College Research Council of the American Society for Engineering Education. (*By*) Clark A. DUNN *and others.* Washington, 1959. 38 pages. (Small business management series, No. 23.)

155. United States Technical Cooperation Administration. *How to select dynamic industrial projects.* Washington, 1958. 1 vol.

156. VILLERS, Raymond. *Research and development; planning and control. A research study and report prepared for the Financial Execs. Research Foundation.* New York, 1964. 185 pages.

157. WADE, Worth. *Industrial espionage and mis-use of trade secrets.* Ardmore, Pa., Advance House, 1964. 134 pages.

158. WIREN, Alexis Robert *and* HEYEL, Carl. *Practical management research.* New York. London, McGraw-Hill, 1945. 222 pages.

PERSONNEL

General works

159. American Management Association. *How to establish and maintain a personnel department.* 3rd ed. New York, 1946. 116 pages. (Research report, 4.)

160. ARGYRIS, Chris. *Personality and organization; the conflict between system and the individual.* New York, Harper, 1957. 291 pages.

161. ATWOOD, Jay F. *Interchange of personnel; progress, problems and prospects.* Chicago, 1963. 30 pages. (Public Personnel Association. Personnel report, 631.)

162. BARATIN, Henry Louis. *Organisation et méthodes dans l'administration publique.* Paris, Berger-Levrault, 1961. 203 pages.

163. BENN, B. A. *The management dictionary; standardization of definitions and concepts of the terminology in the field of personnel management.* New York, Exposition Press, 1952. 381 pages.

164. BINHAM, Walter Van Dyke *and* MOORE, B. V. *How to interview.* 4th ed. New York, Harper, 1959. 277 pages.

165. CARNEIRO, Ennor de Almeida. *Alguns aspetos da administração de pessoal; classificação de cargos, avaliação de cargos, remuneração.* Rio de Janeiro, 1955. 72 pages. (Brazil. Departa- mento Administrativo do Serviço Público. Ensaios de administrãço, 1.)

166. CASE, Harry L. *Personnel policy in a public agency; the TVA experience.* New York, Harper, 1955. 176 pages.

167. Colombia, Departamento Administrativo del Servicio Civil. División de Adiestramiento. *Manual de administración de personal en el servicio público colombiano,* por P. PATRÓN FAURA. Bogotá, 1961. 233 pages. (Administración de personal, 14.)

168. COPEMAN, George. *Promotion and pay for executives.* London, Business Publications, 1957. 216 pages.

169. DALE, Ernest *and* URWICK, L. F. *Staff in organization.* New York, McGraw-Hill, 1960. 241 pages.

170. DIVERREZ, Jean. *L'appréciation du personnel.* Paris, Ed. de l'Entreprise Moderne, 1962. 171 pages.

171. DOROUS, Roy M. *and* JONES, M. H. *Handbook of employee selection.* New York, McGraw-Hill, 1950. 349 pages.

172. DOULTON, Joan *and* HAY, D. *Managerial and professional staff grading.* London, Allen and Unwin for the Royal Institute of Public Administration, 1962. 141 pages.

173. FFORDE, J. S. *An international trade in managerial skills.* Oxford, Blackwell, 1957. 153 pages.

174. FRENCH, Wendel. *The personnel management process; human resources administration.* Boston, Houghton Mifflin, 1964. 624 pages.

175. HONEY, John C. *Personnel administration in Puerto Rico.* (Rio Piedras? 1950?.) 532 pages.

176. Institut Technique des Administrations Publiques, Paris. *Problèmes du personnel dans la fonction publique.* Paris, 1959. 11 parts in folder.

177. JACQUES, Elliot. *Measurement of responsibility; a study of work, payment, and individual capacity.* Cambridge, Harvard University Press, 1956. 143 pages.

178. LAPIERRE, Claude. *L'évaluation des emplois.* Paris, Les Editions d'Organisation, 1959. 284 pages.

179. MAES, Georges. *Comment recruter, sélectionner et utiliser le personnel de bureau.* Bruxelles, Ed. Comptables, Commerciales et Financières, 1947. 264 pages.

180. MANDELL, Milton M. *Recruiting and selecting office employees.* New York, 1956. 175 pages. (AMA Research report, 27.)

181. MEE, John F., *ed. Personnel handbook.* New York, Ronald Press, 1951. 1167 pages.

182. NIGRO, Felix A. *Public personnel administration.* New York, Holt, 1959. 499 pages.

183. NORTHCOTT, C. H. *Personnel management; principles and practice.* 3rd ed. revised and enlarged. New York, Philosophical Library, 1956. 428 pages.

184. Office Management Association. *Clerical job grading and merit rating.* Revised and enlarged ed. London, 1960. 91 pages.

185. Organization for Economic Cooperation and Development. *Evaluation of supervisory and management training methods; co-ordination of research,* by R. MEIGNIEZ *and others.* Paris, 1963. 159 pages.

186. PFIFFNER, John McDonald, *and* FELS, M. *The supervision of personnel; human relations in the management of men.* 3rd ed. Englewood Cliffs, N.J., Prentice-Hall, 1964. 369 pages. (Prentice-Hall industrial relations and personnel series.)

187. PIGORS, P. *and* MYERS, Ch. *Personnel administration; a point of view and a method.* 4th ed. New York, McGraw-Hill, 1961. 749 pages.

188. PINILLA SÁNCHEZ CONCHA, Antonio. *Trabajo y politica laboral.* Lima, 1959. 366 pages. (Lima, Universidad Mayor de San Marcos. Instituto de Relaciones Humanas. Biblioteca. Serie A : Relaciones del trabajo.)

189. SCHELL, Erwin Haskell. *Technique of executive control.* 8th ed. New York, McGraw-Hill, 1957. 357 pages.

190. SCOTT, Walter Dill *and others. Personnel management; principles, practices and point of view.* 6th ed. New York, McGraw-Hill, 1961. 623 pages.

191. STAHL, O. Glenn. *Public personnel administration.* 5th ed. of the earlier work of W. E. MOSHER, J. D. KINGSLEY *and* O. G. STAHL. New York, Harper, 1962. 531 pages.

192. Supervisory management. *Leadership on the job; guides to good supervision.* New York, American Management Association, 1957. 303 pages.

193. United Kingdom Committee of Enquiry into the Organization of Civil Service *(Report).* London, 1963. 59 pages. (Cmnd. 2171.)

194. United States Civil Service Commission. *Classification principles and policies.* Washington, 1963. 74 pages. (Personnel management series, 16.)

195. ————. *Selecting supervisors.* Revised ed. Washington, 1956. 53 pages. (Personnel methods series, 2.)

196. ————————. *The training of federal employees: training policies, organization for training, training programs and activities, training methods, problems and recommendations, status report to the President.* Washington, 1958. 146 pages. (Personnel methods series, 7.)

197. WATTS, William W. *Personnel administration.* New York, Ronald Press, 1952. 683 pages.

198. WATKINS, Gordon S. *and others. The management of personnel and labor relations.* 2nd ed. New York, McGraw-Hill, 1950. 974 pages.

199. WILDMANN, Charles. *Labor-management relations.* New York, Reinhold, 1959. 142 pages.

200. YODER, Dale. *Personnel management and industrial relations.* 5th ed. Englewood Cliffs, N.J., Prentice-Hall, 1962. 667 pages.

201. YUZUK, Ronald Paul. *The assessment of employee morale; a comparison of two measures.* Columbus, 1961. 67 pages. (Ohio State University. College of Commerce and Administration. Bureau of Business Research. Monograph, 99.)

Scientific and technical

202. American Council on Education. Research Staff on Scientific Personnel. *Educational status, needs, and opportunities of industrial research scientists in the Philadelphia metropolitan district* ... Washington, 1951. 75 l., mimeographed.

203. American Institute for Research. *Evaluating the performance of research personnel; a manual for supervision.* Pittsburgh, 1951. 49 pages.

204. American Management Association. *The management of scientific talent*, ed. by J. W. BLOOD. New York, 1963. 240 pages. (Management report, 76.)

205. ————————. *Optimum use of engineering talent; meeting the need for technical personnel.* New York, 1961. 416 pages. (Management report, 58.)

206. ————————. Research and Development Division. *The management of scientific manpower.* With a special supplement on engineering education. New York, 1958. 160 pages. (AMA management report, No. 22.)

207. ————————. *Strengthening the research effort : personnel, tools, potentials, ed.* by Elizabeth MARTING. New York, 1956. 63 pages. (Research and development series, No. 2.)

208. BEER, Stafford *and* REVANS, R. W. *Operational research and personnel management.* London, Institute of Personnel Management, 1959. 25 pages. (Institute of Personnel Management, London. Occasional papers, No. 14.)

209. BENNETT, Edward Martin, *and others, eds. Human factors in technology.* New York, McGraw-Hill, 1963. 685 pages.

210. BLAU, P. *Bureaucracy in modern society.* New York, Random House, 1956. 127 pages.

211. BRONOWSKI, Jacob. *Science and human value.* London, Hutchinson, 1961. 94 pages.

212. California Institute of Technology, Pasadena, California. Industrial Relations Section. *Supervision of scientific and engineering personnel*, compiled by J. T. LLOYD *and* R. D. GRAY. Pasadena, 1956. 82 pages. (Bulletin, 26.)

213. Columbia University. Bureau of Applied Social Research. *Review of studies in the flow of information among scientists.* New York, 1960. 2 vols. in 1.

214. Conference on Industrial Research. 2nd, Columbia University, 1951. *Proceedings. Selection, training and use of personnel in industrial research.* June, 1951. Ed. by David B. HERTZ *and* Albert H. RUBENSTEIN. New York, King's Crown Press, 1952. 274 pages.

215. Conference on Industrial Research. 6th and 7th, Columbia University, 1956. *Proceedings.* Human relations in industrial research management including papers from the sixth and seventh annual conferences on industrial research, Columbia University, 1955 and 1956. Ed. by Robert Teviot LIVINGSTON *and* Stanley H. MILBERG. New York, Columbia University Press, 1957. 418 pages.

216. Conference of Industrial Research Directors and Managers. 4th, Warwickshire, England, 1955. *Report... The education and training of graduate staff for industrial research.* London, Federation of British Industries, 1955. 54 pages.

217. DANIELSON, Lee Eric. *Characteristics of engineers and scientists significant for their utilization and motivation.* Ann Arbor, Michigan, Bureau of Industrial Relations, University of Michigan, 1960. 130 pages. (Bureau of Industrial Relations. Report, 11.)

218. Deutsch and Shea, Inc. *Chemists and chemical engineers evaluate recruitment ads.* New York, Industrial Relations News, 1963. 50 pages.

219. ————————. *Technical manpower recruitment practices.* New York, Industrial Relations News, 1963. 32 pages.

220. Drexel Institute of Technology, Philadelphia. *The role of the individual in modern research. Panel discussion... November 1, 1951 ... held in ... Philadelphia ...* By David H. DAWSON *and others.* Philadelphia, 1951. (Various pagings.)

221. Engineering Manpower Commission. *The engineering manpower situation, present and future: an analysis,* by H. A. FOECKE. New York, 1965. 12 pages.

222. European Productivity Agency. *Selection and training of foremen in Europe: report on the status, selection and training of foremen in Europe,* by S. GRABE *and* S. SILVERIER. Paris, 1956. 172 pages. (Project, 234.)

223. FLANAGAN, John C. *Critical requirements for research personnel.* Pittsburgh, American Institute for Research, 1949. 66 pages.

224. FRENCH, Earl B. *Personnel problems in industrial research and development.* Ithaca, Cornell University, New York State School of Industrial and Labor Relations, 1963. 46 pages. (Bulletin, 51.)

225. HERTZ, David B. *and* RUBENSTEIN, Albert H. *The selection, training and use of personnel in industrial research.* New York, King's Crown Press, 1952. 274 pages.

226. HOWER, Ralph Merle *and* ORTH, C. D. *Managers and scientists; some human problems in industrial research organizations.* Boston, Division of Research, Graduate School of Business Administration, Harvard University, 1963. 323 pages.

227. Industrial Research Institute, New York. *Research is people; a discussion of the recruitment, motivation, recognition, rating, and evaluation of research personnel,* held at the 1956 Spring Meeting of the Industrial Research Institute at White Springs. New York, 1956. 69 pages.

228. KORNHAUSER, William. *Scientists in industry; conflict and accommodation.* Berkeley and Los Angeles, University of California Press, 1962. 230 pages. (University of California. Institute of Industrial Relations. Publication.)

229. MARCSON, Simon. *The scientists in American industry; some organizational determinants in manpower utilization.* Princeton, N.J., Princeton University, Department of Economics, 1960. 158 pages. (Research report series, No. 99.)

230. Michigan University. Institute for Social Research. *Human relations in a research organization; a study of the national institutes of health.* Ann Arbor, Michigan, 1953. 2 vols.

231. MORADIAN, Thomas. *The research and development engineer as manager.* New York, Holt, 1963. 152 pages.

232. National Manpower Council. *A policy for scientific and professional manpower.* New York, Columbia University Press, 1953. 263 pages.

233. National Research Council. *Research and development personnel in industrial laboratories.* Washington, 1952. 13 pages.

234. National Science Foundation. *Methodological aspects of statistics on research and development costs and manpower.* Washington, Government Printing Office, 1959. 132 pages. (NSF 59-36.)

235. ———. *Scientific research and development in colleges and universities; expenditures and manpower, 1958.* Washington, Government Printing Office, 1963. 140 pages. (Surveys of science resources series, NSF 62-44.)

236. ———. *Scientists, engineers, and technicians in the 1960's; requirements and supply.* Washington, 1964. 68 pages. (NSF 63-34.)

237. NOLTINGK, Bernard Edward. *The human element in research management.* New York, Van Nostrand, 1959. 91 pages.

238. ORTH, Charles D. *Administering research and development; the behavior of scientists and engineers in organizations.* Homewood, Illinois, Irwin, 1964. 585 pages.

239. PEARSON, Donald Stuart. *Creativeness for engineers; a philosophy and a practice.* 4th ed. State College, Pa., 1961. 159 pages.

240. RAUDSEPP, Eugene. *Managing creative scientists and engineers.* New York, Macmillan, 1963. 254 pages.

241. Rensselaer Polytechnic Institute of Connecticut. East Windsor Hill, Connecticut. Conference on management of research and development improving utilization of scientific and technical personnel. *Proceedings.* 24-25 January 1963, *ed.* by D. C. COYLE. East Windsor Hill, Connecticut, 1963. 124 pages.

242. Research Conference on the Identification of Creative Scientific Talent. *Scientific creativity; its recognition and development.* Selected papers from the proceedings of the first, second, and third University of Utah Conferences : " The Identification of Creative Scientific Talent ". Ed. by Calvin W. TAYLOR *and* Frank BARRON. New York, Wiley, 1963. 419 pages.

243. ROE, Anne. *The making of a scientist.* New York, Dodd, Mead, 1953. 244 pages.

244. Scientific Manpower Commission. *Salaries of scientists and engineers; a summary of salary surveys.* Washington, 1965. 30 pages. (Staff report, 65-1.)

245. SIMBERG, A. L. *Creativity at work; the practical application of a complete program.* Boston, Industrial Education Institute, 1964. 186 pages.

246. Stanford University. Graduate School of Business. *Motivation of scientists and engineers; a survey of management policies and practices in selected companies.* Stanford, Calif., 1959. 47 pages.

247. TOEDT, Theodore A., *and others. Managing manpower in the industrial environment.* Dubuque, Iowa, Brown, 1962. 872 pages.

248. United Kingdom Advisory Council on Scientific Policy. Committee on Scientific Manpower. *Scientific and technological manpower in Great Britain, 1962.* London, 1962. 1 vol.

249. United States Agency for International Development. *Human resources; training of scientific and technical personnel.* Washington (1963?). 204 pages. (Science, technology and development, vol. 11.)

250. United States Bureau of Labor Statistics. *Scientific research and development in American industry; a study of manpower and costs.* Washington, 1953. 106 pages. (Bulletin No. 1148.)

251. United States Office of the Assistant Secretary of Commerce for Science and Technology. *Studies in scientific and engineering manpower,* by M. S. GREEN. Washington, 1963. 50 pages. (Staff report, 63-1.)

252. VERDIER, Paul André. *Basic human factors for engineers; the task analysis approach to human engineering of men and machines.* New York, Exposition Press, 1960. 111 pages.

253. WIESNER, Jerome Bert. *Where science and politics meet.* New York, McGraw-Hill, 1965. 302 pages.

FINANCING

General works on budgeting and cost accounting

254. DEAN, Joel. *Capital budgeting: top management policy on plant, equipment and product development.* New York, Columbia University Press, 1951. 174 pages.

255. DUVERGER, Maurice. *Institutions financières.* Paris. Presses Universitaires de France, 1956. 444 pages.

256. ELKINS, Eugene R. *Programme budgeting; a method for improving fiscal management.* Morgantown, 1955. 38 pages. (West Virginia University. Bureau of Government Research. Publication, 14.)

257. GHEZ, R. *Introduction au contrôle budgétaire.* Paris, Dunod, 1961. 173 pages.

258. GILLESPIE, Cecil Merle. *Cost accounting and control.* Englewood Cliffs, N.J., Prentice-Hall, 1958. 824 pages.

259. HOSTELET, Georges. *Les caractères et les emplois compares des différentes espèces de budgets et de bilans.* Courtrai, Groeninghe (1954?). 399 pages.

260. JECHT-Horst. *Problème des öffentlichen Budgets.* Berlin, Duncker and Humblot, 1964. 101 pages. (Verein für Socialpolitik. Schriften. Neue Folge, 31.)

261. MOSHER, Frederick C. *Program budgeting; theory and practice, with particular reference to the U.S. Department of the Army.* (Chicago?) Public Administration Service, 1954. 258 pages.

262. NEUNER, J. J. W. *Cost accounting principles and practice.* 5th ed. Homewood, Illinois, Irwin, 1957. 944 pages.

263. PESET, Jean. *Técnica del presupuesto.* San José, 1959. 145 pages. (San José. Escuela Superior de Administración Pública América Central. Ciencia de la administración 24.)

264. Public Administration Service, Chicago. *Modernizing government budget administration; the application of technical co-operation in improving budget administration in the governments of developing countries.* Chicago, 1962. 104 pages.

265. SHAKDHER, S. L. *Budgetary system in various countries.* New Delhi, Lok Sabha Secretariat, 1957. 123 pages.

266. SHERWOOD, Frank P. *The management approach to budgeting.* Brussels, 1954. 65 pages. (International Institute of Administrative Sciences. Publication, 22.)

267. SICA, Salvatore. *Il bilancio e il suo controllo nel mondo.* Roma, Istituto Poligrafico dello Stato, 1953. 677 pages.

268. SPREUTELS, Maurice. *Government budgeting; les classifications budgétaires des Etats Unis, les méthodes de l'Organisation des Nations Unies [et] la comparaison avec la Belgique et l'Europe occidentale.* Bruxelles, Centre pour Administration et Documentation, 1963. 173 pages.

269. WALKER, Harvey. *Curso de elaboración y ejecución presupuestaria.* San José, 1956. 80 pages. (San José. Escuela Superior de Administración Pública América Central. Ciencia de la administración, 23.)

270. WELSH, G. A. *Budgeting; profit-planning and control.* Englewood Cliffs, N.J., Prentice-Hall, 1957. 487 pages.

271. American Management Association. *Cost reduction and control for the supervisor.* (New York?). 1963. 4 parts.

272. ————————. *Tested approaches to cutting production costs, overhead, materials, payroll.* New York, 1955. 125 pages. (Special report, 4.)

273. ARIES, Robert S. *and* NEWTON, R. D. *Chemical engineering cost estimation.* New York, McGraw-Hill, 1955. 263 pages.

274. Batelle Research Institute, Columbus, Ohio. *Research by co-operative organizations; a survey of scientific research by trade associations, professional and technical societies and other co-operative groups, 1953.* Washington, 1956. 47 pages. (NSF 56-12.)

275. BETTINGER, Clarence Edward. *Engineering economy.* 3rd ed. New York, McGraw-Hill, 1958. 379 pages.

276. Canada. Dominion Bureau of Statistics. General Assignments Division. *Industrial research-development expenditures in Canada, 1957.* Ottawa, 1958. 31 pages. (Reference paper.) (Catalog no. 13-509, occasional.) Mimeographed.

277. CARROLL, Phil. *Overhead cost control.* New York, McGraw-Hill, 1964. 314 pages.

278. ————————. *Timestudy for cost control.* 3rd ed. New York, McGraw-Hill, 1954. 301 pages.

279. Conference on Industrial Research. 1st, Columbia University, 1950. *(Proceedings.) Costs, budgeting and economics of industrial research.* June, 1950. Ed. by David Bendel HERTZ *and* Albert H. RUBENSTEIN. New York, King's Crown Press, 1951. 261 pages.

280. ————————. 4th and 5th, Columbia University, 1954. *(Proceedings.) Coordination, control and financing of industrial research;* proceedings of the fifth annual conference on industrial research, June, 1954, with selected papers from the fourth conference, June, 1953. Ed. by Albert H. RUBENSTEIN. New York, King's Crown Press, 1955. 429 pages.

281. Conference of Industrial Research Directors and Managers. 2nd, Warwickshire, England 1950. *Report... The planning and financial control of industrial research.* London, Federation of British Industries, 1950. 88 pages.

282. DEARBORN, DeWitt Clinton, KNEZNEK, Rose W. *and* ANTHONY, Robert N. *Spending for industrial research, 1951-1952.* Boston, Harvard University, Graduate School of Business Administration, 1953. 103 pages.

283. GIUSTI, Gino Paul. *An economic study of research and development expenditures in the United States since World War II.* Ann Arbor, Mich., University Microfilms, 1959. (Microfilms AC-1 No. 59-4450.)

284. HOORN, J. van. *Tax treatment of research and development; a comparative survey of national fiscal measures and of their impact on research* [*Paris*] *Organization for Economic Cooperation and Development*, 1962. 302 pages. Published also in French.

285. HOUGHTON, Philip Stephen. *Workshop costs and costing.* London, Chapman and Hall, 1953. 295 pages.

286. HOUGHTON, Philip Stephen. *Estimating and planning for engineering production.* Glasgow, Blackie, 1950. 366 pages.

287. JOHNSON, Ellis A. *and* MILTON, Helen S. *A proposed cost-of-research index.* Bethesda, Md., Johns Hopkins University, Operations Research Office, 1960. 16 pages. (Staff paper ORO-SP-142 (rev.).)

288. MCFADDEN, James A. *and* TUSKA, C. D. *Accounting and tax aspects of patents and research.* Princeton, N.J., Van Nostrand, 1960. 311 pages.

289. McNeill, Winfield I. *Evaluating the cost and utility of industrial research and development;* address presented at the Industrial Research Conference at Columbia University, New York City, June 7-11, 1954, Cambridge, Mass., 1954. 15 l.

290. Mills, Lawrence D. *Techniques of value analysis and engineering.* New York, McGraw-Hill, 1961. 267 pages.

291. Minasian, Jora R. *The economics of research and development.* Chicago, Dept. of Photoduplication, University of Chicago Library, 1960. (Microfilm 6622T.)

292. National Industrial Conference Board. *Cost of research and development, 1953, 1956.* New York, 1958. 1 sheet. (RD maps of industry, no. 1174.)

293. ————. *Private industry, R and D [research and development, 1958] financed by industry, government.* New York, 1960. 1 sheet. (RD maps of industry, no. 1281.)

294. National Science Foundation. *Federal funds for research development and other scientific activities; fiscal year 1962, 1963 and 1964.* Washington, Government Printing Office, 1964. 180 pages. (Surveys of science resources series, NSF 64-11.)

295. ————. *Federal research and development budget, 1953.* Washington, 1954.

296. ————. *Funds for research and development in industry; performance and financing, 1961.* Washington, Government Printing Office, 1964. 123 pages. (Survey of science resources series, NSF 64-9.)

297. ————. *Methodological aspects of statistics on research and development costs and manpower.* Washington, 1959. 132 pages. (NSF 59-36.)

298. ———— *Scientific research and development of non-profit organizations; expenditures and manpower, 1957.* Washington, Government Printing Office, 1961. 58 pages. (Surveys of science resources series, NSF 61-37.)

299. Tucker, Spencer Allen. *Cost-estimating and pricing with machine-hour rates.* Englewood Cliffs, N.J., Prentice-Hall, 1962. 253 pages.

300. United Kingdom Department of Scientific and Industrial Research. *Industrial research and development expenditure, 1958.* London, H.M. Stationery Office, 1960. 13 pages.

301. United States Bureau of Labor Statistics. *Science and engineering in American industry; final report on a 1953-54 survey.* Pt. 1, *Research and development costs and personnel.* Pt. 2, *Factors affecting company expenditures for research and development.* Washington, 1956. 119 pages. (NSF 56-16.)

302. United States Congress. House. Select Committee on Government Research. *Federal facilities for research and development.* Washington, 1964. 246 pages. (Study, 3.)

Office management

303. American Standards Association. *Office equipment and supplies.* New York, 1951. (American Standards, X.)

304. American Management Association. *Men, machines and methods in office.* New York, 1958. 148 pages. (Management report, 6.)

305. Aspley, J. C., *ed. Office manager's handbook,* 3rd revised edition. Chicago, Dartnell Corporation, 1965.

306. Birn, Serge Alexander, *and others. Measurement and control of office costs; master clerical data.* New York, McGraw-Hill, 1961. 318 pages.

307. Holmstrom, John Edwin. *Records and research in engineering and industrial science.* 3rd edition, rewritten and enlarged. London, Chapman and Hall, 1956. 491 pages.

308. Lazzaro, Victor *and others. Systems and procedures; a handbook for business and industry.* Englewood Cliffs, N.J., Prentice-Hall, 1965. 464 pages.

309. LEFFINGWELL, W. H. *Textbook of office management*. Revised edition. New York, McGraw-Hill, 1959. 625 pages.

310. MILLS, Geoffrey *and* STANDINGFORD, Oliver. *Office organization and methods*. 3rd edition. London, Pitman, 1963. 360 pages.

311. MITCHELL, William E. *Records retention; a practical guide*. Syracuse, N.Y., Ellsworth, 1959. 48 pages.

312. NILES, Henry Edward *and* NILES, M. C. H. *The office supervisor; his relations to persons and to work*. 3rd edition. New York, Wiley, 1959. 307 pages.

313. NIMWEGEN, J. van. *Grondslage van de Administratieve Organisatie*. Revised edition. Alphen a/Rijn, Samson, 1959. 273 pages.

314. RIPPEN, Kenneth H. *Office building and office layout planning*. New York, McGraw-Hill, 1960. 182 pages.

315. ROBICHAUD, Beryl. *Selecting, planning and managing office space*. New York, McGraw-Hill, 1958. 361 pages.

316. STANDINGFORD, Oliver. *Simplifying office work; an introduction to O and M techniques for management*. London, Pitman, 1964. 144 pages.

317. THURLING, F. C., *Office practice today*. 2nd edition. London, Pitman, 1963. 300 pages.

318. WYLIE, Harry L., *ed. Office management handbook*. 2nd edition. New York, Ronald Press, 1958. 1 vol. (various pagings.)

INSTITUTIONS

319. American Society for Testing Materials. *Directory of testing laboratories; commercial-institutional*. Philadelphia, 1963. 58 pages. (Special technical publication, 333.)

320. Australia. Commonwealth Scientific and Industrial Research Organization. *Outline of activities*. Melbourne, 1959. 11 pages.

321. Batelle Memorial Institute, Columbus, Ohio. *Directory of selected scientific institutions in the USSR; with an introduction to the administration of science and technology in the USSR*. Columbus, Ohio, 1963. 1 vol.

322. BIRR, Kendall. *Pioneering in industrial research; the story of the General Electric Research Laboratory*. Washington, Public Affairs Press, 1957. 204 pages.

323. Connecticut Development Commission. *Directory of Industrial Research Laboratories in Connecticut*. Hartford, 1959. 58 pages.

324. France. Ministère de l'Industrie et du Commerce. *La recherche industrielle en France; documentation sur les organismes de recherches publics et professionnels*. Paris (1959?). 229 pages. (Industrial research in France; documents on the public and professional research organizations.)

325. France. Office National des Universités et Ecoles Françaises. *Laboratoires scientifiques; répertoire*. (2e éd.) Paris, S.E.V.P.E.N., 1961. 578 pages. (Enseignement supérieur.)

326. Gale Research Co. *Research centers directory*. 2nd edition. Detroit, 1965. 666 pages.

327. GRIGG, F. J. T. *Dominion laboratory, Wellington, New Zealand*, Dominion Laboratory, 1958. 31 pages. (New Zealand. Department of Scientific and Industrial Research. Information series, No. 17.)

328. Helsingfore. Statens Tekniska Forskningsanstalt. *The State Institute for Technical Research, 1.10.1956*. Helsinki, 1956. (Unpaged.)

329. Hyderabad. Central Laboratories for Scientific and Industrial Research. A souvenir brochure, published on the occasion of the laying of the foundation stone on Sunday, the 6th November 1949 at 4.30 p.m., by J. N. Chaudhuri. Hyderabad, 1949. (Unpaged.)

330. India. Board of Scientific and Industrial Research. *Board of Scientific and Industrial Research, a review*. New Delhi, Council of Scientific and Industrial Research, 1954. 235 pages.

331. India. Council of Scientific and Industrial Research. *A review*. New Delhi, 1954. 142 pages.

332. India. Ministry of Information and Broadcasting. *India's national laboratories*. Delhi, Government of India, Ministry of Information and Broadcasting, Publications Division, 1954. 79 pages.

333. Institut pour l'encouragement de la recherche scientifique dans l'industrie et l'agriculture. *Cinq années d'activité : un bilan 1945-1950*. Bruxelles (1950?). 23 pages. (An evaluation of five years (1945-1950) of activities of the institute for the promotion of research in industry and agriculture.)

334. Italy. Consiglio Nazionale delle Ricerche. *Istituti e laboratori italiani di recerca scientifica*. Roma, 1953. 221 pages.

335. Japan. Agency of Industrial Science and Technology. *The Agency of Industrial Science and Technology*. Tokyo, 1952. 14 pages.

336. Kosiol, Erich. *Institut für Industrieforschung 1948-1958; zehn Jahre Forschung und Lehre*. Berlin, Duncker und Humblot, 1959. 141 pages. (Berlin. Freie Universität. Institut für Industrieforschung. Veröffentlichungen, Nr. 7.) (Institute for industrial research 1948-1958; ten years of research and education.)

337. Melville, Sir Harry Work. *The Department of Scientific and Industrial Research*. London, Allen and Unwin, 1962. 200 pages. (The New Whitehall series, No. 9.)

338. National Research Council. *Industrial research laboratories of the United States*. 11. edition. Washington, 1960. 698 pages. (Publication 844, NAS-NRC.)

339. National Science Foundation. *Bibliography on the economic and social implications of scientific research and development, 1916-1959*. Washington, 1959. 53 pages. (NSF 59-41.)

340. ———. *Directory of independent commercial laboratories performing research and development, 1957*. Washington, 1958. 59 pages. (NSF 57-40.)

341. New Jersey. Bureau of Commerce. Division of Planning and Development. Research and Statistics Section. *Industrial research laboratories in New Jersey*. Trenton, 1961. 148 pages. (New Jersey. Department of Conservation and Economic Development. Research reports, No. 124.)

342. New York State Department of Commerce. *Directory of industrial research laboratories in New York State*. Albany, 1964. 355 pages.

343. New Zealand. Department of Scientific and Industrial Research. *D.S.I.R. handbook*. 4 edition. Wellington, 1960. 91 pages.

344. Organisation for Economic Cooperation and Development. *Guide to European sources of technical information*. Directory. Paris, 1964. 292 pages.

345. ———. *Industrial research associations in France, Belgium and Germany*. Paris, 1965. 1 vol. (Various pagings.)

346. Paris. Université. Institut d'étude du développement économique et social. *Recherches et applications techniques en matière de développement économique et social et répertoire d'organismes français*. Paris, Presses Universitaires de France, 1963. 199 pages. (Etudes tiers monde; problèmes des pays sous-développés.)

347. Pennsylvania. Bureau of Industrial Development. *Industrial research and testing laboratories in Pennsylvania; a directory of commercial laboratories, manufacturing firms, trade associations and educational institutions providing research, testing and development services to industry*. Harrisburg, 1958. 225 pages. (Pennsylvania plant location factors, report No. 1.)

348. Pittsburgh University. Mellon Institute of Industrial Research and School of Specific Industries. American Institute of Management. Mellon Institute of Industrial Research. (New York?) 1955. 8 pages. (Management audit. Special audit No. 127, April 1955, vol. 4, No. 17.)

349. Produksjonsteknisk forskningsinestitutt, Oslo. *Production research in Norway; the Research Institute of Production Engineering and its activities.* Oslo, 1951. 26 pages.

350. Stanford Research Institute. Descriptive booklet. Menlo Park, California, 1948. 19 pages.

351. Stichting Technisch Documenten Centrum. *List of scientific and industrial research establishments in the Netherlands.* (Amsterdam, 1951?) 27 l.

352. Stockholm. Tekniska Högskolan. *KTH; its organization, staff, laboratories and current research work.* Stockholm, 1948. 77 pages, mimeographed.

353. Scandinavian Council for Applied Research. *Scandinavian research guide; directory of research institutions within technology and science exclusive of life sciences.* Blinders, (1961?). 2 vols.

354. *The T.N.O. guide.* The Hague, Central Organization for Applied Scientific Research in the Netherlands, 1962. 110 pages. Text in English and Dutch.

355. United Kingdom Department of Scientific and Industrial Research. *Combining for research; the work of the grant-aided industrial research organizations.* London, 1961. 31 pages.

356. United Kingdom Department of Scientific and Industrial Research. *The work of the department of scientific and industrial research.* London, 1960. 31 pages.

357. United States Federal Council for Science and Technology. *Technical information and the federal laboratories.* Proceedings of a Symposium. Washington, 1964. 88 pages.

358. VELANDER, Edy. *Organization of scientific technical research in Sweden.* Stockholm (1947?). 16 pages. (Reprint from Affarsekonomi No. 10A - 1947, 8th management congress issue.)

359. Virginia. Division of Industrial Development and Planning. *Industrial research laboratories in Virginia, 1955.* Richmond, 1955. 20 l.

360. WHITE, Frederick Andrew. *American industrial research laboratories.* Washington, Public Affairs Press, 1961. 227 pages.

361. Wisconsin. Department of Resource Development. *Industrial Research in Wisconsin.* Madison, 1963. 82 pages.

BUILDINGS

362. *Architectural Record. Building for research.* New York, Dodge, 1958. 224 pages.

363. BRASS, Allen. *An annotated bibliography on laboratory buildings.* Ottawa, National Research Council, Division of Building Research, 1959. 17 pages. (Bibliography, 16.)

364. COLEMAN, Harry Schipp, *ed. National Research Council report on design, construction and equipment of laboratories.* New York, Reinhold, 1951. 393 pages.

365. Nuffield Foundation. *The design of research laboratories.* London, Oxford University Press, 1961. 211 pages.

PUBLIC RELATIONS

366. ADAMS, Alexander B. *Handbook of practical public relations.* New York, Crowell, 1965. 327 pages.

367. ASPLEY, J. C. *and* VAN HOUTEN, L. L., *eds. The Dartnell public relations handbook.* 3rd. edition. Chicago, Dartnell Corporation, 1961. 992 pages.

368. BERNAYS, Edward L. *and others. The engineering of consent.* Norman, Oklahoma University Press, 1955. 246 pages.

369. CANFIELD, Bertrand R. *Public relations; principles, cases, and problems.* 4th edition. Homewood, Illinois, Irwin, 1964. 622 pages.

370. CUTLIP, Scott Munson. *Effective public relations.* 3rd edition. Englewood Cliffs, N.J., Prentice-Hall, 1964. 512 pages.

371. ELDRIDGE, Seba. *The dynamics of social action.* Washington, Public Affairs Press, 1952. 119 pages.

372. FINN, David. *Public relations and management.* New York, Reinhold, 1960. 175 pages.

373. GARCÍA VALENCIA, Antonio. *Las relaciones humanas en la administración pública mexicana.* México, Ed. Porrúa, 1958. 210 pages.

374. HAAS, C. R. *La publicité; théorie, technique et pratique.* 2e éd. refondue. Paris, Dunod, 1958. 490 pages.

375. JACOBS, Herbert Austin. *Practical publicity; a handbook for public and private workers.* New York, McGraw-Hill, 1964. 210 pages.

376. KISCH, Richard. *The private life of public relations.* London, MacGibbon, 1964. 183 pages.

377. KOBRE, Sidney. *Dynamic force of public relations today.* New York, Brown, 1964. 296 pages.

378. LEBLANC, R. Ch. *Comment humaniser les relations de l'administration avec le public.* Bruxelles, 1952. 107 pages. (International Institute of Administrative Sciences. Publication, 9.)

379. LERBINGER, Otto *and* SULLIVAN, A. J. *Information, influence and communication; a reader in public relations.* New York, Basic Books, 1965. 513 pages.

380. LEVY, Harold P. *Public relations for social agencies; a guide for health welfare, and other community organizations.* New York, Harper, 1956. 208 pages.

381. MELCHERS, Daniel *and* LARRICK, N. *Printing and promotion handbook; how to plan, produce, and use printing, advertising, and direct mail.* 2nd edition, New York, McGraw-Hill, 1956. 438 pages.

382. MENÉNDEZ, Antonio. *Movilización social.* México, Ed. Bolsa Mexicana del Libro, 1963. 367 pages.

383. PACKARD, Vance. *The hidden persuaders.* New York, McKay, 1957. 275 pages.

384. PAUL, Benjamin D. *and* MILLER, W. B. *Health, culture and community; case studies of public reactions to health programs.* New York, Russell Sage Foundation, 1955. 493 pages.

385. PIMLOTT, J. A. R. *Public relations and American democracy.* Princeton, N.J., Princeton University Press, 1951. 265 pages. (Studies in public opinion, 2.)

386. Politz (Alfred) Research, Inc., New York. *A study of four media: their accumulative and repeat audiences.* Conducted for *Life.* New York, Time, 1953. 176 pages.

387. Public Relations Society of America. *Public relations register,* vol. 16 : 1964-1965. New York, 1965.

388. PYE, Lucian W., *ed. Communications and political development.* Princeton, N.J., Princeton University Press, 1963. 381 pages. (Studies in political development, 1.)

389. RUHL, Eleanor S. *Public relations for government employees; an action program.* Chicago, 1953. 32 pages. (Civil Service Assembly of the U.S. and Canada. Personnel reports series, 524.)

390. SCHWARTZ, Alvin. *Evaluating your public relations.* New York, National Public Relations Council, 1965. 52 pages.

391. STEPHENSON, Howard. *Handbook of public relations.* New York, McGraw-Hill, 1960. 855 pages.

392. TOWNSEND, Derek. *Advertising and public relations; a four language dictionary and glossary of terms.* New York, International Publications, 1964. 152 pages.

393. VERDIER, H. *Les relations publiques; information et action.* Paris, Ed. de l'Entreprise Moderne, 1959. 254 pages.

394. WILLIAMS-THOMPSON, Richard. *Tell the people.* London, World's Press News Publishing, 1956. 112 pages

395. WRIGHT, Theon *and* EVANS, H. S. *Public relations and the line manager.* New York, American Management Association, 1964. 240 pages.

REPORT WRITING

396. CROUCH, William George *and* ZETLER, R. R. *A guide to technical writing.* 3rd edition. New York, Ronald Press, 1964. 447 pages.

397. DEDERICH, Robert M. *Communication of technical information.* New York, Chemonomics, 1952. 116 pages.

398. EHRLICH, Eugene H. *and* MURPHY, D. J. *The art of technical writing; a manual for scientists, engineers and students.* New York, Crowell, 1964. 182 pages.

399. GEORGIN, Charles. *Cours de rédaction des rapports.* Paris, Eyrolles, 1960. 287 pages.

400. GLOAG, John. *How to write technical books, with some pertinent remarks about planning technical papers and forms.* London, Allen and Unwin, 1950. 159 pages.

401. HOLSCHER, Harry Heltman. *How to organize and write a technical report.* 2nd edition. Ames, Iowa, Littlefield, 1965. 176 pages.

402. LINTON, Calvin D. *How to write reports.* New York, Harper, 1954. 240 pages.

403. TURNER, Rufus Paul. *Technical report writing.* New York, Holt, 1965. 210 pages.

404. TURNER, Rufus Paul. *Technical writer's and editor's stylebook.* New York, Sams, 1964. 208 pages.

405. ZALL, Paul M. *Elements of technical writing.* New York, Harper, 1962. 208 pages.

PATENTS

406. ARLT, Erich *und* ERASMUS, H. *Erfinder — und Warenzeichenschutz In- und Ausland.* Berlin, VEB — Deutscher Zentralverlag 1954. 3 vols in 7.

407. BOUJIR, André. *Direction des entreprises et brevets d'invention; stratégie de l'entreprise et recherche technique.* Paris, Editions de l'Entreprise Moderne (1961?). 187 pages.

408. DESBOIS, Henri. *Cours de propriété littéraire, artistique et industrielle.* Paris, Les Cours de Droit, 1961. 534 pages.

409. MCFADDEN, James A. *and* TUSKA, C. D. *Accounting and tax aspects of patents and research.* Princeton, N.J., Van Nostrand, 1960. 311 pages.

410. MELMAN, Seymour. *The impact of the patent system on research.* Washington, Government Printing Office, 1958. 62 pages. (U.S. Congress. Senate. Committee on the Judiciary. Subcommittee on Patents, Trademarks and Copyright. Study, 11.)

411. National Association of Manufacturers of the United States of America. Patents and Research Committee. *Trends in industrial research and patent practices; a survey of the general patterns in research activities, and patent policies within different types of industry.* New York, (1948?). 79 pages.

412. OUDEMANS, G. *Draft of the European Patent Convention;* commentary with English and French texts. London, Stevens, 1963. 247 pages.

413. PALMER, Archie MacInnes. *Non-profit research and patent management in the United States.* Washington, National Academy of Sciences, National Research Council, 1956. 54 pages. (Publication, 371.)

414. RUDY, Stephen J. *Patent asset evaluation; a proposed method of evaluation of patent assets in industrial management operations.* Yonkers, New York, the author, 1955. 44 pages.

415. SCHERER, Frederic M. *and others. Patents and the corporation; a report on industrial technology under changing public policy, 2nd edition,* Boston, 1959. 195 pages.

416. TUSKA, C. D. *An introduction to patents for inventors and engineers.* New York, Dover Publications, 1964. 192 pages.

417. WADE, Worth. *Patent guide for the research director.* Ardmore, Pa., Advance House, 1964. 72 pages.

PERIODIC PUBLICATIONS

418. American Management Association. *Management report.* 1957. irreg. New York.

419. BALL, Ian D. L., *ed. Industrial research in Britain.* 1964 (annual). Harrap, London.

420. *Industrial laboratories; the new magazine of research, product and process development, engineering.* 1950 (monthly). Industrial Laboratories, Chicago.

421. *Industrial laboratory* (English translation of "Zavodskaia Laboratoriia") 1958 (monthly). Instrument Society of America, Pittsburgh, Pa.

422. *Industrial research.* 1946 (annual). Todd, London.

423. *Industrial research; the management magazine of technical progress.* 1959 (quarterly). Scientific Research Publishing Co., Chicago.

424. International Institution for Production Engineering Research. *Annales.* 1952 (annual). Scriptor, Lausanne.

425. *Journal of scientific and industrial research.* Section D. Technology. 1942 (monthly). Publications Directorate, Council of Scientific and Industrial Research. Rafi Marg, New Delhi.

426. *Pakistan journal of scientific and industrial research.* 1958 (quarterly). Pakistan Council of Scientific and Industrial Research, Karachi.

427. *Research applied in industry.* 1947 (monthly). Butterworths Scientific Publications, London.

428. *Research management.* 1958 (bi-monthly). Interscience, New York.

429. South African Council for Scientific and Industrial Research. *Research review.* Navorsingsoorsig. 1951 (quarterly). Pretoria. Text in English and Afrikaans.

BIBLIOGRAPHIES

430. ARLEN, Edith. *Industrial research and the professional employee; a bibliographic review.* Chicago, Chicago University, Industrial Relations Center, 1955. 139 pages. (Significant sources in management, organization, industrial relations, No. 3.)

431. BAGLEY, William Alfred. *Facts and how to find them; a guide to sources of information and to the methods of systematic research.* 6th edition, London, Pitman, 1962. 148 pages.

432. BATCHELOR, James H. *Operations research: an annotated bibliography.* 2nd edition. Saint Louis, Saint Louis University Press, 1963. 3 vols.

433. BRASS, Allen. *An annotated bibliography on laboratory buildings.* Ottawa, National Research Council, Division of Building Research, 1959. 17 l. (Bibliography, No. 16.)

434. BUSH, George Pollock. *Bibliography on research administration; annotated.* Washington, University Press of Washington, 1954. 146 pages.

435. Case Institute of Technology, Cleveland. Operations Research Group. *A comprehensive bibliography on operations research, 1957-1958.* New York, Wiley, 1963. 403 pages. (Operations Research Society of America. Publications in operation research, No. 8.)

436. Industrial Research Institute, New York. *Bibliography on research in industry; organization and management.* New York, 1945. 31 pages.

437. International Committee of Scientific Management. *List of publications concerning management terminology.* Wiesbaden, 1963. 96 pages.

438. Little, Arthur D., Inc. *Management of industrial research : a selected and annotated bibliography.* Cambridge, Mass., 1950. 14 pages.

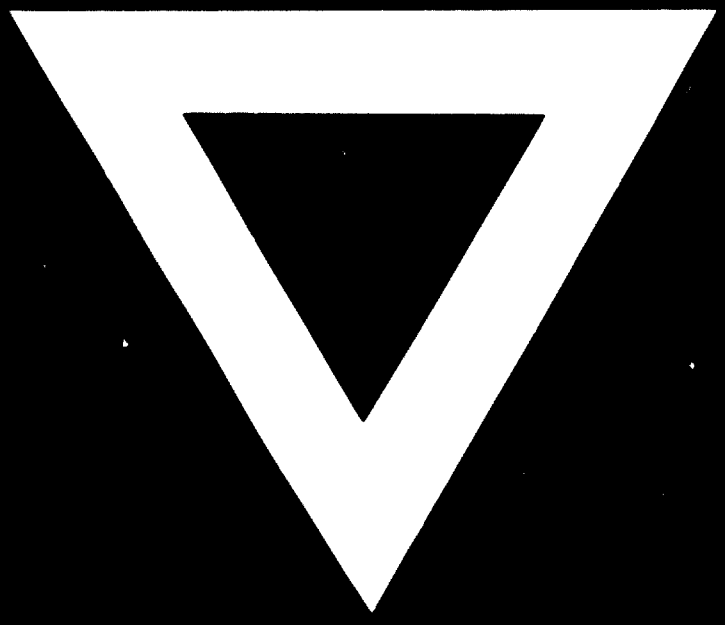
439. National Industrial Conference Board. Division of Business Practices. *Bibliography on research in industry : organization and management.* New York, Industrial Research Institute, 1945. 31 pages, mimeographed.

440. National Science Foundation. *Bibliography on the economics and social implications of scientific research and development, 1916-1959.* Washington, 1959. 53 pages. (NSF 59-41.)

441. ————. *A selected bibliography of research and development and its impact on the economy.* Washington, Government Printing Office, 1958. 21 pages. (NSF 58-18.)

442. United States Department of the Army. *Select bibliography on administrative organization.* Washington, 1960. 38 pages. (Pamphlet, 10-5.)

443. WASSERMAN, Paul. *Information for administrators; a guide to publications and services for management in business and government.* Ithaca, N.Y., Cornell University Press, 1956. 375 pages.



4.9.74