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FEASIBILITY STUDY CONSIDERATIONS FOR THE ESTABLISHMENT OF INDUSTRIAL RESEARCH INSTITUTES IN DEVELOPING COUNTRIES

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Technological Division
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2511

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Introduction

1. The governments of developing countries are today engaged in the difficult task of industrialising their countries as a vital means of improving the social and economic well-being of their peoples. Industrialisation as a continuing process is dependent on a great variety of factors, one of which is the establishment and proper prosecution of a suitable programme of industrial research.

2. The United Nations Interregional Seminar on Industrial Research and Development Institutes in Developing Countries, which was held in Beirut, Lebanon, in November/December 1964, and was attended by numerous expert participants and observers from both the developed and the developing countries, attested to the crucial role of industrial research institutes in the industrialisation process when it recommended as follows, inter alia:

> Developing countries should take the necessary steps as soon as possible to establish appropriate industrial research and development facilities...on lines most applicable to the practical requirements and national development goals.

3. It is generally agreed that institutional industrial research, as opposed to the lone-researcher approach, offers special advantages that are appropos to the peculiar needs of developing countries. Not surprisingly then the number of such institutes in developing countries has increased steadily if slowly in the past five years.

4. Considering that most if not all developing countries would like to establish at least one industrial research institute each, one can readily appreciate that the hesitancy with which many of them view the problem is due directly to the practical difficulties inherent in it. Not the least of these difficulties is the question of determining the feasibility of such an institute and its chances of a viable and useful life if established.

5. The establishment of an industrial research institute, like that of an industrial manufacturing project, calls for careful pre-investment or feasibility study. Answers must be sought to an assortment of complex questions including an appraisal of the countries resources—human, financial, raw material and otherwise — as well as the state of technology and other social and economic variables.

6. The purpose of this paper is to provide assistance and practical guidelines in the identification and evaluation of these feasibility determants or "considerations." In the chapters that follow individual attention is given to the various considerations which properly should precede the decision on the part of the government of a developing country as to whether or not the time is right, given the set of socio-economic circumstances prevailing in the country, to set up and operate an industrial research institute.

7. This paper deals primarily with the multi-purpose type of institute, that is, one which is capable of dealing with problems in a diversity of industrial branches or scientific disciplines. While it is recognised that a number of specialised institutes exist and have proven highly valuable in some developing countries, it is felt (and the Beirut Seminar supported this view) that the multi-purpose institute offers obvious advantages that are especially appropos to the needs of developing

Countries.

The Concept of an Industrial Research Institute

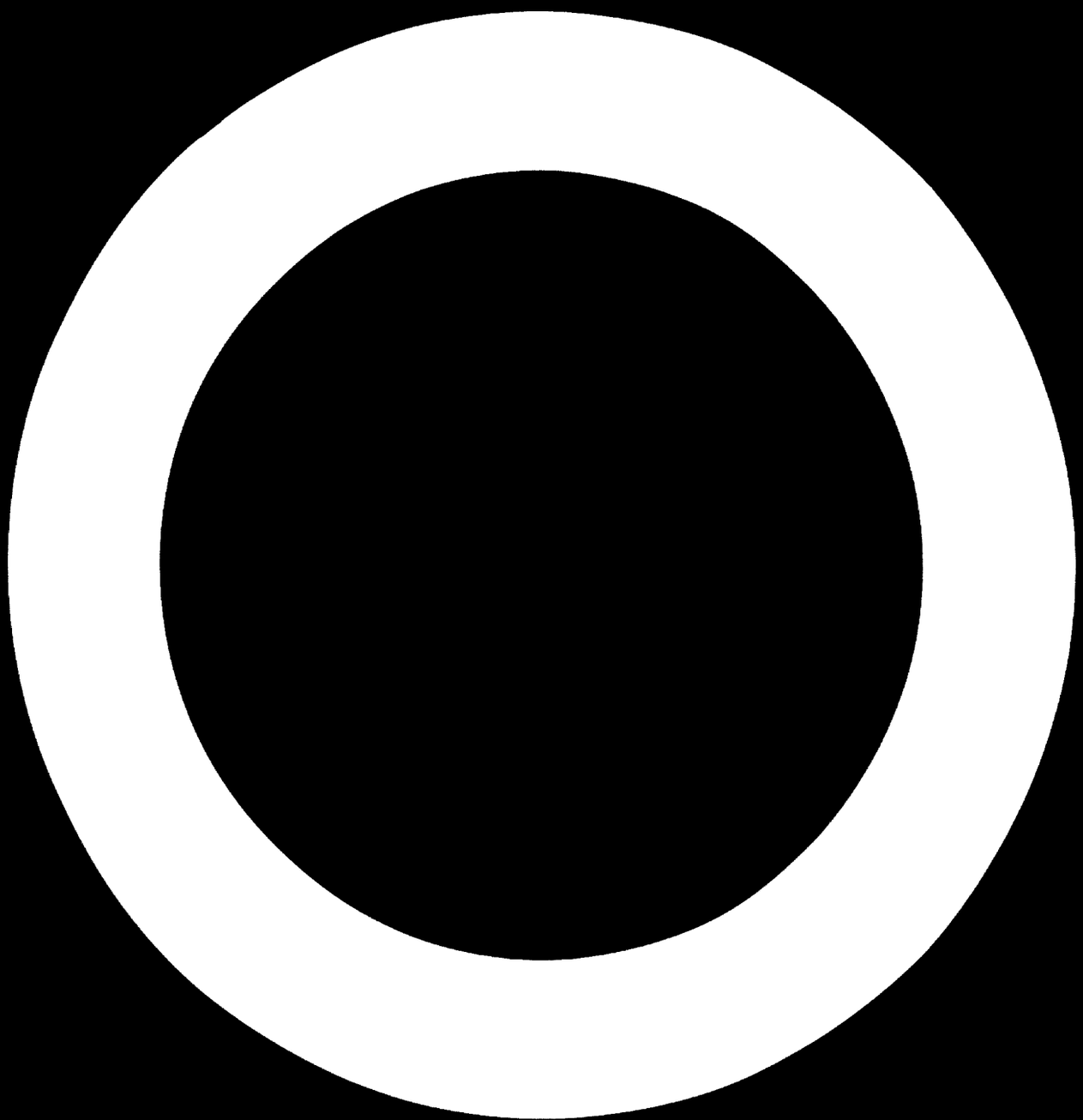
8. The Industrial Research Institute is a relatively recent innovation stemming from the needs of modern technology. The concept has evolved out of the need to provide central, co-ordinated bodies of scientific knowledge, facilities, and personnel capable of meeting the broad research requirements for attaining technologically-based economies.

9. In the developed countries, the traditional research institute is the outgrowth of research needs recognized by the country's industries. In this case, the institute is set up to serve already existing technology and is usually financially supported by projects sponsored by companies or the government. The sponsors normally come to the institute with specific problems to be solved. The Institute in turn makes use of its store of information, personnel and facilities in seeking the desired solutions.

10. In a developing country, however, where the technological base of the economy is generally inadequate, the task falls on the institute not only to seek solutions to problems brought to it from without but also, and perhaps more importantly, to take initiatives in the choice of areas of research operations thereby steering the economy in the direction favoured in the national development programme. Thus, to some extent, the Institute in a developing nation fulfills a normative as well as scientific role.

11. There is a certain level in the techno-economic evolution of a developing country when the establishment of industrial research institute becomes desirable. And this level can be determined by evaluating many interrelated economic, geographic, industrial and population factors.

For instance, there should be at least a beginning of local industries, mining and/or agriculture, as well as enough native or imported talent capable of at least starting research; also the economics of erecting the institute and conducting research should bear a reasonable relationship to the country's financial capabilities. On the other hand, the premature establishment of an institute could lead to misdirection of technical effort and finances and wasted years. Such a precipitate action may be due to lack of experience and of suitable data concerning the nation's economic factors as well as a poor assessment of resources and their possible uses. Background information and careful judgment are prime pre-requisites for the success of a national research institute. In other words, the inopportune establishment of a research institute can prove as detrimental as the absence of an institute when the time is right.



Organised research and development plays a crucial role both in creating new knowledge leading to a broadening of technological horizons, and in the adaptation of scientific innovations to practical use.

16. So far as technological change is concerned, the industrial research institute in a developing country should properly emphasise the intensive application of its scientific knowledge and technical expertise to the problems of raising the productivity of inputs as well as overall efficiency of production.

17. The formulation and application of industrial standards and specifications, an essential requirement in the industrialization scheme of any country, is another function which the research institute in a developing country can provide. The institute will require special laboratory facilities necessary to conduct studies and continuing testing of materials and products to ensure their conformity with established standards.

18. In a somewhat related area, the institute can also assist in instituting quality control within the various factories through the systematic use of analytical methods and inspection procedures designed to ensure adherence to proper standards. It may also provide an equipment valuation service for the benefit of industry as well as undertake technical trouble-shooting on a adhoc or standby basis.

19. The carrying out of research on a variety of subjects is of course one of the primary functions of the research institute. This line of activity will of course account for the highest proportion of its financial outlay and occupy most of the time of its technical personnel.

20. The Research Institute is the place to which individuals, smaller companies not supporting their own laboratories, and some government agencies can go to have research work performed. Indeed, even some companies that do have their own research laboratories often wish to utilise the facilities of a research institute to gain perspective on their work or to perform smaller short-term projects for which they do not wish to add full-time staff members.

21. A Research Institute provides many benefits to the potential sponsor of research, not the least of which is an unbiased and completely objective view. This objective view can be maintained because the institute's goals are not linked in any other way to those of the sponsoring organization other than to do the best possible job of research. In other words, the institute functions as the research and development arm of the sponsoring organization with all the advantages of an in-house group, including the fact that the proprietary interests of the sponsoring organization are served.

22. The institute's research programme may include such activities as the introduction and adaptation of foreign technology, the development of commercial applications for local raw materials and the perfecting of production processes. Attention may also be given to developing uses for waste material as well as improving the quality and usefulness of by-products.

23. Another phase of the work of an industrial research institute is that generally referred to as "development". This phase embraces the long and expensive stages of work between the conception of an idea and the actual translation of that idea into a tangible proto-type product or process. In the developed countries, it is not unusual to find that the development phase of an institute's work accounts for two-thirds or more of the cost of combined research and development.

24. In addition to performing the technical services just described, the institute normally carries another set of functions which may be described as techno-economic. The distinction between this group of activities and the other, purely technically group of activities is mainly one of convenience as these services are essentially similar in character. Among these are feasibility studies for the establishment and operation of industrial enterprises. Such studies may embrace operations research which is a comparisonof alternative production processes input combinations, as well as problems relating to raw materials utilization, environmental conditions, estimation of market demand, cost accounting and so on.

25. The institute may also undertake marketing studies for the purpose of developing and improving the marketing practices of a particular enterprise or groups of enterprises. It may assist the managements of enterprises by providing them with forecasting data that will enable them to plan production and can also offer expert advice on such matters as packaging, labeling, storage, transportation, industrial location, etc.

26. Still another group of services which are mainly routine in nature, can help to improve the overall economic environment. In this category maybe included such services as establishing a technical library necessary not only for the work of the institute itself but also as a reference centre of information for local industry and other interested groups. The institute may carry out, in addition, an information service designed to answer technical inquiries on specific production, management and general engineering problems, on investment possibilities, market trends, industrial products and processes and similar matters.

As its competence grows, the institute should eventually be in a position to prepare training material for the technical and management staff of industry.

27. Another important area in which the institute could materially assist local industry is that of the development and licensing of patents. This is of course a function that the institute can take on only after acquiring the necessary experience. Since its research activities will consist of both self-initiated and sponsored work, the institute sooner or later will find it necessary to organize a system for the handling and licensing of patents. In this way it may develop into the country's first recognized agency in this field as well as a point of contact for the transfer of information on patented processes and products, both domestic and foreign.

28. If the institute is to perform its assigned functions with maximum effectiveness, it should have a reasonable degree of autonomy to influence the line of research, always of course within the bounds of national development objectives. While its initial financing may almost certainly have to be provided by the government — and even if this support must continue — the institute should be free of political pressure.

29. In the developing country, the formulation of scientific and technical policies is considerably more difficult than it is in a developed country, where there is a solid base of technology and a history of technological progress to guide the policies. Technological progress in the developing country may be barely discernible and its direction, therefore, always requires careful consideration and planning. This is extremely important in the field of applied research.

30. Because of the institute's broad spectrum of scientific capabilities and the fact that in a developing nation, it will probably be the only such central scientific body, it is well suited to play the role of scientific advisor to the government.

31. In summary, then, the Industrial Research Institute is a vital national asset for bringing about rapid and efficient industrialisation.

III. Natural Resource Endowment as a Determining Factor in the Establishment of an Industrial Research Institute

32. Natural resources may be defined as the non-renewable and renewable occurrences of nature which characterise and differentiate a given area of land and which can be exploited for the benefit of man. They include both physical occurrences such as minerals, forests, soils, water, grasslands and game, and intangible and qualitative phenomena such as land fertility and scenic beauty and climate.

33. In a given country the aggregate of such natural properties may be quite large. They are not, however, constant with regard to quantity and quality. Both the degree and composition of natural resources vary considerably from country to country and from time to time within the individual country.

34. The types of industries which a country pursues are determined to a major extent by the types of natural resources it possesses. For example, if a nation is rich in oil, then a petrochemical industry is a logical choice. It is essential, therefore, that the nation's natural resources be examined carefully prior to making recommendations for or against the establishment of an industrial research institute.. While the abundance or lack of natural resources may not be the determining factor in whether or not to establish an institute, the type of available resources will certainly help dictate the type of institute that might be established.

35. Examining raw materials and other elements of production (e.g., hydroelectric power) in the light of quality and price, may uncover opportunities for competitive production for the domestic and export markets. Another factor is to re-examine old, known resources utilizing current scientific and technical knowledge with a view to discovering new industrial possibilities. Moreover, it is generally advisable to keep under constant review older, developed but never completely implemented projects which may suddenly prove feasible when markets or related industries have changed. Possibilities of new opportunities springing from old ideas sometimes unfold when changes occur in the economic environment.

36. If a fairly comprehensive survey of the country's natural resources has not been undertaken prior to the feasibility study for an industrial research institute, it is strongly recommended that one be carried out. Such a survey should attempt to answer questions like: (1) What are the country's known resources? (2) Is the economy dominated by one principal natural resource? (3) What are the relative strengths of the mineral and vegetable resources of the country? (4) What are the power resources? Can they be, or are they being, tapped for the benefit of industry?

37. After this information has been compiled, it is very instructive to look at current industrial developments in the countries or regions with somewhat similar conditions or in neighbouring countries whose industrial output might affect local demand. By observing successful resource utilization as experienced elsewhere, possibilities of new projects may suggest themselves. It is common experience for research and development institutes to discover promising industrial development projects based on local natural resources and to submit them to selected members of the business community for sponsorship. The direction of research should thus aim at the maximum utilization of the country's natural resources.

38. It must be noted that in a country somewhat devoid of the so-called "richer" natural resources (oil, iron ore, etc.), a central research institute may be an even greater necessity than in a country where the direction of industrialization is clearly indicated by the presence of such resources. For example, a country with an abundance of oil resources would most logically gravitate toward a petrochemical base. However, a country whose natural resources are less basic will need technological help in many varied areas to get the most from them.

39. The geographical location of raw materials or natural resources may or may not influence the location of the institute. Raw materials sources may influence institute location indirectly through their influence on the location of industries themselves. Frequently industries are located in close proximity with sources of raw materials. There are of course several factors other than sources of raw materials which influence industrial location — power, fuel, markets, labour, transportaton, etc. It is rare that an industry finds all the factors favourable in one place. To maximumise the utility of these factors an industry must find a location at which the highest number of them are favourable.

40. To the extent then that the research institute is located near the centre of industrial activity, which in turn is situated near the sources of raw materials, the location of the institute may be said to be influenced by the location of raw materials. Whether the establishment of the institute precedes the setting up of the industrial enterprises which it is expected to serve, or is preceded by it, the need for proximity between the institute and the enterprises is an important consideration at the feasibility study stage.

41. Research aimed at converting the country's raw materials or natural resources into produced goods will constitute a fair amount of the institute's work. Therefore, some at least of the types of equipment which will be required will depend on the types of resources to be processed. It is unlikely that all or even most of the country's natural resources will be known prior to the establishment of the institute. But some advance idea of what exists will be helpful in determining the requirements of the institute in terms of types of equipment and financial capital. This is another reason why it is beneficial to the country to carry out as soon as practicable a survey of its natural resources even if the question of setting up an industrial research institute were not being considered.

42. In summary, then, it may be said that while the abundance or lack of natural resources will not in itself dictate the feasibility of a research institute in a given developing country, it will help dictate the general direction and configuration of the institute. Even though a country has an abundance of a particular resource, peripheral or less abundant resources should be considered as a means of broadening the base of industrialization in the country. Further, if the country lacks a strong resource base, this may indicate that a broad industrial research institute would be of great value in optimizing the use of the limited available resources. Resources or the lack thereof hold the key to the type of economic development and industrialisation to be initiated. A lack of material wealth can poss a stimulus to planners to make the best of an existing situation and to seek enterprising innovations around which to build an industrial economy. The types of resources available should be borne in mind in planning the institute and especially the types of equipment it will require.

IV. INDUSTRIAL AND SCIENTIFIC MANPOWER

43. The availability of trained competent personnel has a crucial bearing not only on the feasibility of establishing an industrial research institute, but also on the general breadth of activities the Institute can undertake. In order to determine whether from the point of view of the availability of suitable manpower a given country can support an industrial research institute, it is necessary to understand the types of personnel required for both the institute and the hopefully resulting industries.

44. The personnel of a research institute may be broken down into four classifications — management, technical, administrative and support. When viewed in terms of training and experience, the management and technical personnel classifications are the most critical. Administrative people such as secretaries, clerks, bookkeepers, etc. and support personnel suchas janitorail, machinists, plant maintenance, etc. may usually be trained in a fairly short order if necessary. However, research is a specialized business. Research management requires a knowledgeof business, economics, all technical fields encompassed by the institute, plus the ability and experience to deal with professional and subprofessional research personnel. This latter capability is especially important in that dealing with highly competent and trained scientific and engineering personnel requires a completely different concept from that required for managing, say, the labour force in a steel mill.

45. Institute management at all levels should be handled by personnel who are either of technical background with administrative ability, or of business administration background with exceptional understanding of research and development operations. Particularly in the case of an institute in a developing nation, it is vital that the Director of the Institute and his second echelon assistants should be highly experienced in research and development management.

The persons who constitute the top management of the institute should also be knowledgeable and experienced in general economic and technological development as it applies to developing countries. This is especially important when it is considered that the research institute is being established and guided mostly or perhaps solely from within the country and will perform a national advisory function with regard to advancing technology.

46. It is not unlikely that top management personnel may not be found within the confines of a developing country. The initial managerial team of trained and experienced foreign personnel may well have to be brought in to guide the institute through its infancy. While it is possible to use local managerial personnel in conjunction with foreign management consultants, this is far from being the most desirable route in the beginning.

47. It must be recognised that academic training alone, no matter how thorough, is not sufficient for the efficient and effective operation of an industrial research institute. There is no substitute for practical experience which may only be gained through years of applied effort. Here again is a reason that the initial direction and management of the institute as well as the initial team of scientists and engineers will probably, of necessity, be brought in from abroad.

48. While foreign personnel would be used in the beginning and perhaps for some time into the future, it is vital thatevery effort be made to utilize available native talent quickly so that the institute may maintain a true sensitivity and perspective with regard to the economic needs and desires of the country itself.

49. The principal personnel performing research and development functions comprise a team of engineers, scientific specialists, and technicians. For purposes of this study, these definitions are provided: An engineer has a university level education (four years or more) in an engineering study -- chemical, mechanical, metallurgical, civil, electrical or industrial. A technician has a technical education of at least two years beyond secondary school in some area of technology. Arbitrarily, one may describe a scientist as a person with university-level professional education in a basic science such as chemistry, physics, geology, mathematics, botany, physiology, agronomy, etc. There will of course be some overlap and some deviation not only in education but in capability.

50. The work of scientists or scientific specialists in the research institute is mainly concentrated in research and to some degree, in development and design. A university education is necessary, with experience in research and development. A scientist generally serves an apprenticeship under a qualified and experienced researcher.

51. The well educated engineer is normally flexible enough to handle a variety of job functions. Generally, however, engineers work in the functions of design, development, applications, and production/construction.

52. Engineers and scientists are not trained and experienced overnight. Their work is as demanding of professional excellence as the practice of medicine and surgery or the law. A soundly established Institute will set reasonably high standards of education and experience that must be met by prospective employees. A series of examinations or the requirement of licensing are methods commonly used in various countries. Naturally, qualifications can be raised as the supply of available talent increases.

53. Skilled technicians are, by and large, the operating backbone of an Institute. Their work is generally in the service and operation, production, and application areas. They are an important part of the team and usually work under the supervision of the scientists and engineers. They are normally most familiar with the operation and maintenance of existing equipment and instrumentation. A technician may begin as an apprentice and work his way "up the ladder" in much the same way as members of various skilled labor unions or guilds maintain the high quality and standards of their job functions.

54. In establishing/research institute directed primarily toward research for a manufacturing economy it is necessary to take into account the general availability of industrial andmanufacturing personnel in the country. Here the planning authorities must look beyond just the requirements for the institute and investigate the country labour force as a whole. Hand in hand with this goes the problem of education and training which will be discussed in more detail later. It must be realised that education and training facilities are completely entwined with the general problem of supplying personnel for the institute and resulting industry.

55. It will be impractical to specify quantitatively the personnel requirements that will be applicable to every institute. In each case the number of men required in a particular category or scientific discipline will have to be determined according to the envisaged initial size and functions of the proposed institute and may then be modified as appropriate from time to time.

So far as professional technical persons are concerned, the intitial requirement of a new institute is likely to be small, perhaps between six and ten. These will include an engineer, a chemist, a chemical engineer, a socio-economist and possibly a few persons with special skills in the country's main industries.

56. An important consideration at the planning stage then is whether the above nucleus of professional technical staff can be found locally and/or abroad for recruitment and what the long-term prospects for additional recruitment would be like. Linked with this consideration is the question of adequate remuneration of these professional men. Owing to the high competitive demand for their services, professional technical people, to the extent that they respond to higher salary and other incentives, are likely to be attracted to the highest bidder. It is generally agreed that the institute must be able to attract and retain the best talent available if it is to fulfil the role of problem-solver for industry. It will not be able to command the respect and win the confidence and patronage of industry unless it can demonstrate that the professional competence of its men is at least as high as, and preferably much higher than, that in industry.

57. The financial base of the institute should, therefore, be such as to enable the institute to offer its professional staff salary and other benefits that are at least comparable to the best in the country.

58. Financial incentives alone may not be sufficient to attract certain types of professional staff to the field of applied research. In developing countries a large proportion of the nationals to be recruited in this category are likely to be young university graduates. Experience has

indicated that university science graduates tend to favour working on "pure" research rather than "applied" research when they enter the business world. It will be well for the institute planners to watch for signs of such predisposition and to take educational measures to try to counteract it. While doing so they should be careful to emphasize that their action does not constitute a devaluation of "pure" research but that the limited resources of a developing country are best devoted to those lines of activity that are constrained by considerations of economic returns in a reasonable period of time.

59. This question of attitude on the part of the prospective research personnel is of particular importance. Work in a research institute is most demanding and calls for little less than complete dedication and perseverance even when one's best efforts are frustrated by negative results. It will be a pitiful waste of time, energy and money for any country to sink large amounts of funds into and go through the painstaking process of setting up an institute only to have it staffed by people who feel no sense of commitment to its success and do little more than carry out perfunctory experiments and watch the clock.

60. Of all institute personnel, none holds a more crucial position than the director. Finding the right person to occupy this position is a matter that should receive the most careful consideration of the institute planners. He should be well qualified both as an administrator and in terms of his conversance with scientific or engineering work. The view is widely held that the director should have a dual qualification, namely an administrative and a technical qualification. There have been instances, though, of successful institute directors who do not possess a technical background.

Nevertheless if a person can be found with this dual qualification so much the better.

61. In any event, it is essential that the prospective director should have had many years of previous practical experience as an institute administrator. If a director with such experience cannot be found within the country, the planners should not hesitate to look for one abroad. The practice in some developing countries of appointing an indigenous but inexperienced director to head an institute or an industrial enterprise merely as a matter of national pride has very often proved both costly and self-defeating in the long run. If qualified and experienced local personnel are available, all other things being equal, they should by all means be given priority. If none are immediately available, it would be in the country's best interest, as an interim measure, to look elsewhere and to try to get the best talent available. Local counterpart staff should then be attached to the foreign personnel as understudies and they should replace the foreign personnel when and only when they have acquired sufficient experience. In the search for a director and other high-level staff, full advantage should be taken of the assistance available through international co-operation programmes as well as through bilateral programmes.

62. Sub-professional technical staff, too, are vital to any institute of applied research. These are the laboratory assistants, machinists, instrument minders, electricians, welders, carpenters, library staff, etc. Like the professional technical men they, too, are often in short supply in developing countries. The institute's prospective requirements for them must be realistically estimated and a determination made as to the availability of qualified candidates.

Adequate provision should be made for on-the-job training to supplement the formal training already acquired by these technicians and to orient them specifically to the jobs that they will do at the institute.

63. The ratio of sub-professional technicians to professional technical staff, sometimes called the support ratio, varies from institute to institute between one and three non-professional staff to one professional. This range may be used as a basis for a rough estimate of sub-professional technical staff requirements.

64. It should be emphasized that human resources, like raw materials, must continually undergo a form of up-grading if maximum results are to be achieved. All levels of institute personnel will need and should be provided opportunities for continuing self-improvement in their respective specialities. The means for achieving this should be carefully explored at the planning stage. This includes a careful appraisal of the country's educational and technical training facilities to determine whether or not they are adequate to provide the proposed institute with the scientific stimulation and technical support that it will need.

65. Another important matter that should be considered at the planning stage is the possible use of outside consultants by the institute. Hardly any institute exists anywhere that does not at one time or another find it necessary or desirable to submit a research problem to another institute, a university research wing or to an individual consultant for possible solution or verification.

66. The research institute in a developing country will be no exception to the need for such external assistance.

On the contrary it will need it the more. It is important therefore, to ascertain whether or not the proposed institute, if and when established, will be able to find elsewhere certain necessary skills and facilities that may be lacking within its own organization. This need will be particularly pressing during the early stages of the institute's life when its own personnel, equipment and experience are likely to be inadequate to handle the country's multi-faceted industrialization problems.

67. There are different types of outside consultants. They include individuals who operate on a part-time basis (e.g. university professors) or as full-time professional consultants. In recent years, especially in the developed countries, there has been a marked trend toward the organisation of consulting firms. Some of these firms specialise in a relatively narrow area of activity; a few are capable of operating in many and varied areas including for example, applied research, engineering development, marketing studies, economic investigations and management studies.

68. Other sources of consultative service include univerisities, suppliers of equipment, suppliers of materials and suppliers of proprietary information. Local facilities of the kind mentioned in this and the two preceding paragraphs should be examined to determine whether they can meet the needs of the institute. To supplement such local service, foreign consultants may be sought and hired on an ad hoc basis or on fixed-term contracts as appropriate.

69. As the institute matures, it will most probably develop and expand its personnel resources to the extent necessary for meeting most of its research needs. Even so, it will continue to find itadvantageous under the appropriate circumstances to utilise the services of outside consultants.

V. TRAINING

70. One feature of many developing countries is the overwhelming reserve of unskilled labour. The lack of technical skills so essential to the exploitation of available resources and to the development of industry constitutes one of the most serious obstacles to industrialisation. Vocational training programmes, even those designed to teach the simplest of skills, are hampered and often well-nigh impossible to implement in areas where there is widespread illiteracy.

71. As mentioned in the preceding chapter, the Institute, as well as industry, must have a source of native talent on which to draw. It will be extremely undesirable, to say the least, for the Institute to hire totally untrained personnel with the idea of giving them a basic education and molding them tofit a job with the Institute. While on-the-job training is necessary and desirable, the Institute's primary occupation should be research and technical guidance — not basic education.

72. The existence of one or more universities and other institutions of higher learning, especially in the technical and scientific disciplines, is of special importance if the country is to be able to supply the qualified which the institute will acquire. Although initially the university may produce undergraduates in the liberal arts only, it should in time aim at expanding its programmes to higher levels and to include a suitable combination of technical and scientific disciplines. The Research Institute if and when established, should support and encourage its staff to continue advanced study, for instance, by providing study leave periods and financial incentives, as appropriate, to enable them to participate in refresher and self-improvement courses and similar programmes.

It would also offer advice on request to the country's training institutions with respect to the content of the technical courses on their curricula.

73. The technical institute is one of the most effective instruments for securing a technological orientation of a country's educational system. The government should examine its existing technical institutes to determine whether or not they are adequate forsupplying the needs of the institute and an expanding economy for technicians at the sub-professional category. If there are no such institutes, or if existing ones are inadequate, consideration should be given to their establishment or expansion and improvement. It is often possible to turn out highly skilled technicians in two to four years at such institutes and it would be advisable to formulate a long-range technician training scheme on that basis. In the beginning, graduates from the technical schools may be utilized in a semi-engineering capacity under the direction of university graduates.

74. It is sometimes said -- and no doubt this is an exaggeration -- that R & D personnel differ from the population at large in intelligence, education, work habits, and basic personality patterns. It is true, however, that to be effective as a researcher, a person must develop an extensive body of knowledge in one or more technical fields. He must learn a variety of skills and techniques and be able to apply them in the systematic and exacting manner characteristic of research work. Furthermore, he must continue to add to and improve his reservoir of knowledge throughout his career.

75. As already suggested, the Institute should encourage advanced education or a continuing education of its personnel through a programme of financial assistance and incentives. Normally an institute will enter into an arrangement with the technical schools and universities in the country to help guide them into offering courses and programmes which fit both present and projected needs of the institute and industry.

76. It is also quite common for a research institute to have arrangements with a technical school or university allowing its employees to teach technical courses in the educational institution in the evenings or other off duty hours. In some cases, the institute might find it desirable to grant a certain percentage of personnel time toward this end.

77. The Institute will want to have in-house programmes for training its own staff. A typical programme may be considered in three parts: pre-employment training, job-orientation and on-the-job training.

Pre-employment training.

78. The Institute will inevitably find gaps even in the most educated prospective employee with respect to the level of expectation in his prospective job. For example, the newly graduated engineer or specialist will probably be lacking in various writing and speaking skills, knowledge of economic and social matters peculiar to his situation, and administrative capabilities. He may be lacking in such aspects as careful planning, job execution, systems analysis, or operations research, and the normal capabilities of technicians and skilled workers. The institute's personnel, regardless of level, needs to learn the teamwork approach to problems. Teamwork should be taught without stifling creativity, originality, enterprise, individuality, or personal responsibility. These are all basic tasks which the institute will face and must deal with whenever a new employee is hired.

Job Orientation

79. The institute must introduce the new employee, regardless of formal training, to company policies, protocol, history and tradition, location of physical facilities, and certain day-to-day matters. Orientation at the outset will have beneficial effects on loyalty, security, work relationships and work habits.

On-the-job training

80. At the beginning of the programme, the institute must plan for the personnel needs of its divisions, keeping in mind the progress each individual is making. Certain professional employees must qualify for the job openings, meeting requirements in terms of education, training, experience, and background. Non-professional employees, such as technicians, machinists, labourers, etc., must either be taught their skills in the institute or be sent to where such training can be acquired. Once the institute and the various train-programmes are established, new employees can be trained on the job as needed.

VI. SECTORAL ORIENTATION

81. It is important that at the planning stage a reasonably clear conception be formed of the particular sector or sectors of the economy to which the services of the institute will be geared. Being an industrial research institute, the institute will, of course, devote a major proportion of its effort to serving the industrial (i.e. manufacturing) sector. But its services will by no means be limited to that sector. Its resources, in terms of professional expertise and physical facilities, should, therefore, be planned in such a way as to enable it to solve problems in the non-manufacturing sectors as well. These other sectors will include mining, commerce, transportation, agriculture and services.

82. The manufacturing sector is the most versatile. Manufacturing establishments, e.g. machine shops, textile mills, food processing plants, depend to a large extent on the gradual advancement of technology to fulfil such functions as designing of processes, creation of patterns, and the assembly of tools. Manufacturing, simply, is the collection of raw products and their fabrication in desired new forms and combinations. The enhancement of manufacturing is commonly referred to as "industrialisation," probably because of the expansion of almost all types of supporting industries.

83. Before the decision to establish an industrial research institute is made, one major acitvity should be to determine, from the viewpoint of economy, which industries, existent or proposed, have the prospects of being of high value to the country. This determination will help to define the breadth of the institute.

Applied Research and Development

84. Once the country's natural resources have been substantially surveyed, some determination made as to their possible uses, the next logical step is to attempt to convert at least some of them into finished products.

It is generally undesirable for a country to have to export its raw materials cheaply and then import expensive finished products. However, certain manufacturing industries, with their costly machine tools, high power needs, large water consumption, and skilled labour requirements, present a major obstacle to many developing nations. Therefore, the industrial research institute, with emphasis on practical applications, should be organized and directed toward:

1. Utilization of the nation's natural resources that can be applied to the manufacture of profitable products, and
2. The production of goods for home consumption and/or export.

85. In many countries, the reliance of the economy on a single crop often results in chaos when international market prices fall. Moreover, adverse weather conditions and other exigencies beyond human control tend to affect such economies rather drastically. Applied research and development can help to develop new marketable processes, techniques, and products to serve as a buffer against periods of such economic adversity.

VII. ORGANIZATION

General Remarks

86. This chapter on organisation is included mainly to give an overview, background and general philosophy of the industrial research institute as an organisation. A proper understanding of the functional organisational structure of the proposed institute will be of assistance in determining the feasibility of establishing the institute. A review of the organizational structure will assist the planners in determining whether or not the rather involved services of such an institute can be effectively utilized and whether or not the country is capable of supporting the institute from the standpoint of needed personnel. It will also enable them to relate existing technology to the needs of the institute and of the country.

87. Even in a country that possesses an abundance of natural resources that are convertible to new and desired forms, the conversion process will be either impossible or greatly handicapped without a suitable technology. Essentially, technology consists of both the human resources and mechanical facilities necessary for transforming raw materials into produced goods. The facilities include sciences, trade practices, craft skills, machinery, electrical and mechanical power, patterns and designs, business organisations, the financial structure, social drives and incentives.

88. A country's technology may be simple and inadequate, or advanced and efficient. In either case, an improvement in technique, a new invention, or an increase in knowledge or skill may affect the success of the conversion process.

89. In the handling of research projects, the team approach is most conducive to success. Its essence is that researchers with various professional backgrounds bring their diversified talents to bear on a particular problem. This not only enhances the chances of solving the problem but also brings about a cross-fertilization of ideas among the researchers thereby further improving their future research effectiveness. With this basic orientation in mind we may now turn attention to some of the fundamental organisational considerations.

The Board of Management

90. Since the normal governmental machinery may not suit the organizational requirement for close policy direction and supervision of the institute, the procedure adopted in many countries is to appoint a governing body — which will be referred to in this report as the Board of Management — to formulate institute policy, and secure and supervise its execution.

91. The Board may be appointed by and be responsible to a Government Minister or other senior government official. Normally the research policies that it formulates will reflect and be guided by the overall development aims and objectives enunciated by the government.

92. The question of who should serve on the Board of Management is of course of great importance and practice on the point varies from country to country. One consideration, and no doubt there arecthers, that should guide the selection is the needto have people who will be effective in "selling" the institute to industry, i.e. in securing industry's full support of the institute through sponsoring of research projects and in a number of other ways.

93. The Board should also be representative of the major interests in the nation and especially those that are most likely to be affected by the existence of the institute. These will include for instance, representatives of the government, leading industrialists, other enterprise managers or administrators, labour leaders, members of professional associations, representatives of financial institutions and of the scientific and academic community. The number of Board members may be in the neighbourhood of 10 to 15.

94. Normally the Board would meet periodically under the chairmanship of one of its members elected by it or designated by the relevant Minister or other official, to plan the work of the institute and review past activities. It would also furnish progress reports, work programmes and estimates of financial requirements to the responsible Minister for official action.

Institute Director

95. Reference was made in an earlier chapter to the importance of the office of institute director to the success or failure of the institute. This matter bears re-emphasizing here. It is the director's responsibility to see that the policy decisions of the institute's Board of Management are translated into action. He is responsible for steering the internal every-day activities of the institute efficiently and harmoniously. As the institute's chief executive he must be itsprincipal spokesman in all its relations with outside interests. He must render a periodic account of his stewardship to the Board and obtain its mandate for future programmes.

96. It is obvious that the effectiveness of the institute in realising the objectives for which it is being created will depend to a very large extent on the competence, fore-sight and decision-making ability of the director.

97. He may be appointed from among the Board members or from elsewhere. Either way he is normally a Board member. As stated earlier, it is generally preferred that he possess a technical as well as an administrative background and have several years of experience in research management. Only when every effort has been made without success to find such an individual should the planners settle for a less qualified person.

Internal organization

98. The initial organizational structure will depend largely on the initial size of the institute and the capabilities of its staff. Most institutes begin on a rather modest scale of operations and with a small staff of somewhere between six and ten people. These would normally include, beside the director, an engineer, a chemist, a chemical engineer, a socio-economist and perhaps a few other individuals with qualifications covering the country's principal industrial activities.

99. At the beginning, when the staff of the institute is small, the institute director will be able to exercise personal administrative control of its operations and no formal organization may be necessary. As the institute expands, both in size of staff and number of programmes, some division of administrative responsibility will be necessary and the director will have to delegate some of his responsibilities to some of his more capable senior officials.

The outlines of divisions or sections and sub-sections may well appear from this delegation of responsibility.

100. No rigid organisational form will fit into every situation. The director must rely on his own discretion, paying due regard to the views which the Board of Management may express on the matter, to evolve an organisational schema that suits the needs of the environment. It should be flexible enough to permit modifications which growth and changing circumstances may dictate and coherent enough to allow for easy contact and communication between the various divisions.

101. The internal organisation of an institute that has reached a fairly advanced and complex stage may be instituted on functional basis or on a technical one. The former type of organisation may have the following divisions:

(a) General Administration

(b) Resources Division

(c) Research Division

(d) Design and Development Division

(e) Economic and Social Division

(f) Advisory and Consultant Services Division

(g) Library and Documentation Unit

102. This organisation, in view of the rather large number of supervisory personnel which it will require, may not be practical in cases where the supply of such personnel is very limited.

103. On the other hand an organisation based on technical specialisation may cover the same functional areas with a smaller number of supervisory personnel. Such an organisation may consist of:

(a) General Administration;

(b) Technology Division;

(c) Engineering Division;

(d) Economic Studies Division.

The functions of the various divisions under the technical form of organisation are described below.

General Administration

104. This has to do with the general housekeeping activities of the institute and embraces such matters as budgeting, accounting, maintenance and servicing of facilities, library services, personnel administration, including staff training, inventory control, secretariat services, etc.

Technology Division

105. This division will handle the technological problems involved in product and process development, including technological research, feasibility studies, quality control, production standards and specifications, equipment valuation and technical trouble-shooting.

Engineering Division

106. Engineering design and development research are two important functions of this division. The design function covers a wide range of technical areas such as preliminary design, design analysis, etc. Engineers in preliminary design are responsible for generating the ideas and defining the approaches to be applied to the designing and development of a new product, process or system.

Those dealing with design analysis apply various evaluation techniques to determine the most desirable form for the product, process of system and recommend any changes in design likely to achieve that goal.

107. The function of application engineering bridges the gap between research and development on the one hand and actual production on the other. It translates research and development prototypes into practical producible equipment, final goods or processes.

108. An application engineer prepares the plans and designs for utilising a product that will meet a specific need. He may work entirely within the institute or represent it to those outside it who are interested in the results of its technical research studies.

109. In a small institute the different engineering functions just described may be the responsibility of one engineer with a small staff of supporting technicians.

110. Perhaps after the institute has gained sufficient experience it may decide to engage in operations research. This activity, if an when embarked upon, would apply to many levels of the institute's structure. Operations research is the methodology of analysing and comparing alternative production processes or input combinations with a view to adopting that combination yielding the highest return per input unit. It is an important tool for aiding management decision-making in determining optimum cost-benefit relationships.

Economic Studies Division

111. This division will have primary responsibility for various techno-economic studies and marketing surveys.

Its range of activities will include items such as raw materials problems market estimation, pro-forma costing, analyses of growth opportunities, socio-economic conditions, productivity improvement and management problems.

Technical Information and Consultation

112. Information services are an essential activity of every institute and often one of the first activities to be organized. They should be backed up by an up-to-date library with a qualified librarian (preferably one having a technical orientation) in charge. The usefulness of the library will be enhanced if it is made available for the use of the industrial public. Technical digest services and training manuals may also be provided as part of the programme of information services.

113. Supplying and receiving technical information must be viewed as the collective responsibility and privilege of all technical personnel and all divisions, although one competent individual should be designated to spearhead the programme. Not only must there be consultation among the technical and other staff, there must also be a channel or channels for answering on a consultative or standby basis, technical enquiries originating from sources outside the institute (see para.130).

114. The following organization chart illustrates the structure based on a technical division of responsibilities as just described.

O R G A N I Z A T I O N C H A R T

Board of Management

Public Relations

Director

Staff Assistant

Technology Division	Engineering Division	Economic Studies Division	General Administration
			Budgeting
			Accounting
			Facilities Maintenance & Services
			Library
			Personnel

C o n s u l t a t i v e R e l a t i o n s h i p s

U s e r s o f R e s e a r c h R e s u l t s

VIII. FINANCE

Types of Expenditures

93. At the beginning, the industrial research institute, like any other organization, will require a capital outlay of two types — for initial buildings, equipment, and general facilities and for initial operating expenses. The capital required to put up the physical facilities for the institute can be handled in several ways. It could be a budgetary provision made by the government or it could be raised through a special tax or assessment on the country's industry. It might be possible in some cases to encourage the ownership of the industrial research institute by the country's industry. In this case, the initial capital outlay could be provided as a loan by the government to be paid back over a long period of time, perhaps with payments not beginning for a number of years after the operation of the institute has begun. Capital loans could also be made by the country's financial institutions and guaranteed by the government.

94. A decision must be made at the outset whether the institute is to be operated on a profit or non-profit basis. There are several considerations that enter into this decision. Not the least of these is the possibility that the profit making institute is likely to be a bit more practical in its approach. Because it is related to a profit making industry, it will tend to be more cognizant of the economic factors involved in research development. It must be remembered, however, that normally the net profit shown by a research organization is much less than that which one might expect from, say, a manufacturing or service organization. At any rate, the utility of a research institute in a developing country, lies mainly in its capacity to serve and stimulate industry and little, if at all, on the state of its profit-and-loss account.

Continuing Financial Support

95. Apart from the funds required for the initial capital expenditure, the maintenance and continuity of the Institute will require a steady source of financial support. This can be established in several ways: self-support, subsidies or grants, government support, or a combination of these.

96. The self-supporting structure should be aimed for, at least in the long run. This approach compels the institute to adopt a business-like outlook and provides it the impetus to seek out contracts and make its research and development capability known to industry. It means that the institute, like the industry it serves, will become competitive. However, in many countries, financial support for an institute by industry is virtually impossible, especially at the outset. Thus, the institute will probably, of necessity, be supported mainly or even solely by government.

97. At the same time, however, the government and the institute itself should encourage the country's industrial enterprises to sponsor research and development activities at the institute. Governmental encouragement may take the form of tax concessions, matching funds or grants, or other monetary incentives. Also, it is important that the results of the research derived by an industrial sponsor be protected. No industry or company will want to pay for research, the results of which are to be made public and available to all other companies for their use. A good patents system, then, is essential.

Breakdown of Costs

98. The costs of conducting research may be broken down into "direct" costs and "indirect" costs. Indirect costs, sometimes known as "overhead" costs are those expenses that do not rise or fall with increases or decreases in the volume of production.

Because of this characteristic, they are also known as "fixed" costs. Examples are interest in borrowed capital, maintenance costs, fireinsurance premiums and at least part of administrative salaries.

99. Indirect costs vary from institution to institution mainly due to differences in accounting systems and operating procedures. Accounting systems are influenced by the institute's organisational structure, its policies, and the laws established by the government as well as by administrative and operating procedures and existing support services. Such things as administrative expenses, cost of information services, and even the requirements for heat, power, light, and water affect overhead costs. In any event, the reviewing system used by the institute to evaluate a research proposal will determine the value of the projectin comparison with its direct and indirect costs.

Programme Sponsorship

100. The institute, beside initiating a number of research projects on its own, must make every effort to secure sponsored projects from industry and governmental bodies. In executing research projects, including sponsored projects, the institute must have proper authority and autbnomy to do its job as a major contributor of research and development technology with as little intervention as possible by the sponsor or any external agency. This is not to say that the sponsor or other body concerned should not participate in the planning of the project. For maximum effectiveness, however, short-term changes in the established plan resulting from external intervention should be kept at a minimum. Whenever circumstances warrant, the institute should seek out additional sponsors to assume sponsorship of newly discovered processes or inventions.

101. It may be advantageous to encourage the formationof industrial co-operatives or trade associations. These associations could then sponsor research projects the results of which may then be made available to all member companies and would thus be proprietary within the association. The trade association may also provide funds for basic research by assessing each member company a percentage of the total cost of the project. In this way each company gets the benefit of basic research and may sponsor its own projects at the institute to further its own proprietary interests.

102. So far as governmental financial support is concerned, it may be a good idea for the government to appropriate an annual budget as well as a long-term provision covering a period of four or five years. The institute should be required to submit a detailed budget at the beginning of each appropriation year with projections for the succeeding three or four years. Obviously, as the institute begins to project beyond one or two years the budgets will, of necessity be somewhat general in nature.

103. In summary, the institute should make every effort to become self-supporting at the earliest practicable time by earning sufficient revenue mainly from industry-sponsored research. It may be necessary for the government to remain in the background for some time by encouraging industry to support research work. Oneway in which the government could do this would be to make it possible for industrial enterprises to obtain loans, guaranteed by the government, to be used for sponsored research work. Other sources of income can, of course, include endowments, bilateral financial aid, and international financial aid.

IX. SUPPORTING SERVICES

104. Supporting services to an Industrial Research Institute can take two forms — internal and external. External supporting services will mainly be furnished by the government, at least in the beginning. In this chapter we are mainly concerned with internal supporting services. Outside of training, the two major internal supporting services are those of information and testing facilities.

105. Much of the world's technological information is readily available to anyone who desires it. This information is, in fact, so extensive that it has led to the development of a whole new industry — the industry of literature research, acquisition, compilation, codification, dissemination, etc. For example, the United States alone, there are over 1,000 information sources pertaining to the physical and biological sciences and engineering.

106. The industrial research institute needs an information facility to support the technological endeavours of its staff, to furnish industry with the latest "state-of-the-arts" information, and to provide an information retrieval capability. Many developing countries do not have such facilities. Recognizing the need for them, those developing countries which have industrial research institutes have seen to it that their institutes develop and maintain documentation and library divisions. One such institute is the regional institute known as the Central American Research Institute for Industry (ICAITI) a United Nations supported institution located in Guatemala City, Guatemala. ICAITI was formed in 1956 for the purpose of improving and expanding Central America's industry by modernizing existing facilities and helping to develop new industry.

107. A flexible organisation similar to ICAITI's Documentation and Library Division could be adopted as the basis for an information division by any industrial research institute. The functional units within the Division may deal with the following:

(a) Documentation - handles the compilation and codification of books, periodicals, industrial catalogues, organisational documents, along with such miscellaneous literature as reports, private communications, booklets, patents, reprints, maps, studies, etc.

(b) Acquisition and literature search - aimed at acquiring desired information and documents. Acquisition may be handled by a committee responsible for screening requests and providing overall advisory authority. Literature search is a complex procedure involving an extensive sifting of the world's massive output of technical data.

(c) Miscellaneous functions - these are the important functions of disseminating knowledge, information, and data in the form of books, periodicals, catalogues, articles, data sheets and miscellaneous lesser materials.

(d) Standards - collects and maintains standards of various countries of the world.

(e) Extension services - a group to aid outside industrial, government and academic users of research information or in connection with any technical or economic problem.

Information Division

108. While the information division is normally known as a support division or group within the institute, it can nevertheless act as a major technical division by the acquiring of projects which deal with the search, collection, storage and retrieval of information. For example, a particular industry may wish to sponsor a literature search to determine a state-of-the-arts information covering a particular technique that it is interested in. In this case the information division acts as a prime technical division in the handling of this project. The institute may also aid the government in refining, updating and expanding its information gathering processes.

109. There are several areas where extra consideration must be given with respect to the operations of such a division:

Staff - employees in this Division should be technically-oriented and have experience in library-science. They should be able to discriminate between useful literature and that which is of little or no consequence.

Technical publications - as soon as practicable, the institute should publish its non-confidential research findings in annual reports and specialized industrial pamphlets. Project studies, various research papers, and feasibility reports should also be published.

The Division can also provide technical writing, editorial, and reproduction help to a researcher who desires to publish his results.

Public relations - this function should be handled by a competent staff member who is administratively close to the institute director. He should be intimately familiar with the technological capabilities of the institute and with current research developments outside the institute. This public relations activity would provide the essential service of achieving wide dissemination of the results of the institute's studies to facilitate their use by industry.

In time, as the facilities of the institute expand, a public relations section may be set up to serve as liaison between the institute and industry, the citizenry, other research establishments and the nation's colleges and universities.

Testing Laboratories

110. Testing laboratories are simply for the practical application of technological and engineering "know-how" at the pre-production stage. These "labs" are necessary in every branch of industry.

111. The testing laboratory while considered here as a division, actually functions in a manner that cuts across divisional lines.

Like the information division, the testing laboratory will serve the other divisions of the institute as well as external organizations. Routine tests and backchecks constitute an important part of its work. If the country does not already have standard testing laboratories, the institute's testing laboratory should be made readily accessible to the country's industries and government. It must be pointed out, however, that the testing laboratory function should not be permitted to get out of balance with the research function of the institute. If this begins to happen it would be wise to spin-off the testing laboratory and run it as as a subsidiary entity or an entirely independent entity from the research institute itself. The reason in favour of such a step is that an overpowering testing function tends to stifle research creativity.

112. The Division would analyze mining, petroleum, soil and soil composition samples of industrial products; take bacteriological studies of lakes, waters, and seas; make land surveys, smoke and pollution studies; and hold responsibility over use of the country's standards of weights and measures.

113. For industry, as an example, institute specialists could extract and study metallurgical and mining samples. Metals could be tested for tensile strength, fatigue strength, hardness, or susceptibility to corrosion in the local climate. Textile fibers could be tested, along with, for example, dyes and weaving accessories, or could be compared to new developments in the field of organic chemical fibers.

114. The in-house support phase of the Division would be to furnish certain laboratory services for the institute. These services could be chemical and physical analyses, instrumentation development and maintenance, pilot plant operations, and specialized assistance and consultation for the various types of industry, product, or process being studied.

115. This Division demands a high-quality staff of specialists supported by a team of well trained, practical-minded technicians. The equipment for such an undertaking would be expensive and would require a variety of facilities, and possible field offices for on-site analyses and sampling.

116. It should be determined whether or not there are specially equipped foreign laboratories that could receive and analyze samples more economically than could be done locally, especially at the beginning of the programme. Also, there may be qualified foreign consultants who could extend their specialized services under contract. The institute would find it advantageous to seek aid of such consultants or laboratories for several reasons:

(a) To furnish fresh approaches to technical problems.

(b) To monitor and provide liaison with the latest advances in technology.

(c) To keep the initial capital outlay down until services were required to such an extent as to support a local laboratory service.

117. Thus, the answers to many questions can be found in the testing laboratory. These answers may involve only a simple chemical analysis, or assay, to determine, for instance, whether a piece of rock is mineral laden, or should be laid down as rock-bed materials; or, whether the desert will yield oil and gas, or just cactus.

118. The personnel and facilities will necessarily be either spread quite thin at the beginning, or will be set up to participate on the first major studies to be undertaken. For example, if mining is the major effort of the nation, the Division will first concentrate on mining and its associated industries, and then perhaps cater to a proposed finished product including support facilities or utilities.

119. In time, appropriate personnel, equipment, and facilities to support all phases of industrial activity should be provided for in this Division. An initial cost may prove the project expensive, but the Division should plan to accomodate inquiries from every sector of the economy, industrial and otherwise.

X. RESEARCH POLICY

Commercial vs. Government Work Projects

120 ~~107~~. In its early stages in a developing country, much of the institute's research activity may be government generated. This is to be expected since in many developing countries the government is the prime mover of industrialization. Where, however, there is a private industrial sector to be served, the institute's research policy should aim also at encouraging research sponsorship from that sector as soon and as fast as possible. The institute should at the same time pursue a vigorous programme of self-initiated projects.

121 ~~108~~. It is important to obtain government projects where certain answers could have important commercial overtones. These would generally be projects which commercial enterprises could not afford to explore on their own account. Government work, in some cases, can uncover and simultaneously develop new and badly needed technologies for long-range private sector planning.

Research and Development vs. Production

122 ~~119~~. It must be re-emphasised that it is highly important in the development of new products and processes for heavy attention to be devoted to development and prototype production. The situation could conceivably arise in which a division of the Institute could develop a product for which commercial industry would not or could not assume production.

If the need for the item in the economy is substantial enough, the research division of the Institute itself could set up production of the item until an outside enterprise could take it over.

123. It is conceivable that in such a case the Institute alone may have the technology and equipment necessary to produce the product; also if the product is a highly complex one it may be quite difficult to separate the engineering and production phases. Care should be taken, however, especially at the early years of the institute's life, that such work is not permitted to overburden the institute and endanger its primary mission of research and development.

Product Planning and Control

124. A heavy commercial orientation on the activities of the Institute is most desirable. A small professional staff represented by members of each division and the Administration, constituting a policy committee, would evaluate new project proposals prior to launching extensive research and development work. This committee could evaluate feasible ideas in two stages:

(a) New ideas should be subjected to preliminary studies which should include market research and engineering and financial appraisals. This work should be co-ordinated by a team consisting of the heads of the various divisions.

(b) The new proposal — once graduated from phase one — can then be considered in the light of long-range future development plans. This should be followed by a more intensive study of the financial and competitive aspects of the new product, company (the sponsor, if such is the case) capabilities, the current state of the art, and the state of market demand.

125. Recommendations, based on the above studies, should then go to the management for a decision.

New Product Development

12b. If management decides to approve the new product, budgets are established and formal research and development begins at the Institute. The following steps are necessary:

(a) Research and development must have a fairly free hand in the early stages. The engineers and specialists should be encouraged to fully exercise their individual capabilities towards the realization of the common objective;

(b) The project, as it moves along, should flow naturally into the design and production stage where the research is translated into an economically producible, and useful product;

(c) Good equipment, competent and experienced personnel, inspection and quality control are of the highest importance;

(d) Co-ordination and liaison between all involved -- divisions, administration of the Institute, sponsor, etc. -- are essential throughout the research and development and production phases.

Market Development

12c. In addition to technical or technological research, the Institute should devote some attention to economic or socio-economic research including market studies and trade analyses. These are especially useful in guiding long-range research developments into areas from which items to be marketed some 5-20 years away will be developed. This should be carried on concurrently with new-product development.

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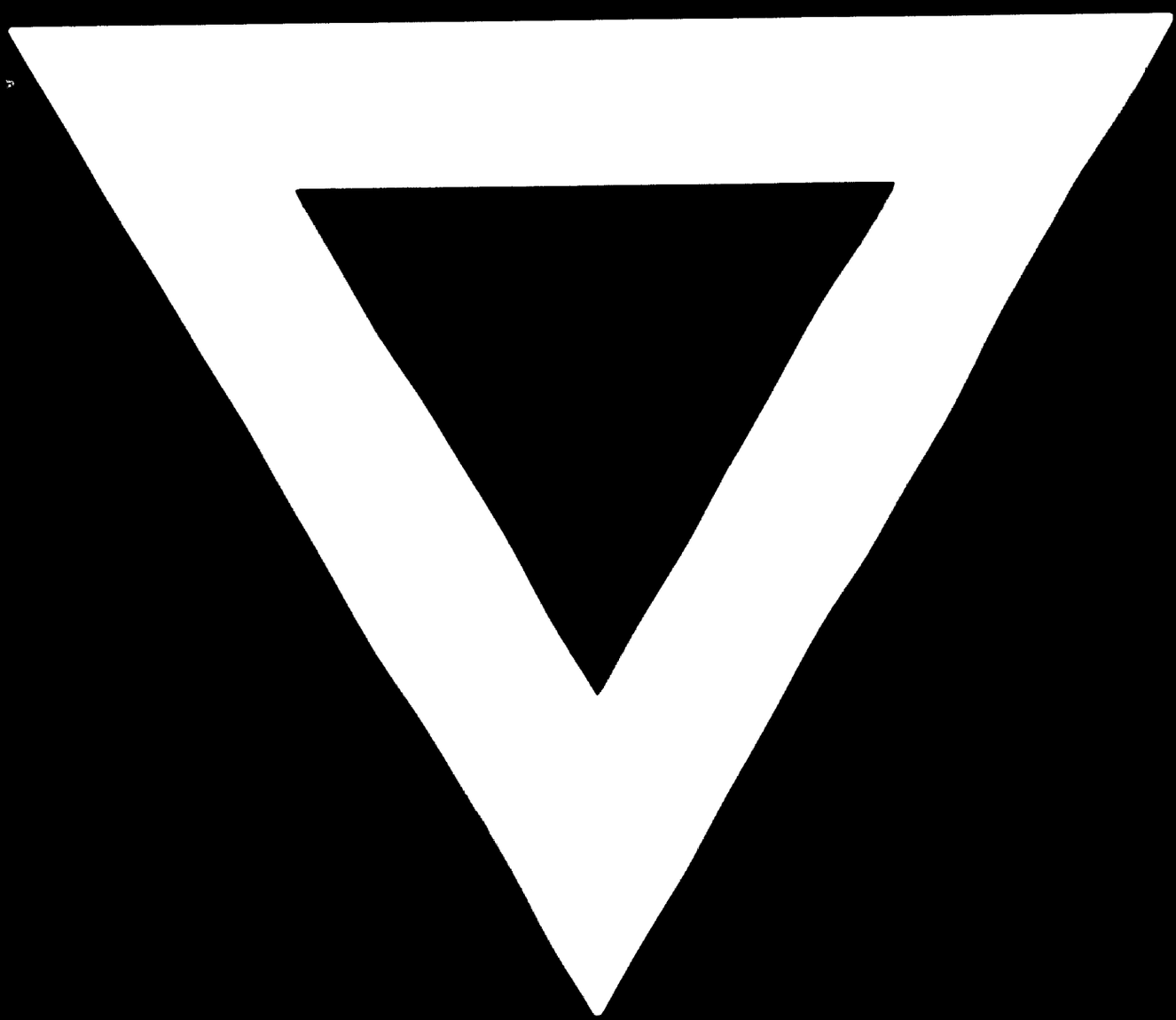

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