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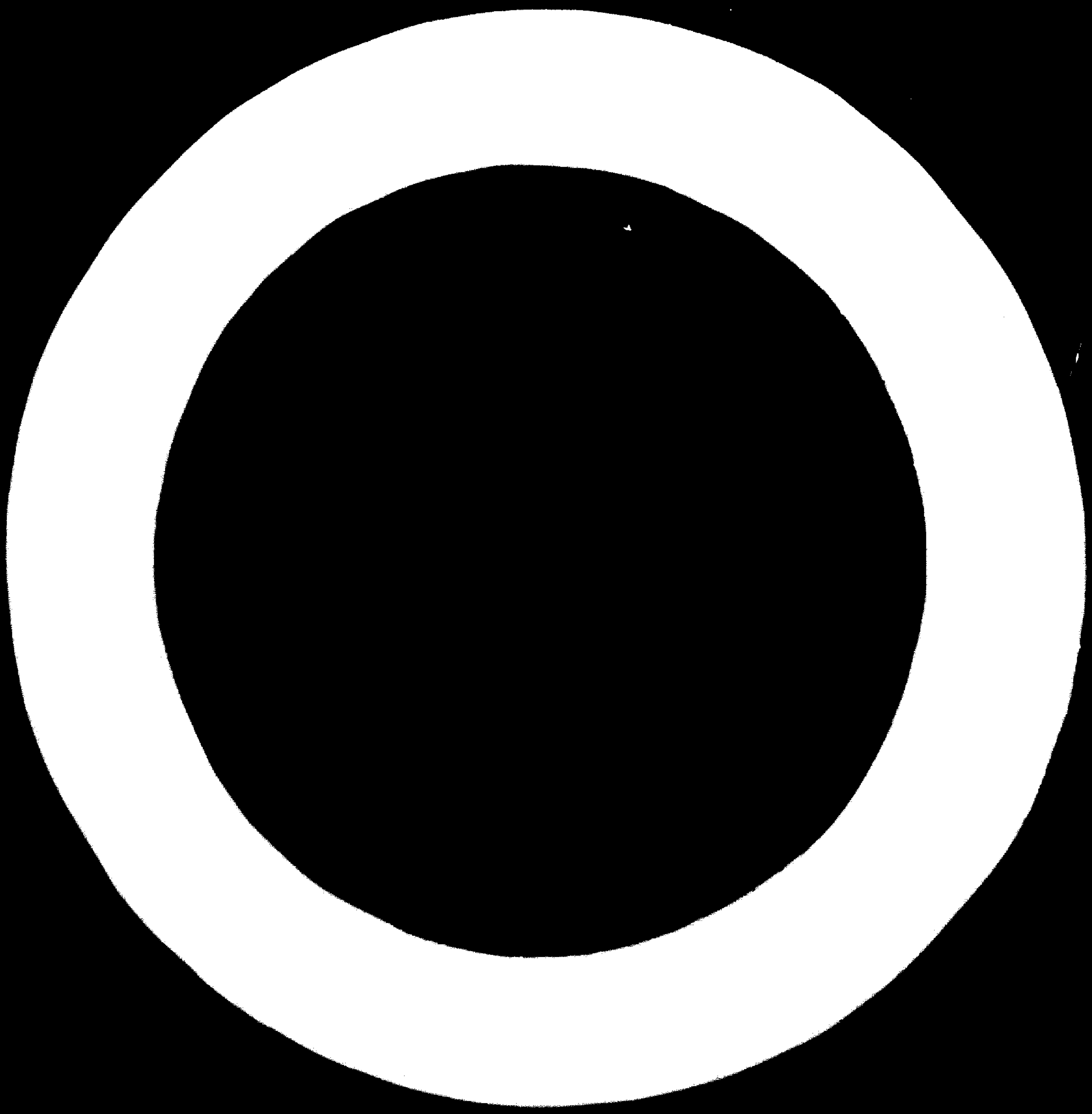

PROCEEDINGS OF THE INTERREGIONAL SEMINAR ON INDUSTRIAL RESEARCH AND DEVELOPMENT INSTITUTES IN DEVELOPING COUNTRIES

Volume I. Parts One to Three

BEIRUT, LEBANON

30 November to 11 December 1964

UNITED NATIONS
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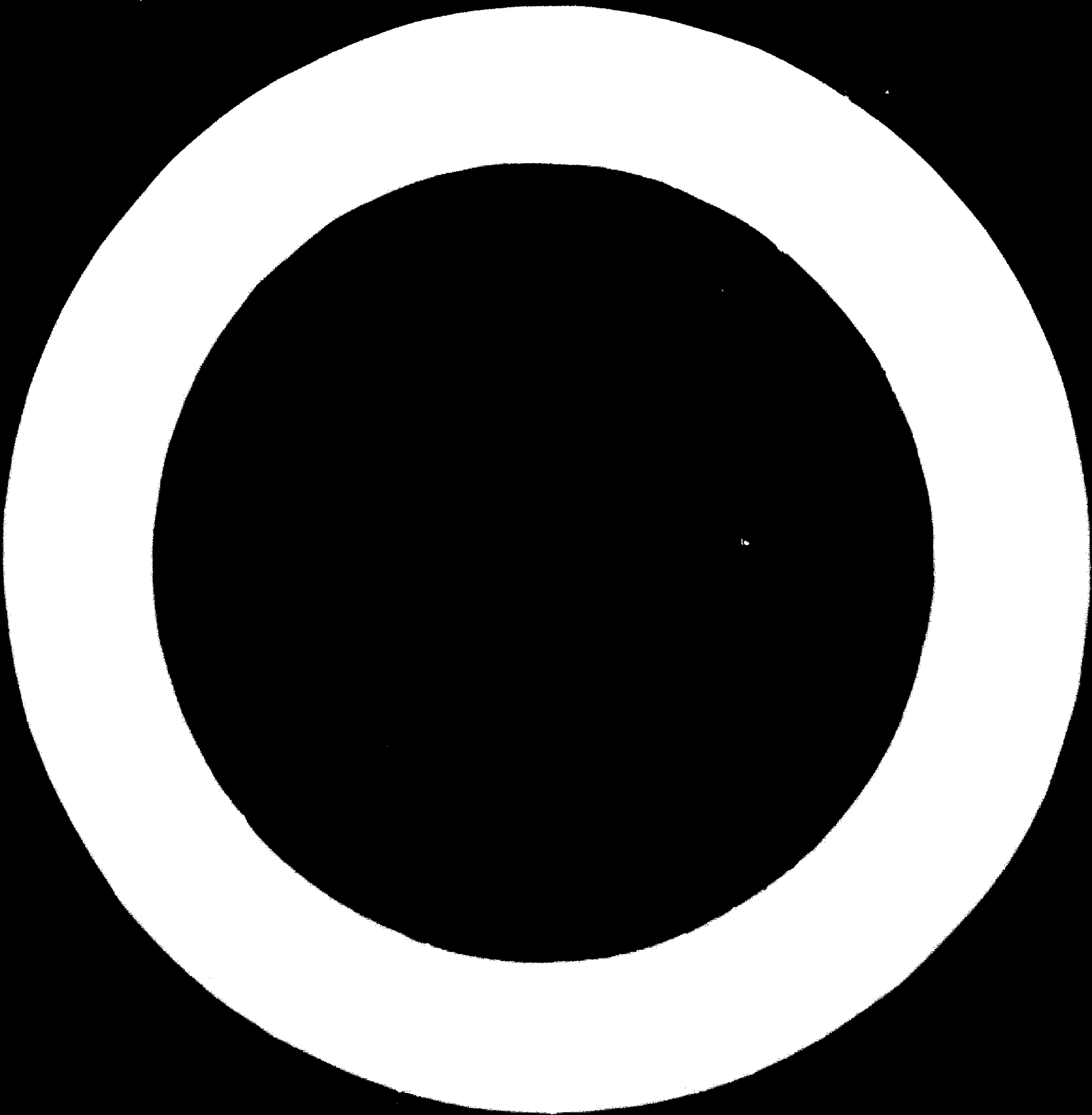
Volume I

Volume II



Part One - Report of the Seminar

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ANNEXES

INTRODUCTION

1. The present decade has witnessed a major upsurge of industrial activity in the developing countries of Africa, Asia and Latin America. In these countries, as in the more advanced ones, industrialization is recognized as a primary avenue to economic growth and development. Along with this recognition, and with the adoption of a development programme based on it, goes the need to establish or strengthen certain industrial services designed to cater to, and thereby expedite, the industrialization process. Industrial research and development are among the most important of these services.

2. Realizing the need to stimulate industrial research and development activity in the developing countries within an institutional framework, the United Nations, through the Centre for Industrial Development in co-operation with the Bureau of Technical Assistance Operations, and as part of its continuing programme of technical assistance to the developing countries, organized in 1964 an Inter-regional Seminar on Industrial Research and Development Institutes in Developing Countries, to provide a forum for a careful examination and discussion, on an inter-regional scale, of the special problems and other aspects of the organization and operation of such institutes. Representatives of twenty-five developing countries participated in the Seminar; these representatives were persons holding high positions of responsibility in the industrial activities of their countries and many possessed high professional and academic qualifications. Others in attendance and taking part in the proceedings included fourteen observers representing nine industrialized countries, seven representing the United Nations and its specialized agencies, and two representing private industrial institutions. Eight expert consultants chosen by the United Nations from various geographical areas and three members from the Centre for Industrial Development, including the Director of the Seminar, were also in attendance.

3. The documents submitted to the Seminar represent a valuable fund of information on the subject of industrial research and development institutes and related topics reflecting the experiences of countries at varying stages of economic development. These documents consist of: (a) country reports prepared by participants and dealing with various aspects of industrial research and development in their respective countries; (b) discussion papers prepared by expert consultants and observers; (c) working papers prepared by the Centre for Industrial Development; and (d) reference papers prepared by the Centre for Industrial Development, as well as by participants and expert consultants.

4. For the purpose of discussion, the proceedings were organized under three broad categories: (a) the concept and objectives of industrial research institutes (b) industrial extension services; and (c) organizational concepts and problems. The report of the Seminar includes a number of conclusions and recommendations that delineate possible areas of further action in this matter by the United Nations, and specifically by the Centre for Industrial Development, as well as by the Governments of the developing countries.

I. ORGANIZATION OF THE SEMINAR

5. The United Nations Inter-regional Seminar on Industrial Research and Development Institutes in Developing Countries was held from 30 November to 11 December 1964 at the Industry Institute, Beirut, Lebanon. The Seminar was attended by forty-eight participants and observers from Algeria, Argentina, Austria, Ceylon, Colombia, Czechoslovakia, Federal Republic of Germany, France, Ghana, India, Indonesia, Iran, Iraq, Italy, Lebanon, Libya, Madagascar, Malaysia, Mexico, Netherlands, Nigeria, Poland, Pakistan, Philippines, Saudi Arabia, Sudan, Syria, Thailand, Union of Soviet Socialist Republics, United Arab Republic, United Kingdom of Great Britain and Northern Ireland, United Republic of Tanzania, Upper Volta and Zambia; and from the Economic Commission for Africa, the United Nations Special Fund, the International Labour Organisation, the Food and Agriculture Organization of the United Nations, the United Nations Educational, Scientific and Cultural Organization, the Battelle Memorial Institute and Arthur D. Little, Inc. Eight expert consultants and three members of the United Nations Headquarters staff also were present. 1/

6. The welcoming address was given by the Honorary Chairman, H.E. Najib Salha, Minister of Planning of Lebanon. 2/

7. An opening statement was then read for I.H. Abdul-Rahman, Commissioner of the United Nations Centre for Industrial Development, by Azmi Afifi, Special Technical Adviser, Centre for Industrial Development, and Director of the Seminar. 3/

8. The Seminar unanimously elected the following officers:

(a) E. Lartey (Ghana) as chairman, and M. Taslimi (Iran) as rapporteur, for the discussion on the concept and objectives of industrial research institutes;

(b) S. Siddiqui (Pakistan) as chairman, and I. Deschamps (Mexico) as rapporteur, for the discussion on industrial extension services;

(c) S.M.A. del Carril (Argentina) as chairman, and Ai-Kim Kiang (Malaysia) as rapporteur, for the discussion on organizational concepts and problems;

(d) K.N. Saad (Lebanon) as chairman of the Co-ordinating Committee, composed of E. Lartey (Ghana), Baldev Singh (India), M. Taslimi (Iran), K.N. Saad (Lebanon), Ai-Kim Kiang (Malaysia), I. Deschamps (Mexico), C.G. Manuel (Philippines) and M. Halfawy (United Arab Republic).

1/ For details, *see* annex III.

2/ *See* annex I.

3/ *See* annex II.

9. After adoption of its agenda, 4/ the Seminar proceeded with the presentation and discussion of working papers, discussion papers and country reports. A list of these papers and reports is given in annex V.

10. At its final meeting, the Seminar unanimously adopted the present report containing recommendations and the conclusion reached. The Seminar expressed its sincere appreciation of the generous hospitality afforded by the Lebanese Government and by the Industry Institute and its gratitude to all expert consultants and observers.

4/ For details, see annex IV.

II. DISCUSSIONS OF MAJOR TOPICS

A. The concept and objectives of industrial research and development institutes

11. Research, both scientific and technological, as well as socio-economic, is an essential instrument in developing the human and material resources of a nation. Industrial research is of basic significance in laying the foundation for a sound industrial base and in accelerating the economic growth of developing countries.

12. Industrial research also plays an important supporting role in the formulation and implementation of national policy and economic development plans where these exist. It was considered advisable that industrial research should not be involved directly in the executive functions of Governments.

13. The need was stressed to graft indigenous research onto imported technology as soon as possible and to nurture such graft to full fruition to achieve increasing self-dependence.

14. It was agreed that the broad spectrum of industrial research should be given attention. Much discussion centred around the difference between basic, or fundamental, and applied research, and a consensus of opinion was reached that no clear line of demarcation could be drawn a priori. Perhaps this subject could best be looked at in the light of the expectation of short-term as against long-term benefits. It was agreed that developing countries should emphasize applied research, but that fundamental research should not be neglected.

15. Investment in industrial research should be recognized as in fact an investment in industry and even in the future of the nation.

16. Industrial research should cater to all types of industry, regardless of size, public as well as private, using such different methods of approach as are necessary. It should further attempt to develop technologies best suited to local needs and conditions.

17. The functions of industrial research and development include discovery of new products, prospecting for and utilization of raw materials, development, improvement or adaptation of production methods, techniques, processes or suitable equipment, pilot-plant trials, operational research, formulation of standards, quality control, marketing research, feasibility studies, and design and productivity studies.

18. The institutionalization of industrial research was considered to be one of the most effective means of promoting industrialization in the developing countries. A clearer delineation of responsibilities for industrial research and development functions can thus be achieved.

19. It was agreed that the industrial research and development institute should also be prepared to provide the services required in the implementation of an

industrial project on a rational and economic basis. It was noted that such services included feasibility studies covering, inter alia, markets, raw materials, plant location, capital requirements, production costs and potential profitability. They also included consulting services covering the choice of the most appropriate process and equipment and of a plant layout.

20. Furthermore, they cover design and construction supervision services where appropriate and should also extend through the initial stages of production and beyond. Services to existing industries would, in all likelihood, include consultation and trouble-shooting, production and quality control and advice on management problems. Such services could well, in turn, lead to further research on behalf of industry.

21. Whereas the integration of industrial research and development functions within one institute was given favourable consideration, it was felt that under certain conditions some functions could be better undertaken by other organizations, including appropriate government agencies. However, the value of team work and co-operation should at all times be preserved.

22. The selection of industrial research programmes and projects should be made in the light of national needs in both the private and public sectors. The research institute should also be in a position to respond to specific requests from industry.

23. It was noted that measurements were of extreme importance in research and development. In order to measure, it was necessary to adapt reference standards and to provide calibration facilities. The formulation of standards of quality and of codes of practice also was an important tool for industrial development. Accordingly, it was the consensus that research and development institutes should have testing facilities to serve both the needs of its research and of production and quality control.

24. It was recognized that industrial research institutes could contribute significantly to the efforts in both these fields through their laboratory facilities and the wealth of professional experience available within these institutes. Research and development institutes could also assist in promoting the application of standards by industry. Mandatory application of such standards, where appropriate, should be controlled by the State.

B. Industrial extension services

25. The term "industrial extension services" includes the whole range of activities by which scientific, technical and economic knowledge may be transferred into industrial practice to bridge the gap between industrial research and development, and the actual utilization of the results thereof.

26. With a view to its speedy application, industrial research should not be conducted in isolation, but in relation to the practical needs and requirements of industrial development. The research organization could only meet its responsibilities towards the nation by being fully associated with its industrial development objectives. An important function of such extension services was therefore to provide close contact between the problems of commercial production and the conduct of industrial research, and to promote the closest

co-operation and association between research groups all the way from laboratory bench-work through pilot-plant operations and those responsible for commercial production.

27. Particular attention was given to the role of industrial research institutes in connexion with:

(a) The responsibility of such institutes in the application of the results of industrial research;

(b) The choice of extension methods, including consultation and industrial information services.

28. It was generally agreed that industrial research institutes should give most serious attention to the processes of transmission of research and development results in order for such results to find effective use in the country's industries. Such institutes must also help accelerate the application of research results by industries in the developing countries. To do this most effectively, it was necessary to develop the appropriate mechanisms, firstly, to get to know the needs of industry and; secondly, to stimulate interest and generate confidence in research and development on the part of industry.

29. In obtaining and transmitting information generated or obtained by industrial research institutes, it was noted that two gaps must be bridged. The first gap was that between the research and development institute and the world reservoir of scientific, technical and economic information; and the second was between indigenous research organizations and the country's industries.

30. In the attempt to reach the country's industries and to stimulate their interest in science and technology, maximum use should be made of such tools as personal visits and contacts, demonstrations, training courses, in-plant trials and pilot operations, films, radio, exhibits and seminars. Seminars naturally also served to bring research institutes into close contact with similar organizations abroad.

31. Library and documentation facilities were strongly emphasized, not only as a necessity in the day-to-day research and development activities of the institutes, but also for the provision of information services to industry. It was considered important that such facilities should be made available for direct use by industry.

32. Industrial information services might include:

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

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

(c) Technical digest services;

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

33. In addition to the published literature, other mechanisms should be reviewed for locating research and industrial information of a practical nature which might be available through other institutes or organizations in the rest of the world. Such information might have to be adapted to local conditions with institute help before its introduction in industry.

34. In this and other connexions, it was considered worth while by the participants to explore fully the availability to research and development institutes in the developing countries of assistance in the field of extension services, among others, from international organizations, specialized agencies, foreign Governments through bilateral aid, other research institutes, and private consulting firms.

35. The need for adoption of the most appropriate extension techniques to meet the highly complex requirements of the whole spectrum of industrial development was repeatedly considered. It was agreed that no single solution could be devised which would automatically apply under the varying local conditions and environments prevailing in the developing countries and the methodology of industrial extension would thus have to be varied.

36. It was, however, considered that the circumstances and requirements of the developing countries were likely to be best served in many instances by a system in which the industrial research institute would also be responsible for the provision of extension services in its own field of activity. Integration of responsibility for both research and extension within the one institute would often help to ensure effective operation.

C. Organizational considerations and problems

37. It was noted that industrial research and development in the advanced countries were generally handled by one or more - most often a combination of several - of the following types of organizations:

(a) Laboratories of individual factories or firms;

(b) Autonomous non-profit corporate institutions of broad scope, which perform work on contract for both the Government and private enterprises;

(c) Specialized institutes, set up either by the Government or co-operatively (or with government subsidy) to serve particular fields of industry;

(d) Departments or institutions under certain ministries of Governments;

(e) Private consulting and research organizations operating for profit.

However, the developing countries to date had comparatively few organizations of types (a) or (e). Those which had initiated industrial research had done so under a variety of organizational patterns, most of which fell into categories (b), (c) and (d), or combinations thereof. Many developing countries had not yet launched institutional industrial research facilities, but were currently formulating plans for them as essential elements in their national economic and industrial development programmes.

38. In the choice of organizational patterns for the institutes, consideration must be given to a number of factors, such as:

(a) The level of economic and industrial development and the expected scale of growth:

(b) The type and scale of operation of industries existing or planned for development;

(c) The administrative set-up in the country;

(d) Special needs of any predominant raw materials;

(e) Financial resources and availability of scientific and technical personnel.

39. It was felt that a major benefit deriving from the Seminar was ample discussion of such topics as multi-purpose and specialized institutes, national or sub-regional institutes, and similar organizational aspects. This was of value to each developing country in making a choice of the preferred form of organization, or in some cases possible reorganization, of its industrial research structure for the most effective impact.

40. However, it was noted that where limited staff and resources were to be employed to offer a wide range of services to multiple types of industry, the multi-purpose institute offered obvious advantages.

41. As a useful compromise, some countries had situated numerous specialized institutes within one physical complex or "technological centre", which also permitted them to share the use of certain common facilities.

42. Concerning regional or sub-regional industrial research institutions, it was observed that some were operating successfully despite the inherent problems of regional operation. Such success depended on an unusual homogeneity of the peoples, their historic ties and concurrent programmes of economic integration or common markets.

43. It was the general opinion that the industrial research institutes themselves should assume a leading role in the selection and initiation of research projects relating to industrial development, since they were best equipped to identify these problems and to estimate their chances of solving them. At the same time, such research projects, other than those requested directly by industry, should be decided upon in collaboration with economic and industrial planning authorities to ensure their relationship to over-all development goals. On the whole, it was felt that this collaborative form of research selection was more fruitful than systems of external direction by co-ordinating bodies or rigid control by government, administrative and planning authorities. Moreover, once projects had been agreed upon, the institute should have sufficient autonomy in the execution of its functions.

44. In the view of many representatives, the choice of research projects should not be too restricted and while applied research was the primary objective, institute budgets should allow for a certain amount of basic or background

research. It was also acknowledged as essential that an institute be free to pursue promising self-initiated projects, as otherwise many valuable ideas generated by the research men themselves might be stifled.

45. While close co-operation between universities and research institutes should be cultivated, the primary responsibility for industrial research should be vested in the research institutes. Such close liaison would bring about free interchange and cross-fertilization of ideas and thus help to bridge the gap between workers in pure and applied science.

46. Industrial research institutes should also maintain close working relationships with other research and technical organizations, local and foreign, as well as with institutions concerned with industrial development and finance and other aspects of national development and, above all, with the industries themselves.

47. The role which established institutes and organizations could play in the setting up of new ones was recognized as a very useful one.

48. It was observed that most industrial research institutes in the developing countries were, and must be, directly or indirectly financed in a large measure by the Governments. With some exceptions, however, they commonly had some degree of autonomy.

49. Some institutes serving primary industries had funds derived from taxes or levies imposed on the commodities produced. In certain countries, levies were also made on the manufacturing industries to finance industrial research, irrespective of whether they availed themselves of the service or not.

50. In some institutes, the support consisted partly of government grants and partly of fees or contract income earned directly through services to industry. For a new institute, the latter was likely to be the smaller share until industry had learned the value of such services and the institute had gained its confidence through demonstrated performance. In any event, it was generally preferable for a research institute to charge for its work on some basis, both for proper appreciation of the services by the user and to keep the institute oriented realistically toward the actual needs of industry.

51. Nevertheless, it was the consensus that in all developing countries, the Governments had the responsibility and obligation to guarantee adequate financial support on a long-term basis to their industrial research institutes to ensure continuity in their work and to permit them to fulfil their basic objectives.

52. Industrial research and development institutes must be staffed with the most highly qualified people available at all levels. An institute cannot function successfully with a staff inferior to that of the enterprises it expects to advise. Thus, such an institute must be in a position to compete for the best men. In a large number of the institutes reporting to the Seminar, this appeared as one of the chief problems. In particular, those operating under civil service salary limitations were experiencing difficulty, both in attracting the most able staff and in retaining them under competitive conditions. It was considered that the research institutes should have autonomy in the selection of personnel.

53. Apart from this aspect, in view of the common scarcity of research personnel, a number of institutes in developing countries had launched sizable internal and external training programmes. It was felt that such training programmes were of extreme importance and should be strengthened where necessary.

54. Some countries had experienced difficulty in obtaining experts of the types and with the qualifications required, or in obtaining them within a reasonable time to meet the demands of the programme. The staffing problem continued to be the greatest common difficulty of industrial research institutes in most developing countries.

55. In the equipping of laboratories and the setting-up of facilities for research and development, adequate repair and maintenance facilities, workshops and skilled technicians should be included.

56. Some of the institutes in developing countries had been launched with bilateral or international technical assistance. The generally favourable reports on such assistance stressed the value of help in the initial organizational stages and in counterpart training, as well as in providing individual specialists for specific work.

57. It was the consensus that despite the great value of external technical aid, it could not serve as a substitute for the development of local staff, needed in larger numbers.

III. RECOMMENDATIONS AND CONCLUSIONS

58. The following recommendations and conclusions were set forth:

<u>The Inter-regional Seminar on Industrial Research and Development Institutes in Developing Countries,</u>

<u>Recognizing</u> the role of industrial research and development as an essential element in accelerating economic growth,

<u>Conscious</u> that the differing administrative and socio-economic conditions of the countries must influence the institutional instruments required to perform this role most effectively in each case,

<u>Recommends and concludes</u> that:

1. Developing countries should take the necessary steps as soon as possible to establish appropriate industrial research and development facilities or to strengthen existing ones on lines most applicable to the practical requirements and national development goals;

2. With due recognition of the importance of basic research, the emphasis of these research institutes should be upon applied research and development programmes fully oriented toward the needs of industry;

3. Industrial research and development institutes should be given the greatest possible autonomy to enable them to function in the most efficient manner; without the inhibitive influence of ordinary government procedures and restrictions generally incompatible with the needs of successful research operation;

4. Personnel engaged in research and development should be rewarded on a scale that will at all times enable the research institutes to engage and retain the best personnel to be found and to ensure their complete devotion to the work;

5. Governments of developing countries should be called upon to accept full responsibility for the provision of adequate financial support on a long-term basis to their industrial research institutes to ensure continuity in their work and to enable them to fulfil their basic objectives.

6. Equipment and supplies of all kinds needed for industrial research should be exempted from customs duties and taxes, should not be subject to import restrictions or licence, and should be allocated adequate foreign exchange in all cases;

7. The United Nations should enlarge its programme to assist developing countries directly in (a) on-the-spot studies of industrial research and development organizations or needs in individual countries with a view to establishing and/or strengthening such institutions and their operating links with industry, (b) the implementation of such studies, including the establishment, equipping and operating of such institutions and the training of industrial research personnel;

8. The United Nations should study, and keep under review and disseminate information on the organizational aspects, functioning and programmes of the various industrial research and development institutes and similar organizations or departments, with a view to facilitating the interchange of such information between different countries. The United Nations should also assist in the interchange of visits between industrial research personnel in different countries;

9. The United Nations should assist the developing countries by undertaking detailed studies of the various systems of consulting services, patents, different types of licence agreements and contracts, the systems of tenders, the various available licences and know-how etc. The results of these studies should be made available to developing countries,

10. The United Nations should hold periodic meetings, whether regional, continental or inter-regional, to study and discuss various problems and issues in the field of industrial research and development;

11. The Seminar calls upon the developing countries, as well as upon the Centre for Industrial Development, to take the necessary steps to further the implementation of these recommendations;

12. The Seminar wished to express its thanks to the United Nations Centre for Industrial Development for holding this meeting and to the host Government of Lebanon for its hospitality.

ANNEX I

ADDRESS BY H.E. NAJIB SALHA, MINISTER OF PLANNING, LEBANON, AT FIRST SESSION OF THE SEMINAR

I am particularly glad to be able to welcome you and to wish you a pleasant stay in Lebanon and every success in the discussions at your Seminar.

In order to achieve comprehension and understanding between nations, as well as between individuals, there is nothing like knowledge, and particularly scientific knowledge, based on reason and buttressed by experience. For it is the scientists who are most involved in the accumulation of true knowledge, which is also modesty. Truth and modesty are the basis of fruitful and beneficial co-operation, since mutual understanding is impossible when logic gives way to passion, and modesty - the necessary prerequisite for objective knowledge - to pride and egoism.

This is why, in addition to being pleased at having you meet in our country, we are proud that the purpose of your presence among us is to study the contribution of scientific research and research institutes to development and to the growth of industry in the developing countries. We therefore offer the United Nations our most sincere thanks for having accepted our invitation to hold this Seminar in our country.

It is quite obvious that the developing countries need industrial development and their needs are all the more pressing because, owing to the recent appearance of industry and the lack of resources, industrial development there cannot be allowed to take its course without planning and help. Planning based on knowledge and experience constitutes the best support and provides the most solid foundations.

Our small country, at many times in the course of its history and most recently during the last century, has taken a position which shows its love of knowledge and its devotion to the principle of co-operation and brotherhood among men.

This is why, now that you are here for this Seminar under the banner of mutual understanding and in an atmosphere of scientific knowledge in which each may benefit from the learning and experience of all the others, the welcome extended to you by Lebanon is a sincere one and its sincerity is rooted in the traditions of this country's very long history.

ANNEX II

MESSAGE FROM THE COMMISSIONER FOR INDUSTRIAL DEVELOPMENT[a/]

Dr. Abdel-Rahman, United Nations Commissioner for Industrial Development, has asked me to communicate to you his deepest regrets for not being able to attend this Seminar and has requested me to convey to you the following message:

Institutional industrial research is of comparatively recent origin in the world through which opportunity is created for technologists, chemists, economists, engineers and social scientists to work simultaneously in a co-ordinated manner rather than separately. This enables them to view and deal with all the aspects of a given problem so as to achieve effective practical solutions which are demanded continuously by the large variety of industrial activities.

It has been only in the last two decades that developing countries have established research organizations in one or another form. Some of these organizations are still facing many problems in serving the actual needs of industry, and there is admittedly room for improvement in co-ordination and optimum utilization of local research facilities to make of the existing institutions a recognized element of support in the process of industrial development. Further, some developing countries as yet have no such facilities to serve industry.

In this sense, the Inter-regional Seminar on Industrial Research and Development Institutes in Developing Countries can be viewed as properly a part of the evolution that is taking place in the field of industrial research. Its purpose of studying the role of research and development in supporting the process of industrialization is thus a matter of immediate concern within the present stage of evolution reached in this field. With this in mind, the Seminar should be able to deal with such questions as: how can the existing research facilities in the developing country be co-ordinated, utilized to the fullest extent possible and geared towards the real needs of industrial development? What responsibilities do research organizations have for the application of results of scientific and technological progress as well as for the adaptation and transmission of industrial experiences and information? What are the over-all organizational problems of new and existing industrial institutes? How can local research organizations strengthen their relationship with other organizations and private consultants in the country and abroad?

I hope from your examination and discussion of these questions you will be able to draw conclusions and recommendations which will benefit the process of industrialization in developing countries and at the same time offer guidelines for further United Nations activities in the field of industrial research and development.

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a/ Read by Dr. Azmi A. Afifi, Director of the Seminar.

From the point of view of the United Nations it is particularly gratifying to find that the high level of the participants at the Seminar is combined with a wide geographic representation. Many of the outstanding papers prepared by the participants reflect the large variety of conditions prevailing in their respective countries. This should enrich the exchange of ideas and information and make for a better understanding of the practical requirements of research programmes.

The Government of Lebanon has graciously invited the United Nations to hold this Inter-regional Seminar on its soil and in one of its successful industrial establishments - the Industry Institute. May the Lebanese authorities accept my gratitude for providing this opportunity to meet and discuss common problems in such a friendly atmosphere.

Our gratitude also goes to the Governments, specialized agencies of the United Nations, expert consultants and organizations who have generously given active support and co-operation for this undertaking.

To all participants, may I extend my best wishes for a successful meeting.

ANNEX III

PARTICIPANTS AND OBSERVERS ATTENDING THE SEMINAR

Honorary Chairman: H.E. Najib Salha
Minister of Planning of Lebanon

H.E. Professor Joseph Najjar, President of the National Council of Scientific Research, deputized for the Honorary Chairman after the opening session.

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List of those who contributed papers but did not attend the Seminar:

D. Hertz - Organizing integrated industrial research and development institutes

B.R. Williams - The role of research and development institutes in applying science to industry

F. Schippers - Project-wise management of an institute serving industry

J.L.M. Dawson - The psychological effects of industrialization and organization in Sierra Leone

ANNEX IV

AGENDA OF THE SEMINAR

1. Opening addresses

2. Election of officers

3. Adoption of the agenda

4. The concept and objectives of industrial research and development institutes:

    4.1 Research, development and promotion activities to strengthen manufacturing industries;

    4.2 Types of technological and socio-economic research serving industry;

    4.3 Feasibility studies;

    4.4 Laboratory testing and standards.

5. Industrial extension services:

    5.1 Responsibility of the institute for the application of results of industrial research;

    5.2 Scope of industrial extension and choice of extension methods;

    5.3 Consultancy services;

    5.4 Problems of adaptation and transmission of industrial information.

6. Organizational considerations and problems;

    6.1 Multi-purpose, special, national, regional, private and public institutes;

    6.2 Relationship with universities, industry, development corporations, private consultants, and other organizations and establishments in the country and abroad;

    6.3 Financial policies;

    6.4 Problems of staffing;

    6.5 Examples of organizational structure of some institutes;

    6.6 Bilateral aid;

    6.7 United Nations technical assistance.

7. Adoption of recommendations.

Annotated Agenda

I. The concept and objectives of industrial research and development institutes

1. The first item on the agenda is designed to introduce the whole subject of the Seminar and to discuss the various concepts and objectives of industrial research institutes, taking into consideration the varying conditions and levels of development in developing countries.

A. Research, development and promotion activities to strengthen manufacturing industries

2. Discussion will concentrate on the institutional approach to research and development as well as the application of results of research. The institutes will be considered as an interrelated part of the general over-all industrialization efforts in the developing countries.

3. The importance of research and development to industry will be discussed. Though industrial research includes both basic and applied research, more emphasis will be given to the applied type. Research activities of the institutes may cover both self-initiated research in the national interest and research based on specific requests of the private and public industrial sectors.

4. Technological research will have a prominent place in the discussion; however, economic research, which includes industrial planning research, and which is equally as important, will also be discussed.

5. The discussion on development may cover the technical activities related to the translation of industrial research findings into various processes or products. Thus, development activities of the institute may include pilot projects, processes or product design, economic feasibility of processes, market research, etc.

6. The discussion on the concept and objectives of promotion activities of the industrial institutes will include filling the gap between industrial research and development, on the one hand, and manufacturing on the other; strengthening relationships with local industrialists and providing them with various consultative and technical assistance services.

7. The effect of environment on research, and vice versa, will also be discussed.

B. Types of technological and socio-economic research serving industry

8. The integrated approach to technological and socio-economic research will be emphasized during the discussion. Also, research operations will be taken into consideration and attention will be given to team-work and the collective approach to the solution of problems.

9. Industrial research may take the form of discovery and utilization of raw material, development or improvement of production methods and techniques, development or improvement of suitable equipment, operational research, quality control, marketing research, cost and economic profitability, adaptation of production techniques and processes to the local workers and vice versa, problems of absenteeism and labour turnover as affected by type of technology used, product design, productivity studies, etc. Conditions in developing countries will, no doubt, influence the type of research adopted by the institutes.

10. It is intended to cover the general aspects of the selection of research projects since it affects the plan of operation of the institute, the requirements for personnel and cost.

C. Feasibility studies

11. The Governments, local investors and/or industrial development corporations may require feasibility studies on the economic and technical soundness of industrial projects. How best could the institute carry out these studies - alone, in combination with foreign consultants, or by serving as a liaison between the users and foreign firms?

12. The role of the industrial research and development institute in undertaking feasibility studies will be investigated.

D. Laboratory testing and standards

13. Apart from the laboratory testing needed for research, the institute may be called upon to conduct ordinary laboratory testing to assist local industry or government departments with some of their needs. How much of this service should the institute provide?

14. As an important research activity the institute may assist the Government or the industry in formulating standards of identity and quality for industrial products and materials. This service, in some countries, is done on an advisory basis and the regulatory activities are left to other public bodies to carry out.

15. The possible activities of the institute in laboratory testing and formulating standards will be reviewed.

II. Industrial extension services

16. The second item on the agenda will include the discussion of the practical aspects of services provided by the institutes to the manufacturing industry.

A. Responsibility of the institute for the application of results of industrial research

17. In many instances, the rates at which research results are applied by industry is slow. This may be owing to numerous reasons among which are the lack of communication between research and industry; the lack of technical manpower and economic as well as procedural difficulties.

18. Attention will be given to the responsibility of the institutes for the application of results of research and their role in stimulating the desire for change and encouraging appropriate industrial development procedures among local industrialists.

B. Scope of industrial extension and choice of extension methods

19. Industrial extension serves as a two-way channel between the institutes and industry. While it assists the local industrialists in gaining knowledge and adopting suitable methods and techniques in industrial production and management, at the same time it helps the institutes to become acquainted with the real problems of industry.

20. The methods of industrial extension are varied and the choice of a particular type will be influenced by the prevailing conditions. Individual and/or group contact methods will be used by the institute. These methods may include personal visits, demonstrations, training courses, pilot plants, films, radio, exhibitions, publications, seminars, etc. A review of suitable extension methods will be discussed.

21. Field technical assistance may also be an important activity included in extension services in order to raise the productivity of local industry. Such assistance embodies arrangements for the training of high technical personnel and industrial managers. The experience of various countries in this field will be explored.

C. Consultation services

22. The institute may provide expert consultants who visit industrial establishments to study specific problems on the spot. The consultants are either members of the institute or may be engaged specifically to perform a short-term task. The consultative services of the institute encompass various fields, such as plant layout, better use of equipment, production control, cost and accounting, quality control, marketing, etc. The consultation service of the institute may also include assistance to industry in locating sources of specialized industrial information and it may serve as a liaison between the local entrepreneurs and foreign consultants.

23. The importance and role of consultancy services of the institute will be investigated.

D. Problems of adaptation and transmission of industrial information

24. The industrial research and development institutes may serve industry through numerous information mechanisms, such as:

(a) Technical inquiry service, which offers answers to individual inquiries relating to production methods and techniques, industrial management, factory engineering, equipment, marketing, etc.;

(b) General industrial information service which provides industrial information of a general technical nature which is of pertinent interest to local industrialists. Such information may include trends and suggestions in utilization of raw materials; operating instructions; industrial projects and programmes, etc.;

(c) Technical digest service, which reviews available literature and extracts technical information;

(d) Training manuals for the use of skilled technicians and industrial managers.

25. The information needed by industry may be available in the country or abroad. In either case, the institute will seek to accumulate it, adapt it to suit local conditions and transmit it to users. The institute will establish contacts with various sources of information locally and abroad.

26. The discussion will deal with aspects of problems, techniques and machinery of gathering, adaptation and transmission of foreign techniques and knowledge as well as results of local research and studies.

III. Organizational considerations and problems

27. The third item on the agenda will deal with the over-all organizational problems of institutes and will consider ways and means of securing an effective institute serving the purposes of industrialization.

A. Multi-purpose, special, national, regional, private and public institutes

28. This section will include a discussion on organization patterns of industrial research and development activities in Africa and the Middle East, Asia and the Far East, and Latin America.

29. Varying conditions and stages of development in developing countries will undoubtedly influence the nature of the institute. A review of the following types of institutes will be made: the special institute which serves a particular industry; the multi-purpose institute which serves more than one industry and covers a group of activities; the national institute which serves the country as a whole; the regional institute which serves more than one country in the region; the private institute which operates independently; and the public institute which is operated by the State.

B. Relationship with universities, industry, development corporations, private consultants and other organizations and establishments in the country and abroad

30. Because the research institutes are not expected to function in isolation from local and foreign organizations, a system of co-operation and co-ordination should exist between the institute and related organizations, such as universities, industry, development corporations, etc. Some institutes include representatives of these organizations on their boards.

31. Possible ways and means of strengthening the relationship between the institutes and various organizations will be studied.

C. Financial policies

32. The financial security of the institute is an important element in its success. Should the institute be self-supporting? Should it be supported by subsidies or grants from the Government? Or should it adopt a combination of two systems, such as contracts and grants?

33. It is intended to review the various methods applied in the financial administration of institutes.

D. Problems of staffing

34. Discussion will include the need for highly technical personnel and their supporting technical service staff, such as chemical analysts, machinists, photographers, etc.

35. Owing to the shortage of such staffs in many developing countries, the recruitment of foreign personnel is needed. How does this affect the cost of running the institute? What type of training of nationals on the job and abroad is needed? What methods should be adopted to attract local personnel to work in the industrial research institutes? In discussing these points, the specific experiences of developing countries will be reviewed.

36. The subject of whether the industrial extension officer should be a specialist in a particular branch of industry or a generalist will be discussed. Since his role is an important one in gaining the confidence of local industry, the industrial extension officer's training in methods and techniques of extension services will be given attention.

E. Examples of organizational structure of some institutes

37. A review will be made of various organizational structures of national, regional, public and private institutes throughout the world.

F. Bilateral aid

38. Various developing countries have received technical assistance through bilateral aid programmes. The experience of developed, as well as developing, countries in establishing the institutes will be discussed.

G. United Nations technical assistance

39. The policies and programmes of the United Nations to assist the developing countries in the establishment and running of industrial research and development institutes will be reviewed.

IV. Adoption of recommendations

40. The recommendations which will be adopted by the Seminar will be the result of the various papers submitted and discussions that take place. In drawing the recommendations, the participants will take into consideration the possibility of implementing them by countries and by international organizations concerned.

ANNEX V

LIST OF DOCUMENTS

Working Paper 1	The Role of Research and Development Functions in Supporting Industrialization in Developing Countries	United Nations Centre for Industrial Development
Working Paper 2	Organization of Industrial Research	United Nations Centre for Industrial Development
Discussion Papers		
1	The Role of Industrial Research Institutes in Developing Countries	I. Malecki
2	Organizing Integrated Industrial Research and Development Institutes	D.B. Hertz
3	Industrial Research and Development in the United Kingdom	United Kingdom Department of Scientific and Industrial Research
4	The Role of Industrial Research Institutes in Undertaking Technological Research and Feasibility Studies in Developing Countries	N. Tanyolac
5	Formulation and Selection of Projects for a National Institute of Industrial Research	A. Sundralingam
6	Applied Research, Development, Tests and Standards in the Developing Countries	D. Zanobetti
7	Some Aspects on Research and Testing Laboratories and Standards	R. Vieweg
8	The Role of Research and Development Institutes in Applying Science to Industry	B.R. Williams
9	Netherlands Technical Consulting Service	Development Centre, Delft
10	Scientific Information and Technical Advisory Services to the United Kingdom Industry	United Kingdom Department for Scientific and Industrial Research

List of documents (continued)

Discussion Papers		
11	The Scientific and Technical Documentation Centres and their Utilization for Information Needs of Industry in Developing Areas	United Nations Educational, Scientific and Cultural Organization
12	The Organization of Industrial Research in Belgium	Louis M. Henry
13	Industrial Research Institutes for Serving Manufacturing Industries	P.Ç. Trussell
14	Organization Form and Operating Policies for Industrial Research and Development Institutes in Developing Countries	F.W. Godwin
15	Industrial Research in Yugoslavia	B. Rakovic
16	The Management Consultant and the Industrial Research and Development Institute	J.D. Mooney
17	The Organization of Technical Research in the Czechoslovak Socialist Republic	Ing. J. Dittert
18	Organization of Industrial Research in France	Jean-Louis Kahn
19	The Development of Industrial Research Institutes	R.R. Adams
20	Organization of Industrial Research on a Regional Basis with Particular Reference to "ICAITI"	M. Noreiga Morales
21	Project-Wise Management of an Institute Serving Industry	F. Schippers, Delft
22	The Research Institute as a Channel for Utilization of Foreign Technical Skills	L.W. Bass and S.J. Langley
23	The Organization of Scientific and Industrial Research in the United Kingdom	United Kingdom Department of Scientific and Industrial Research
24	Technical Sciences in Poland	I. Malecki
25	Planning of Scientific Research in the Soviet Union	N. Oznobin
26	An Appraisal of German Experiences in Industrial Research and Development for the Industrialization of Developing Countries.	K. Billerbeck

List of documents (continued)

Discussion Papers

27	Austria's Contribution in Industrial Research	K. Döttelbacher
28	Organization Patterns of Industrial Research and Development Activities in Asia and the Far East	Economic Commission for Asia and the Far East

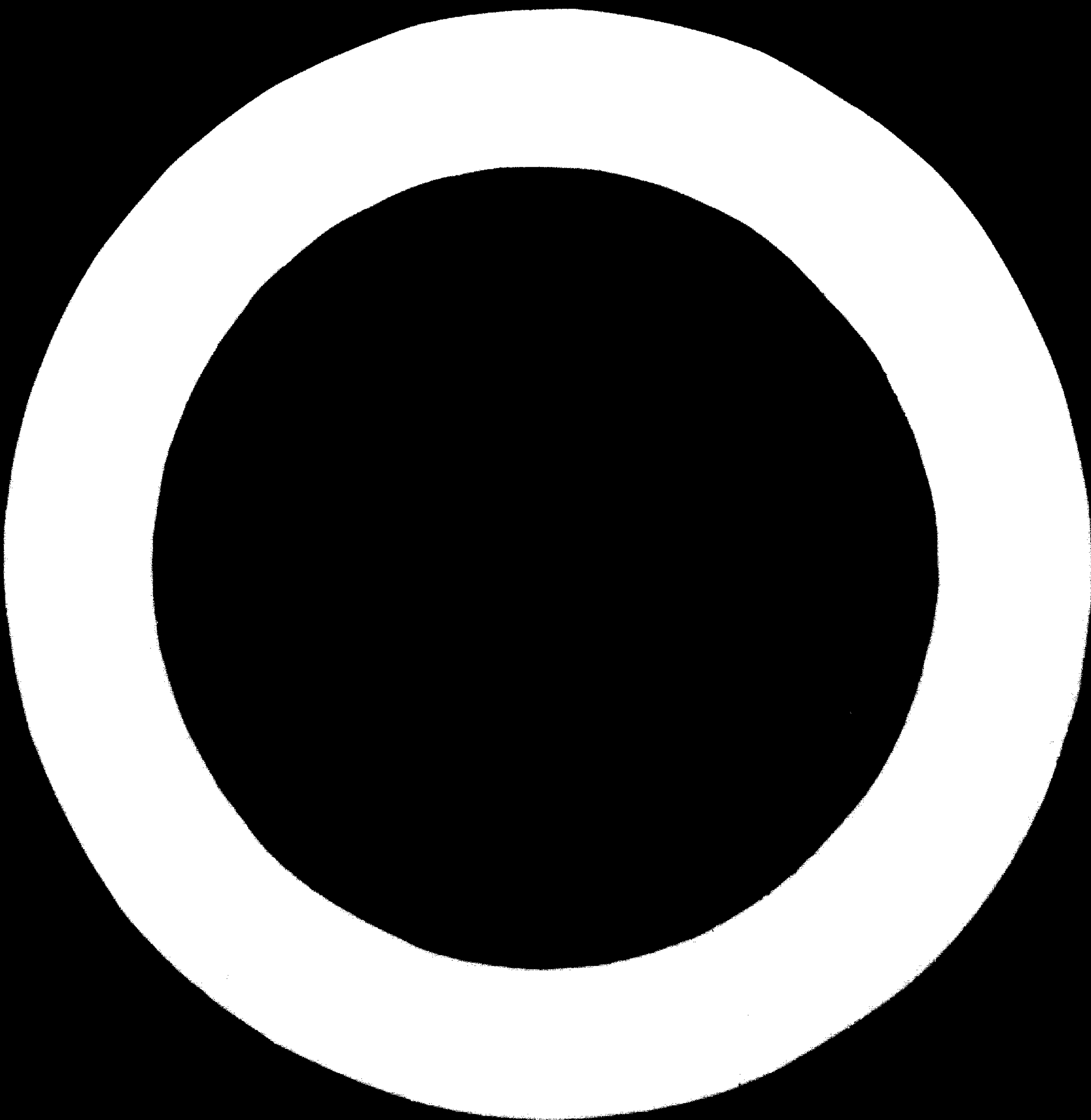
Country Reports

1	Industrial Research in the Philippines	Canuto G. Manuel
2	Industrial Research and Development in Thailand	C. Surasiti
3	Industrial Development and Research in Singapore	A.K. Kiang
4	Report on Industrial Research in India	Baldev Singh
5	Industrial Research in Iran	M. Taslimi
6	Industrial Research in Ceylon	A. Navaratnarajah
7	Planning and Progress of Scientific and Technological Research in Pakistan	S. Siddiqui
8	Report on Industrial Research in Argentina	S.M.A. del Carril
9	The Role of the Mexican Institute of Technological Research with the Scope of the Organization of Industrial Research in Mexico	I. Deschamps
10	Industrial Research Specialized Institutions in Colombia	H. Franco Bravo
11	Industrial Research in the United Republic of Tanzania	J.B. Mkondya
12	Industrial Research and Development Organizations in Libya	S. Al Lishani
13	Industrial Research in Northern Rhodesia	J.P. Allchin
14	The Organization of Industrial Research in the United Arab Republic	M. El H. Halfawy
15	Industrial Research in the Sudan	A.M. Fadlalla

List of documents (continued)

Country Reports

16	Industrial Research in Ghana	E. Lartey
17	Industrial Development in Iraq	F. Sukkar
18	Industrial Research in Syria	A. Sallouta
19	Industrial Research in Lebanon	M.D. Attiyah
20	Organization of Industrial Research in Nigeria	C. Ezeji-Okoye



Part Two - Concept and Objectives of Industrial Research and Development Institutes

All papers in this part of the Seminar proceedings, other than those prepared by the United Nations Centre for Industrial Research and the United Nations Educational, Scientific and Cultural Organization, are published as presented by the author with such editorial modifications as were considered necessary. They express the authors' views and not necessarily those of the United Nations.

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CONTENTS (continued)

I. THE ROLE OF RESEARCH AND DEVELOPMENT FUNCTIONS IN SUPPORTING INDUSTRIALIZATION IN DEVELOPING COUNTRIES

Prepared by the United Nations Centre for Industrial Development

Summary

Industrial research offers a wide variety of supporting functions to serve national goals of industrial development on a regional, national, local or factory level. These functions have a role to play during the planning and execution of programmes and projects, as well as in solving problems of factory production.

It is recognized that industrialization needs three basic elements, namely, studies and research, whether technological or socio-economic; decisions from a proper authority, whether in the public or private sector; and implementation of these decisions and management of industrial production under prevailing conditions of industrial policies.

The developing countries vary in their level and stage of development. In some countries not all the supporting research functions needed for industrialization can be obtained locally. Although some of the functions can be fulfilled locally, there may be under-utilization of such facilities because of the lack of co-ordination, contact and dissemination of information. It is also recognized that research and development activities require better recognition as essential parts of industrialization by those authorities engaged in policy making.

In carrying out their functions, the industrial research and development establishments serve mainly in a consultative and advisory capacity. The decisions regarding policies and execution of programmes rest with the concerned government departments, the public or quasi-public authority, or the management of an individual factory. Yet through institutional research, the country can be sure that its decisions stem from the nature and needs of local environment and are based on facts and knowledge.

It is important to examine each situation on the spot in each country in order to identify the most suitable industrial research organization. In some countries, provinces or a specific branch of industry, it may be necessary to strengthen the existing research centres or units by linking them more closely with industrial development needs and by completing their functions with the addition of supporting units. In other countries, the need may be for the establishment of a multipurpose industrial research and development institute. In still others, co-ordination and liaison between industry and research - adapted in a form suitable to the situation and authority structure in the country - may be needed.

Introduction

1. The process of industrialization requires many interrelated activities, which in their totality contribute effectively to the acceleration of industrial growth. These activities encompass such elements as industrial planning and

policies, creation of favourable industrial environment, development of industrial projects, implementation of decisions, finance, training, management, etc.

2. The purpose of this paper is to illustrate the role of research and development functions in supporting industrialization in developing countries.

A. Illustration of research and development functions in support of industrialization

3. Research and development activities are usually carried out on an advisory and consultative basis. Although organizations which undertake research are not ordinarily decision-making organizations, their work strengthens the position to be taken by policy- and decision-making bodies.

4. The possible functions of industrial research and development in support of industrialization are:

(a) To survey, study, and develop local raw material;

(b) To develop new processes and improve existing ones;

(c) To develop new products or new uses for existing products;

(d) To improve industrial productivity;

(e) To study the technological and socio-economic feasibility of industrial projects;

(f) The development of standards and specifications;

(g) The choice of technology and study of scale of operation;

(h) The study of industrial location and site;

(i) To conduct marketing research and development.

5. The following are illustrations of many of these research and development functions.

Adaptation of foreign technology to suit local conditions

6. Foreign technology is abundant, and in developing countries local industries can utilize many of the available techniques and information. However, much of the foreign technology requires adaptation to suit each local environment - a fact which clearly illustrates the need for on-the-spot organized research and development.

Processes to suit local conditions

7. The technique of vegetable canning is widely known, and one important step is the processing, which involves heating the sealed can at a high temperature under pressure for a certain period of time. The processing temperature and time depend

upon certain factors, among which are the rate of heat penetration in the food being canned, as well as the micro-organisms contaminating the fresh food before the can is sealed. Local varieties of vegetables and sanitary conditions do not necessarily correspond from one country to another. One of the crucial questions facing the manager of a cannery in a developing country is whether or not he should process, for instance, a No. 2 can of beans at 250° Fahrenheit for thirty minutes, as practised in a different country. If he follows this method he may be under-processing the local food and causing food spoilage to occur, which, in turn will affect the health of the population as well as the economics of the factory. If, for example, for safety measures he decides to process the cans for five more minutes, he may be over-processing unnecessarily, which in turn will affect the quality of the product and increase the cost of production, owing to the prolonged heating. In order to eliminate guess-work, possible hazards or economic losses such as these, investigation and research on the spot would be required to determine the suitable processing time for various canned foods and to establish national standards.

Development and use of local materials

8. One of the functions of research and development is to survey the local raw materials in order to find substitutes for expensive imported ones, as well as to allow for the full exploitation of natural resources and agricultural materials. For example, through an on-the-spot study in Ceylon, it was possible to ascertain the possibility of producing citric acid from local molasses. The catalytic oxidation of alcohol from fermented molasses yielded the needed citric acid at a lower cost than the imported one. 1/

9. Although the technique of making artificial fibres is generally known, on-the-spot industrial research was still needed, for example, in the United Arab Republic, in order to properly utilize bagasse in the manufacture of viscose rayon. The local bagasse was investigated and was found to include 25 per cent pith, which is lower in cellulose and higher in ash content than the fibrous part. Early investigations indicated that about 40-50 per cent of the pith had to be removed to produce pulp suitable for viscose. As research continued in the National Research Centre, it was discovered that it was only necessary to remove 3 per cent of the pre-hydralyzed material in order to reduce the ash content to a suitable level. This research also resulted in producing suitable viscose pulps prepared under atmospheric pressures and without more additional chemicals or time than required in the conventional pre-hydrolysis method, which is the alkali method under high pressure. The final result was a superior quality and a less costly product derived through the proper utilization of local material. 2/

1/ Briefing on United Nations Affairs, vol. V, No. 10 (Nov. 1957).

2/ United Nations Conference on the Application of Science and Technology for the Benefit of the Less Developed Areas, "Possibilities of Producing Viscose Rayon and Nylon from Available Local Raw Materials and Blends with Natural Fibres", by H.M. El-Behery (United Nations document E/CONF.39/D/46), pp. 1-3.

Efficient use of equipment

10. Through research, industrialists can obtain knowledge which may lead to more efficient use of equipment. For example, investigation and study on the spot may be needed to assure that waste is reduced, life of equipment prolonged, and a high rate of production is maintained, which in turn raises productivity in the factory. An example from India illustrates how an on-the-spot study in a water-pump plant increased productivity and trebled the capacity of the cupola used for melting raw materials. 3/ The rejected castings were being scraped and re-melted as a procedure which management considered a necessary part of the process, because they were unaware of the relative frequency of the defects. However, through careful investigation and study, it was discovered that although both the layout of the factory and the product were satisfactory, a significant number of castings were rejected, owing to the presence of air pockets in the castings, which could not be discovered until the castings were machined. This defect was owing to the air intake in the cupola being insufficient to produce a consistent suitable temperature, thus causing blowholes in the casting. It was discovered that the temperature control was malfunctioning and the cupola was improperly designed, and that the air intake had been allowed to clog. Correction was made and the capacity of the cupola was trebled.

11. Much information is known about the efficiency of equipment manufactured abroad for use under known conditions. However, using the same equipment under different environmental conditions may result in frequent breakdowns, lower productivity, a shorter span of life or higher cost of production. For instance, working conditions in local factories, the level of education of personnel, or the prevalence of sand or dust in the area may have an adverse effect on the wear and tear of machinery. Through research and development in developing countries, solutions may be obtained to adapt equipment to local environment or vice versa.

Laboratory testing and standards

12. Industrial standardization accelerates industrial development in many ways. For example, it helps conserve labour and materials, it improves the output quantitatively and qualitatively; provides a basis for comparison, inspection and settling industrial disputes, and simplifies training of personnel.

13. Through industrial research, advice and assistance can be given to the Ministry of Industry, chambers of commerce, trade associations, or individual establishments in the formulation, application, review and dissemination of standards of identity and quality for industrial products, manufacturing and engineering standards, purchase specifications and the use of standard marks.

14. Also through the laboratory testing facilities of some of the research organizations, assistance can be given to local industry or government departments to satisfy some of their needs. For instance, it may be necessary in some areas to analyse the clay deposit in order to know its properties and to determine what extra elements are needed to obtain ceramic products of good quality.

3/ Industrialization and Productivity, Bulletin No. 3 (United Nations publication, Sales No.: 60.II.B.1), "Use of Statistical Quality Control in the Industry of Under-developed Countries" by William R. Pabst, Jr., p. 48.

Marketing studies and development

15. There are many marketing functions which can be investigated, studied and developed through research for the industrial sector in general, a group of manufacturers, or a given factory. Thus, assistance can be given to determine the potential market. Who is the potential consumer, what and when will he buy, and how much is he expected to buy are some of the questions which can result in the right selection of products for manufacture if answered scientifically.

16. One of the functions of research is to advise on problems of merchandising. Assistance can be given to a factory, for example, to investigate and solve the problems of packaging, labelling, branding and standardization of products. Assistance can also be rendered in collecting, analysing, evaluating and disseminating pertinent data on the competitive position and market trends related to given products.

17. It is important to create the confidence and interest of consumers in national products, and buying habits can be changed through an effective consumer-education programme. The Government, the chamber of commerce, or trade associations may seek the advisory and consultative services of one of the industrial research organizations in this task.

Location and site of plants

18. Through research, advice and assistance can be given to individual industrialists on the selection of the most suitable location and site for the industrial plant. The importance of proper plant location can be illustrated by an example in which the choice of a chemical plant location alone showed a variation in operation cost of $US400,000 every year. 4/ After deciding on the general location of an industrial plant, the choice of the site can also affect the costs of building, equipment and operation. For example, the general grading and soil conditions affect the decision on the foundation needed for the building, which in turn influences the cost of construction. Thus, industrial research can be of assistance even before a factory is built.

Suitable technique of production and pilot-plant studies

19. A new or improved process may result in a better product, the more efficient use of by-products or better waste recovery. A suitable quality-control programme will ensure uniform quality, increased output and lower-cost products. Good production methods will simplify work and result in the efficient flow of material.

20. One important function of research and development is to assist the country or individual establishments in improving or developing efficient production techniques and methods as well as engineering development. An example from Nigeria shows that the Federal Institute of Industrial Research was successful in achieving mechanized gari production in the country for the first time. 5/ One of

4/ Cost Engineering in the Process Industries, Cecil H. Chilton, (ed.), (New York, McGraw-Hill, 1960), p. 259.

5/ "Industrial Research in Nigeria, Developments at Oshodi", Nigeria Trade Journal, vol. 10, No. 1 (1962).

the first major projects of the institute was the conversion of traditional gari cottage industry to production on an industrial scale. After carrying out some basic research to understand the scientific process involved in gari manufacture from cassava roots, enough information was obtained to construct a pilot plant capable of producing one ton daily. The new process, which involves the use of special techniques and locally designed equipment, resulted in a uniform quality gari product prepared under hygienic conditions and having a long storage life.

Raising industrial productivity

21. In introducing local industrial products, the developing countries compete with foreign goods. If protective measures are taken to help developing local industries, they can, in the long run, be effective, but only to a certain extent. The quality and price of locally produced goods should be reasonable in order to attract the consumer and, at the same time, to protect his interest. If local industrial products are to be exported, they must face a competitive market where protection is not given. For instance, according to one study, based on data in 1959-60, the total cost of producing one yard of cotton sheeting in the Philippines was 131 per cent of that in the United States of America. 6/ This comparison is significant, especially considering that the labour cost per hour in this industry in the Philippines was 20 per cent of that in the United States of America.

22. It can be seen that high productivity plays an important role in a successful industrial development programme. Higher productivity not only provides consumers with more products at lower costs, but also results in improved working conditions, higher wages and an increased return on invested capital. Thus, the benefits of higher productivity are shared between the employers, workers and consumers.

23. There are many interrelated factors which influence the general level of productivity in a given country, i.e.:

(a) Environment: social tradition, human relations and attitudes, natural resources, climatic conditions, education, level of nutrition, sanitary conditions, etc.,

(b) Technology: factory location, layout and size; equipment design, handling and application, and maintenance, product - technique of production, design and by-products; power - type, source, raw materials used, etc.;

(c) Management: production planning, scheduling and quality control; cost accounting and control; personnel practices (recruitment, placement, training, turnover and absenteeism control); marketing (research, planning and merchandising); industrial relations; purchasing (timing, steadiness and reliability, soundness and selection, etc.)

6/ Laurence Davis Stifel, The Textile Industry - A Case Study of Industrial Development in the Philippines (Ithaca, New York, Cornell University, 1963), Data paper No. 49, p. 151.

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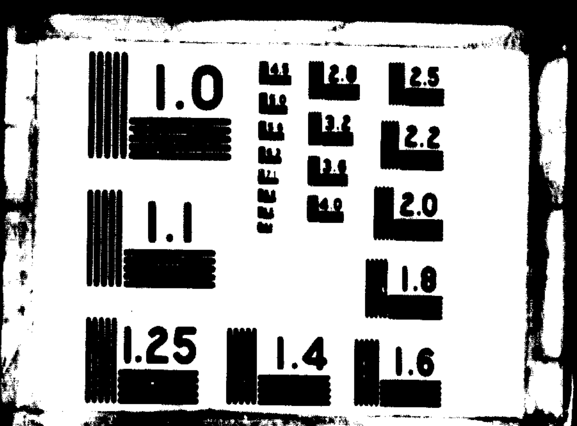

(d) Labour adaptability, attitude to job, stability on job, attitude toward co-workers, aptitude for work, ambition and willingness for improvement, wages and effectiveness of labour organizations;

(e) Availability of capital.

24. The various elements of increased productivity involve collection and analysis of data, research, factory surveys, training, legislation and the proper execution of a programme designed to raise productivity. Research and development functions can play a key role in strengthening the working of policy- and decision-making organizations which are concerned with raising industrial productivity, whether on a national, local, or factory level, since institutional research can approach the problem in its entirety and in a comprehensive manner.

25. For instance, in addition to the functions of research in material or process development discussed in this paper, one of the research functions can be the establishment of procedures, techniques and standards to measure industrial productivity. Through this measurement, all concerned parties are in a position to effect improvements. It may currently be an accepted practice in many countries to measure productivity in terms of labour productivity. If the concept of productivity is thus limited, the tendency to blame labour for inefficient industry may stand in the way of diagnosing the real interrelated factors which hinder progress, and may also place labour in an unfair situation that might lead to unnecessary conflicts. Various measures for raising industrial productivity can be studied and kept under constant review.

26. The measurement of productivity is impossible without an adequate system of industrial accounting. The absence of good cost accounting, for instance, might lead management to economize on labour and thus create a social and economic problem in the community, while the real reason for the high cost of production was probably inefficient utilization of raw materials or the adoption of an inefficient process by management. Research can play an important role in devising a system of industrial accounting which would be suitable for a given industry under local conditions and in disseminating this information throughout the industrial sector.

27. Another possible function of research is to survey, investigate, study and analyse industrial workers' adaptability to and attitude towards jobs. It may be discovered that such items as absenteeism, labour turnover and lack of interest, which contribute to low productivity, are caused, for instance, by low morale owing to poor managerial practices, or by the method and technique of production used in the factory, or by the workers' general attitude towards employment. Programmes for improvement can be established when systematic studies reveal the nature and causes of the workers' varying attitudes towards industrial work.

Pre-investment studies

28. Industrial research may assist the planning authorities or industry itself in conducting specific pre-investment studies to determine the most suitable programme of industrialization, as well as the technological and socio-economic feasibility of industrial projects. It can also verify the studies undertaken by foreign establishments, thereby giving assurance and confidence to local industrialists.

29. One of the functions of research and development may also be the assistance to both the public and private sectors in the preparation of designs, technical specifications and schedules for industrial plants, and in the subsequent technical and commercial evaluation of tenders.

Other supporting functions

30. Organized research can play an important role in strengthening the comprehensive and institutional approach to industrial development. The mere fact that a factory is established does not necessarily mean that it will succeed or encourage the business community to accelerate the rate of factory establishment.

31. There are numerous functions which require study and planning and which, in the long run, affect the attitude of industrialists towards investments. For instance, investors in developing countries need incentives to invest in manufacturing industries rather than in the surely successful and relatively easy business of real estate.

32. The national authorities may undertake measures to promote industrial development through government purchase and procurement, industrial zoning and sites, facilities for hire or hire-purchase of buildings and equipment, regulation of patents and industrial property, industrial extension service, etc. In this connexion, guidance through research can be given to the national authorities.

B. How the functions of research and development can be implemented

33. Any proposed industrial project, whether undertaken by the public or private sector, should be studied and developed in such a way as to avoid future disappointments. Reasons for the establishment of a project may vary from one industry, locality or country to another. Industry, for example, may be established for the purpose of investment and profit making; for the utilization of local material that is being under-utilized at present, thereby increasing the value of natural or agricultural resources, for the production of goods to replace importation and to save hard currency; for the satisfaction of consumers' needs in the area; for the provision of employment opportunities; for the fulfilment of defence needs, etc. These varying reasons affect the decisions of the industrial planner and investor, and influence whatever studies and research are to be undertaken.

34. Policy-making, as well as decision-implementation organizations, and the management of production should take advantage of whatever research facilities are available in the country. These facilities may be in the form of a multipurpose industrial research institute, a research institute for a specific industry, the research department of the Ministry of Industry or the industrial development corporation, the national institute for standards, management development centre or institute, the productivity centre or institute, the university, the national board or council of scientific and industrial research, management or engineering consulting offices, private research laboratories, etc. These various organizations are discussed at length in many of the papers submitted for this Seminar.

35. In some developing countries where many of these different organizations exist, a basic need for co-ordination and optimum utilization is required. In other cases, a need is perhaps greater for one or more additional units to strengthen the existing organization linking it to the industrial development needs. In still other countries, a campaign may be needed to convince policy- or decision-making authorities regarding the importance of institutional industrial research. Some countries may currently require the establishment of only a multipurpose industrial research and development institute.

36. Thus, it can be seen that it is not practical to prescribe one solution for all conditions and circumstances. A local investigation is usually required to determine the type of organization needed. In conclusion, it seems that the question is not whether developing countries should or should not organize institutional industrial research, but rather whether these countries can afford not to establish such activities, regardless of what their form may be.

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II. THE ROLE OF INDUSTRIAL RESEARCH INSTITUTES IN DEVELOPING COUNTRIES

Prepared by I. Malecki*

Summary

The author assumes that the scope of themes of the works of institutes would be established on the basis of detailed analysis of the economic and scientific needs of the country, which have been set by the average and long-term plans.

The reasons for which it is necessary to develop basic, as well as applied, research in the institutes are given. Some desirable proportions between the contributions of basic and applied research are also touched upon.

The tasks of the industrial institutes with regard to the adaptation of international achievements have been analysed and subjected to some factors mentioned in the text. Some aspects of the institute's role as an adviser to the Government, as well as to national or private industry, are presented. Special attention is paid in the report to the problems of the formation and education of scientific staff, assuming that the industrial institutes can complete in great measure the work of universities.

In the report, the functions of the institute are stressed in the general upgrading of the technical level of the country.

The author mentions also some tasks of industrial institutes in the way of normalization of industrial products and in writing scientific publications. The report is illustrated by the examples taken from the experiments of Polish industry, mainly in the period of the reconstruction after the Second World War. Those examples are based on the author's personal observations in some developing countries.

A. Grounds for analyses

1. The present elaboration includes observations, experiments and conclusions based on the following sources:

(a) Activities of industrial research centers in Poland, especially those taking place after the Second World War. Working conditions and tasks of the institutes during this period in Poland are comparable with the present situation in some of the developing countries for reasons given below:

(i) During the Nazi occupation and hostilities, about 60 per cent of the technical contrivances were damaged so that work had to be started on an insufficient technical basis;

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(ii) After the war, industrialization of the country was undertaken, with the result that the industrial production increased 3.73 times in the years between 1950 and 1961; during that time some sections, like the shipbuilding industry and the industry of coal-mining machinery and large (up to 200 Mw) energetical units were established;

(iii) In 1945, Poland experienced a pronounced shortage of experts, owing to human losses during the war and German occupation, and to the six-year period in which the academic schools were totally inactive;

(iv) In 1945, there were no research institutions for industrial purposes, the seven pre-war ones being completely destroyed. In effect, such centres also had to be founded anew. In 1951, there were already thirty-eight; the number has increased to a current total of eighty;

(b) The co-operation of Polish scientific institutes and universities with the scientific centres of developing countries, and the experience gained by individual Polish scientists invited to study by Governments, private enterprises or the United Nations;

(c) The author's personal experience in his directorship of the Institute for Basic Technical Problems of the Polish Academy of Sciences, and in his activities on the international field.

2. The monograph is concerned with the main points of the daily sessions in Beirut (December, 1964) and discusses only problems wherein Poland is experienced. Chief attention is given to the report on programmes of the various institutes, as this is the starting point for further work.

B. Different research tasks of industrial institutes in the developing countries

3. Activities of the institutes and programmes of their studies cover a broad range of topics and depend on following conditions of the given country:

(a) Present and future economic system. The scope and tasks of research in a solely agricultural country are totally different from those in a country where the economy is based both on agriculture and on industry, or where the exploitation of natural resources is the chief economic basis;

(b) The level and number of the body of industrial experts and of the academic staff. This is an essential factor which limits research. On the other hand, one must remember that rapid changes are characteristic of developing countries. In planning future research centres, therefore, a gradual increase in the number of experts, sufficient to satisfy the country demands, can be expected;

(c) The actual network of research centres in Poland. Primarily, universities carry out some of the experiments appropriate for industrial centres. In many developing countries, there exist traditional and established forms of co-operation between science and national economics. In planning research programmes for the newly organized or expanded institutes, all these factors should be considered;

(d) The institute's territorial sphere of activity. Research centres follow a different scheme in small countries and work in a different manner in large countries or in regions including several countries. In African countries, particularly, it is essential to agree upon the region where an institute is to exert its scientific activities.

4. In spite of these multifarious requirements, there is a certain fixed standard of work for a research institute in an average developing country. In this case, a mean level of advancement is conventionally agreed upon when the economic, social and cultural position of the country provides sufficient grounds for industrial research. There need to be at least some beginnings of local industry, mining or efficient agriculture; the country must possess a group of persons able to begin (if not continue) research; the country's economy should provide for a certain allowance for the erection, equipment and maintenance of a research centre.

5. On the other hand, up-to-date industry based on a native staff and an organized network of scientific and industrial research centres capable of fulfilling the demands of technical advancement are still missing in the country.

6. For the determination of specific features of the activities of a future institute, it is essential to assume beforehand the economic and social conditions of the given country. In general, it is a mistake to transfer unchanged organizational institutions from the advanced to developing countries, as the money expenditure is unwarranted and the centres lack a discernment of the actual needs of the country. Unfortunately, one must realize the enormous difference in the actual expenditures on scientific investigations in the developing countries and those with advanced industrialization. Estimative appraisals reveal that some twenty-five countries, representing only one third of world population, account for about 95 per cent of world expenditures on research. The annual outlay <u>per capita</u> on scientific investigations amounts to $US78.4 in the United States of America, to $US35 in the United Kingdom, to $US27 in France, and to about $US9 in Poland, while in the majority of developing countries the respective sum is equal to $US0.1-0.3. Even assuming the greatest possible efforts on the part of their Governments, this striking lack of proportion will continue to exist for a long time. For this reason, it is highly important to economize the existing resources by a judicious choice of the lines of research, which will be discussed in the following pages, and by a well-proportioned disbursement on housing, fittings and maintenance of the institutes, and - what is perhaps most essential - by a long-range, considerate educational policy.

C. Original scientific research of industrial institutes

7. The chief undertaking of an industrial institute in advanced countries consists in the conduct of original scientific and technical investigations intended to convey progress into the processes of production and industrial exploitation and so to reduce the costs of production, improve the quality of manufactured goods and bring about the release of novel articles. In effect, the enterprise or industrial concern serviced by the institute profits by its activities thus contributing to the economic wealth of the entire country. The main advantage of investigations carried out by industrial institutes lies in the introduction of an element of novelty which renders the products marketable and excludes the necessity of imitating foreign designs. The sphere of original

activity of the industrial institutes is largely dependent on the field represented by the centre. According to Polish experience, institutes concerned with technical fields wherein progress is most dynamic (electronics, aircraft industry) carry out original research in 30 to 40 per cent of the total working capacity, while for centres concerned with traditional industry (food, textile) the respective index is no higher than 10 per cent, the remaining competency being limited to advisory, adaptational and designing work.

8. In the developing countries, industrial institutes are limited in the scope of original research; it seems, however, unreasonable to reduce their activities to reproductive work alone. Nevertheless, the original findings of an industrial institute are hardly to be expected to have an immediate bearing on the country's economy. In the developing countries, it is never possible to establish a close relation between the progress in scientific research and the industrial development.

9. An association of this kind occurs in the most up-to-date industries, such as aircraft or plastic production, in some of the advanced countries. In the less developed countries, there is a certain disproportion between the peak achievements of scientific activities and the actual possibility of their incorporation, which cannot be dismissed from day to day. This does not imply, however, that institutes of less developed countries should not undertake original studies; on the contrary, there exist important and pressing reasons for their performance. These reasons stem from the political and economic premises discussed below.

10. Scientific policy in the less developed countries is even more difficult and responsible than in advanced States where the developmental processes are defined and settled. In the less developed countries, these processes are barely perceptible and require careful protection and long-range anticipation of future demands. This is most explicit in the sphere of original scientific research, which requires more time than the erection of industrial plants; the largest of these can be built in three to five years, whereas the education and training of a team of research workers requires no less than ten years. The essential reason for undertaking original scientific investigations are the future needs of the country. Hence, the research programme is a function of a perspective developmental scheme designed from five to ten years in advance. There is obviously no use in undertaking research on the construction of aeroplanes in a country without any grounds for establishing an aircraft industry. On the other hand, investigations in the field of petrochemistry in a country possessing plentiful resources of mineral oil are fully justified.

11. Original scientific investigations are an indispensable provision for the education of an enterprising academic staff, a prerequisite to the attainment of the level of current world standards. From the psychological point of view, it is rather essential for the returning scientific workers to find in their country not only means of applying their knowledge, but also possibilities for further study. It is a well-known fact that about 25 per cent of the fellowship holders from developing countries remain in the foreign educational centres, one of the reasons - especially for the most promising of them - being the lack of prospects for creative work. In this case, at least partial precautionary measures are essential for the scientific progress of the native country. Only when an industrial institute executes its own programme of research can it become an invigorating scientific centre.

12. Original scientific research within an industrial institute is further advisable for educational purposes. Institutes of this type might take over some of the qualifications of universities, chiefly the conduct of post graduate studies and providing the means for work towards doctor's theses within the institute's competence.

13. These goals of original research for industrial institutes of developing countries account for a different choice of objectives than those in centres exclusively for the use of advanced industrial plants. Although it seems paradoxical, owing to their independence from practical demands, studies of this type can assume a long-range aspect and stem from the institute's own basic investigations. Incorporation of a certain amount of basic work into the programme of an institute is an essential educational element. It is often of greater importance than in the advanced countries where work of the industrial institutes is based on fundamental studies carried out in universities and institutes of the academic type. Following are the problems requiring consideration:

(a) In order to start original research, a minimal quantum of means is necessary; to provide these means within a smaller type of industrial institute, a large proportion of the general facilities has to be sacrificed for this purpose; this makes the situation incomparable with wealthy institutes. True enough, in the United States of America and in the United Kingdom the expenditures of industrial laboratories on basic research are limited to 4 per cent of the total; yet, for one thing, the global sum is substantial, and for the other - most of the fundamental work is carried out at universities, where it constitutes no less than 85 per cent of the total programme.

(b) At the current time, basic research serving the purpose of national economy is concerned chiefly with the fields of mathematics, physics, chemistry, biology and earth science. Within the industrial institutes, studies in these branches form the grounds for specialized investigations of the given institute. For example, studies on the theory of dislocation inside crystals may be carried out by institutes of metallurgy with the aim of improving the mechanical properties of steel. This relationship between basic research and the future applications of its findings should be regarded as an essential problem. Encouraging the idea of basic research in the industrial institutes, it is necessary to warn against a tendency, noticed in flourishing scientific centres with an insufficient financial background, of a withdrawal of researchers from practical grounds to more abstract studies. A certain quantum of speculative explorations should necessarily be carried out; however, the appropriate competence for this type of work should belong to the universities.

Conclusions

14. An industrial research institute of a developing country should carry out original investigations for the following purposes:

(a) Direct application in the processes of production (rarely encountered cases);

(b) Preparatory work to establish a basis for investigations of a greater scope, necessary in the future for the country's economy;

(c) Organization of a field of activity for creative research on the part of highest-grade experts,

(d) Tuition and training of specialists by promoting work for scientific degrees and post-graduate studies.

15. Original research should be oriented by:

(a) Present and future needs of the national economy, especially those brought to light by long-range planning for the nearest five to fifteen years;

(b) The necessity of organizing a substantial base for future studies and the requirements involved in the specialized education of a scientific staff. Hence, an institute should be engaged in practical and applied research of its branch;

(c) The level of expenditures on original research, based on estimates of indispensable needs and not on standards of institutes in the advanced countries;

(d) An avoidance of topics unrelated to the present and future needs of the country.

D. Role of industrial institutes in the adoption of foreign achievements

16. In the developing countries, this function of an institute is of prime importance. Industry in a less developed country can be modernized by several means. The easiest way is to work on a full foreign licence, in which case the erected plant is entirely under the control of foreign experts and the exploitation follows exact instructions. There is no need to emphasize the numerous drawbacks of this scheme. In the first place, it is a costly solution, leaving the problem of training a native body of specialists unsolved. Secondly, in such a case there is no opportunity for a continuous improvement of the processes of production. On the other hand, it is not an easy problem to adopt, by local means, written solutions requiring a highly-qualified staff.

17. The indirect way consists in an adoption of foreign achievements with the aid of foreign experts who co-operate with the local staff. Polish experience in these matters has revealed that in the early post-war period a full licence for such novel branches as, e.g., shipbuilding, were actually necessary; gradually, however, domestic research and designing centres became active. The experience gained from the licensed performance provided grounds for re-establishing some other production, usually on a greater scale and exemplifying a subsequent stage of development. In some cases (e.g., the construction of a 2,000-horsepower ship motor) licensed production runs parallel with the native performance, the country model being gradually improved to exceed in quality the licensed type. There occasionally occur situations wherein the assumption, on one's own account, of the designing and construction work creates a better position in purchasing a licence, so that the economic effects are highly favourable.

18. Among the many institutional forms of activity concerned with adaptation, the following are the most typical.

19. In the engineering industry, these activities include:

(a) Designing, model-making and the construction of prototypes, apparatuses and installations which are to be produced;

(b) Preparation of the technological process, chiefly the dressing (treatment) procedure;

(c) Adaptation of the produced wares to requirements of the local users.

20. In the building industry, there are:

(a) Adaptation of construction solutions to local climatic conditions and needs of the users;

(b) Application of local building materials and their improvement;

(c) Designing of buildings and machinery.

21. The exploitation of mineral deposits includes:

(a) Adaptation to local conditions of methods for geological and geophysical inspection;

(b) Geological reconnaissance;

(c) Adaptation to local conditions of drafts of mines and winding gear.

22. In the chemical industry, the activities include:

(a) Acquiring knowledge of technological processes on a laboratory level;

(b) A transfer of laboratory experience to a pilot-plant (semi-commercial) scale of production.

23. The schedule given above portrays the adaptive role of institutes, which simultaneously perform designing, constructive and technological work. In effect, a typical research institute and a designing office become merged.

24. Polish authorities have recently decided to unite several designing offices with research institutes of the same branch. Many other centres already include such design bureaux. Institutes of this kind are usually a success. Main emphasis should be given to the inclusion in the working scheme of institutes of technological problems consisting in the solution of questions of the know-how type. On the whole, tracing, or an adaptation of a machinery design or of a scheme of electronic appliances, is much easier than reproducing the heat treatment of the material or preparing sub-assemblies.

25. The author's experience provided the following example. Soon after the Second World War, Polish radio engineering reached a high level of construction of wireless sets and television receivers; yet, a fairly long time passed before the quality of sub-assemblies was under full control. There is still a necessity to emphasize the importance of the engineering aspect of production, which is liable to be overlooked within institutes preoccupied with the more effective and

less troublesome assembly and construction problems. Engagement in the matters of adaptation requires from an institute highly-qualified personnel, substantial technical background and thorough training. Hence, the necessity for detailed specialization and continuous employment on the part of such institutes, which draw heavily on the financial resources.

26. In making decisions, special attention should be given to the continuity of work in the institute. Usually it is not worth while to establish a particular centre for design and research in order to build a single plant or set in train a single sphere of activity. The task is then better entrusted to a foreign firm, or else the neighbouring countries could co-operate in organizing a regional institute, which could be certain of obtaining orders for a long time - a situation similar to that in the industry of advanced countries. Small and medium-sized firms, even those which strongly compete with one another, could organize common design centres or offices and research laboratories. The decision as to whether a given object is to be made within the competence of an institute, or entrusted to foreign experts, depends on two factors, viz. the country's possibilities of undertaking the work and the calculation. Yet, here too, the long-range educational policy and future advantage need to be taken into account. When the costs of production are equal, the country solution is justified in all cases. The risk involved in the decision is not so much owing to the cost of country adaptive research and designing as to the chance of error in a solution unsupported by the experience of many years; in effect, the country solution may be inferior to that of a well-known firm and more expensive. A hazard of this kind can be reduced either by subjecting the project to expert assessment (a measure, in any case, less expensive than its execution), or by gaining prior experience on smaller schemes. The same holds true in production. Engaging in serialized manufacture on a large scale without preparation is always hazardous. To avoid risk, it is advisable first to carry out semi-serialized manufacture (low-volume production), especially in the institutes lacking experience. Or the process of production could be checked in a quarter-commercial scale, which permits the verification of premature designs.

27. When intensive development of the industrial base is carried out by domestic means, errors are inevitable; at the same time, however, these fallacies are the source of useful experience, provided it is not too expensive. During the peak period of investments in Poland, when in five years' time plants of a total value of $US1.5 million were substantiated, young designers usually committed the following errors:

(a) Unnecessarily luxurious "casing" of industrial establishments, which made the ratio of housing expenses to the costs of machinery too high;

(b) Excessive "stiffening" of the production engineering, which rendered future improvement and renewal of individual elements difficult;

(c) Lack of consideration for the economic use of materials, fuel and electric power.

The past errors are mentioned here because of their frequent reappearance in similar situations in other developing countries.

Conclusions

28. In the first place, industrial research institutes are expected to adapt foreign solutions of scientific problems for the nation's use.

29. The scope of adaptive work is related to the industrial branch. As a rule, however, the institute is engaged in design, construction and engineering activities, in the modelling of prototypes, quarter-commercial scale of production, etc. Chief emphasis should be given to the enterprise involving practical applications.

30. The larger and more complicated the objects elaborated in an institute, the greater should be the long-range demands of the consignees. Hence, institutes engaged in research on complex problems in engineering should service entire regions, rather than single countries.

31. The choice of work in an institute depends on its workability and calculation, considering both the assets of gaining experience in the country and the liabilities involved in the hazard of making errors.

E. Advisory functions of an institute

32. The advisory functions of an institute can be largely diversified and responsible; in the developing countries they are exceptionally important in view of:

(a) An insufficient number of qualified experts on the staffs of independent centres, able to take an active part in scientific and technical sessions;

(b) Management personnel often being incompetent and unable to make decisions without the aid of experts;

(c) The technical staff of industrial centres having a low educational standard and requiring advice to cope with the every-day, simple working problems.

33. Advisory functions vary in dependence on the recipient institutions, as noted below.

Counsel for governmental agencies

34. Industrial institutes of developing countries are usually State-owned, or, at least, State-subsidized, so that counsel for the Government is one of the habitual functions of these centres and includes the following affairs.

Estimates of the actuality and technical correctness of the planned investments and economic schemes

35. It could easily be shown that economic planning is usually optimistic. Very often, the economist who works with total indexes and figures on the time-consuming aspects of an investment fails to apprehend local obstacles which can substantially raise the costs or cause a delay of the planned object.

Teams of experts represent those who can provide the most authoritative advice and are much more competent than technicians who are permanently on the planning staff.

36. The engagement of experts in the institutes instead of in offices has another aspect of importance in the developing countries. Several times it was emphasized that most of the graduates of foreign universities work in the State administration and make no effective use of their acquired knowledge, which gradually becomes obsolete. Apparently some 60 per cent of the chemists in south-east Asia meet the same fate. The ties of governmental advisers with a living field of research and technical activity constitutes an antidote against the assumption of a clerk-like attitude by worthy experts. In some cases, a rotation between production plants, institutes and offices might be possible, yet it is difficult to perform on a broad range, especially in respect to older persons.

Supervision over the performance of engineering tasks by country or foreign associations

37. Institutes may carry out a preliminary appraisal of the necessity and range of the investment, establish the optimum conditions and the detailed technical requirements of the order, control the work and finally carry out the transfer and receiving procedures on behalf of the user of the object. These are not only formal administrative functions. Millions can be lost or saved, depending on the quality of their performance. Likewise, it should be considered that the advisory, and, at the same time, supervisory, staff of the institute can learn much from the foreign company. It has been noticed that often this is the sole opportunity of gaining a thorough knowledge of the technological processes, or of gaining experience which will permit the development of the plant by domestic means. It is essential that the staff of the institute take part in the setting in motion of production and in the transfer of the works to regular exploration.

Counsel in non-technical problems

38. In discussing the foregoing functions, it is sometimes hard to distinguish economic and social problems from the technical matters. One must realize that while an institute carries out its own projects or supervises foreign ones it encounters several economic and social points, the solution of which is beyond its competence. On the other hand, institutes are entitled, and even obliged, to call the Government's attention to the economic and social consequences following particular resolutions in the sphere of technicalities. In Poland, the introduction of economic evaluation into the activities of industrial institutes was greatly emphasized during the last five years. It is not only a matter of organizing bodies of economic calculation at the institutes, the point lies in training the scientific and technical staff to take a critical view of the economic, as well as the technical, aspect of their work. Among others, research centres of the building industry, where each new material or building element is closely scrutinized from this standpoint, can serve as examples.

39. In the developing countries, economic evaluation seems to have an additional aspect. Here, the new industrial investments are of much greater social importance than in countries with established industries; an erection of a plant in a less developed country creates not only a source of earnings; it is, in reality, a factor that revolutionizes the life of entire regions. Though on a lesser scale, Poland witnessed similar phenomena.

40. Some large industrial plants and several smaller establishments were built in regions which, prior to 1945, represented exclusively agricultural areas. Agricultural workers who were employed by these plants had no idea of even the most primitive technological processes and were unaccustomed to working and living in large communities. Hence, there were frequent difficulties and discords, which gradually became disentangled. To avoid them in the future, a continuous analysis and observation of these phenomena is necessary. The Polish Academy of Sciences has already succeeded in accumulating a substantial amount of material concerning sociological changes in the industrialized regions. Studies of this type in all such centres of developing countries seem to be highly desirable and can only be carried out by country means. In many cases they can be entrusted to an industrial institute of the given establishment.

Counsel for industrial institutes

41. Polish experience has been that most of the consultations issued by institutes concerned the overcoming of difficulties in technological processes; problems involved with the necessity of introducing changes in machinery and appliances and their adaptation to local conditions came next. A similar sequence seems likely to occur in poorly industrialized regions.

42. Institutes can play an important role in introducing technical advancement in factories. Control over working facilities and the introduction of improvements worked out in an institute may serve as exemplary cases. As the plants established their own laboratories, institutes would become released from the duty of simple advice on behalf of the study of key problems of the given plant.

43. Counsel has a different aspect when an institute co-operates with one or more large industrial plants, than when the advisory function pertains to several smaller factories, as it often does in the developing countries. In the latter case, the individual counsel described in paragraphs 41 and 42 is replaced by a collective schooling and distribution of duplicated instructions and informative bulletins, which can be regarded as an information service.

44. In addition, consultation includes various kinds of expertises and measurements provided to the industry. The less efficient the equipment of a factory and its laboratories, the more frequent their necessity to consult the institute. Hence, this type of activity of institutes in the developing countries is an important function. It can be highly recommended that an institute should be able to provide all those services which, owing to the precision of measurements or the danger to health (e.g. handling of uncovered radio-active isotopes) require the use of a unique, costly measuring apparatus (e.g., electron microscope) or the labour of highly-qualified personnel.

Conclusions

45. An industrial institute should carry out advisory functions for the Government and for the private enterprise.

46. Technical evaluation issued by the institute should contribute to the schemes of industrial investments.

47. Consultation of an institute should include a universal scrutinizing of the economic and social consequences of industrial activities.

48. Advisory activities concerned with industrial plants are more elaborate in the institutes of developing countries than in technically advanced centres.

49. While providing expertises and measurements for the industry, an institute should give priority to orders requiring the use of unique, costly apparatuses and to those where inefficient measurements may result in a performance harmful to the personnel's health.

F. Education and training of the body of employees

50. There is currently a world-wide tendency to transfer partially the function of universities to non-academic centres, which are to take over some of the educational duties. The problem is of essential importance in the developing countries where there is a permanent shortage of teaching personnel. Nevertheless, education should by no means range first in the institute's performance; it can only come after the fundamental activities in research, designing and construction. For this reason, education in the industrial institutes should not be universal and popular. Following are the most recommendable forms of teaching:

(a) Courses, exhibitions and the like, permitting the technicians and workers to become acquainted with new methods of production worked out in the institute and soon to be introduced. This type of education is closely related to the research work and often the level of this education bears a decisive effect on the actual realization of improved methods. One particular form, the so-called author's control, proved satisfactory. The team that works out the improvement is obliged to superintend its performance in the factory and even to take part in the exploitation of the new gear until the workers gain full control of the process;

(b) Courses, exhibitions, lectures, etc. to inform the body of technicians on the new findings in the institute's competence. It is primarily a matter of a continuous completion of the insufficient academic knowledge of technical workers and of instructing them on new techniques to be introduced in the future. Associations of engineers or social fellowships are largely helpful in these schemes;

(c) Post-graduate studies, as well as those for masters' and doctoral theses, can only be carried out in centres with an academic staff. Until recently, these activities were in the sole competence of colleges, yet the experience of several countries proved that, in many cases, an industrial institute provided better conditions for more advanced studies than those of a university, in that the theoretical aspect of the topics could be directly related to the practical, technical problems; frequently, the technical equipment was superior to that of the university. Projects of large investments, or studies of new technological processes, can be an excellent starting point for post-graduate studies; in addition to their theoretical aspect, they are of practical use. Likewise, the experiments with team studies toward an academic degree should be mentioned. The Polish bill on doctoral degrees accepts collaboration, wherein the various parts of work can be carried out by individual post-graduate students. In practice, such schemes, wherein efforts are united and the studied topics included in the research programme of the institute, have already been carried out;

(d) In countries where the academic personnel is limited in number, the few available experts need to be fully occupied in research and education. Therefore, in spite of the drawbacks, it is advisable to combine the directorship of an industrial institute with lecturing at a university - provided the distance between the two centres is not too great and the faculty the same. By this means, the scope of educational activity of the institute staff becomes broader.

Conclusions

51. An industrial institute should be engaged in the education and specialized training, on a high level, of a limited number of persons.

52. The educational methods should be appropriate for the local conditions, no generalizing being possible in these matters.

53. An industrial institute should co-operate closely with a university, if one is located within a reasonable distance. If the institute's expert staff is on a high level, it can teach post-graduate courses and promote doctoral and masters' theses. Eminent members should become lecturers.

G. The industrial institute's role in the general technical advancement of a country

54. There are two chief tasks to be performed: popularization of technical knowledge and the improvement of the level of production.

55. Information is chiefly based on materials of a special type, published by industrial institutes. Rarely can an institute issue a regular periodical in its field. Only too frequently, the exaggerated desire for distinction leads to publishing time-consuming journals in small impressions and on a low level. All publications of an industrial institute should be brought into line with the requirements of readers and should not involve the time of experts in petty activities. The expected range of information and time necessary for its publication should first be considered. In most cases, these reasons stand for applying "small polygraphy" instead of print. Apparently, it is the chief task of these institutes to issue so-called "express-information" on their own and foreign findings. Experience in the Union of Soviet Socialist Republics has shown the advantage of this type of publication. Pamphlets with instructions on the servicing of machinery designed or supervised by the institute are the second characteristic form of its publications. Instructions on the adaptation of factories or technological processes to local conditions, as, for example, the description of methods of economical building, are of particular importance.

56. It is a general rule in Poland that industrial institutes form the main links of the national network of scientific and technical information. Institutes work out information cards abcut problems studied inside and outside; these cards are pooled and then popularized by the Central Institute for Information and Design. The system has its merits and faults; it seems, however, that in the developing countries, owing to the limited number of users, there is usually no real need to establish an extensive network of information. In such cases, the central organ only functions as a co-ordinative and distributive office.

57. Undoubtedly, published matter has an indirect effect on the technical standard of production; direct influence is, however, also possible by standardization and the control of quality. These activities are unjustly regarded with contempt,

whereas they are of great importance for industrial progress and the acquiring of so-called "technical culture" by the personnel. A few unified systems of standards are currently agreed upon. There is no necessity of establishing a discrete system of standards in each country. Usually the developing countries accept the standards of advanced countries with which they are in contact. The actual introduction of technical standards requires co-operation among experts; it is not recommended that foreign standards be popularized by purely administrative means.

58. In countries with a centre for problems of standardization (e.g., office of standards or board of normalization), there is no need to expand the centre into a large agency. Centres of this type can easily charge institutes with the standardization operations. The functions of institutes in this field may include:

(a) Choice of future standards. Under conditions prevailing in the developing countries, it is not necessary to introduce a rigorous standardization similar to that in great industrial centres. It is sufficient to select a certain number of standards most essential for the country industry,

(b) Adaptation of generally-accepted standards to local needs. For example, several standards are based on climatic conditions of the temperate region and require adaptation to tropical conditions. In some cases, it is permissible to admit a higher tolerance of production within the local range;

(c) Co-ordination of the appliances and machinery supplied by various countries and standardized according to different systems (e.g. materials for wiring systems from the United States of America and from Europe);

(d) The application for domestic industry of various standards established for the internal use of large industrial plants and trusts;

(e) Control over the application of industrial standards presents one of the most difficult problems. Legally acknowledged standards need to be established judiciously, as in the event of difficulties in their application and supervision they remain vague, thus detracting from the standardizing authority. The industrial serviceableness of a standard is the best warrant of its actual use and therefore standardization may gradually become customary.

59. Standardization includes, to a certain extent, the determination and supervision of the quality symbol. It seems that the approach to this problem should be individual, Polish experience has proved that the quality symbol (Q) may contribute to the improvement of production in small factories. The latter being most numerous in developing countries, an introduction of the quality symbol appears to be advisable. On the other hand, it seems unwise to burden industrial institutes with these administrative functions; an institute's role should be limited to co-operation in establishing technical conditions of qualified wares.

Conclusions

60. An industrial institute should assume editorial activities to the degree required for the readership of the country.

61. Institute publications should furnish quick information compatible with the level of readers.

62. Within its competence, an industrial institute should undertake standardizing operations, chiefly consisting in a selection and adaptation of the conventional standards.

63. Industrial institutes may contribute to a general improvement of the technical level of production among others by a co-operation in establishing technical conditions for products marked with the quality symbol.

H. Final remarks

64. Observations and conclusions discussed in this article conform, in the most part, to views of the organizers of the Beirut session, in spite of the differences in opinions on the scope of an institute's functions which came to light in the detailed discussions. A full agreement, however, on the diverse role of an institute in the developing countries, where it is expected to perform several technical and organizational functions going far beyond pure research, seems indisputable. In a few cases, a broadening of the scope of activities could be attained by uniting an institute with university departments into a special institution for scientific and technological education and research. On the whole, however, tuition should not be combined with industrial research and, for this reason, industrial institutes, both in the developing and in the advanced countries, are expected to assume a permanent status.

III. ORGANIZING INTEGRATED INDUSTRIAL RESEARCH AND DEVELOPMENT INSTITUTES

Prepared by David B. Hertz*

Introduction

1. There is growing awareness on the part of government policy makers of the importance of industrial research to economic development. But the undertaking of industrial research requires economic and social resources. The developing countries simply cannot afford to waste any of their usually very scarce supply of technically trained manpower. These resources and the needs of specific nations must therefore be carefully considered if attempts to encourage the establishment of industrial research organizations, either in industry or Government, are to be successful. It is generally agreed that the integrated institute approach to industrial research holds great promise for the developing countries, because it offers a means that might not otherwise exist for them to co-ordinate their industrial research with their needs and resources, and thus achieve results that could not otherwise be accomplished.

2. The advantages of integrated research institutes come through the economies they offer in the co-ordinated utilization of the three key limited resources of the developing nations: trained people, money and time. The financial economies achieved by consolidating research efforts in a central institute often make it possible to provide better research facilities than could be provided through specialized institutes or individual industrial laboratories, since costly duplication of facilities can be avoided. The economies of consolidation should also allow the institute to undertake research projects beyond the financial and technical capabilities of segmented research groups.

3. The existence of an effective industrial research institute can also help in attracting foreign investment to the country, and in training and recruiting the scientists and technicians vital to industrial development. Co-ordination of industrial research in a central institute should also permit a country, through integrated technical and economic analysis, to direct its manpower and financial resources to those projects that would be of greatest benefit to the entire country.

4. As permanent organizations, research institutes also make possible the gradual building up of a valuable reservoir of knowledge on the industrial problems specifically related to the developing nation's progress. This is especially true of the integrated research institute, where experts in many disciplines - technical, economic and scientific - bring their knowledge and experience to bear on the solution of industrial problems. The reservoir of knowledge and experience thus developed can provide valuable perspective on the problems of social adaptability to the technological change and the problems of implementing these changes. Figure I illustrates the potential relationship of an industrial institute in a developing economy to resource development and social and economic requirements, and indicates the types of technologies that such an institute could offer to meet the national needs.

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5. Providing an institutional framework will not, in itself, however, guarantee suitable economic development results. Research undertaken by such an institute would be worth while only if it helped to solve significant industrial development problems. Research institutes must therefore be organized and administered specifically to meet the industrial development needs of the sponsoring nation. Essential to the success of the integrated institute, and perhaps even to the future of the developing countries, is the joining together in one central body of practical economics and practical technology. The proper planning of technological development requires the skills of engineering, science and economics, as well as broad and specific knowledge and understanding of technology, production costs, alternative processes, and potential and actual raw materials. The purpose of this paper is to review the role of research institutes in solving industrial problems and to develop organization concepts and administrative policies and procedures that will enable the research institute to function effectively.

A. Requirements for effective research

6. If industrial research institutes in developing nations are to be effective, they must meet two requirements. Firstly, they must concentrate all the appropriate and necessary technical skills on solving specific problems of industry and translating these solutions into applications that will lead to positive action and improvement in the industrial sector. Secondly, they must focus their research on the critical problems of industry in light of the specific technological, economic and social conditions in the developing nation - that is, they must use the integrated approach to research.

Solving the national problems of industrial development

7. The purpose of the type of research institute considered here is to serve new as well as established industries. The first requirement of a research institute is, therefore, to solve critical problems and to translate the results of this research into practical applications. To do this, the research institute would have to maintain close liaison with current industry in the country, with potential industry and with related external industrial activities. In fact, most of an institute's research activities are likely to be applied research or development projects initiated at industry request, or at the request of potential entrepreneurs, investors or financial supporters of new industries.

8. Since the institute would justify its existence as the research it performs increased the industrial productivity of the nation, a good part of institute resources should be used for actually implementing research recommendations. Time is required to accomplish useful research results. Therefore, the early work of the institute should be planned to rely as heavily as possible on externally generated technology; the role of the institute would be to apply this technology to specific internal problems. Thus, the proper choice of production machinery for a native industry might present a problem beyond the technological capacity of a local manufacturer, but be well within the capabilities of the research institute staff. As the staff of the institute increased its own knowledge and as the nation began to recognize the value of integrated research, research teams could begin to work on broader problems and research directed toward the unique problems of the country's industries, both new and old.

Using the integrated approach to research

9. The second requirement for the industrial research institute is that in doing its research it should take into account the dynamic process of economic development. Industrial and economic development means that unusual and dramatic changes are taking place in many sectors of an economy. The existing economic structure is being modified and augmented; a new structure is being built.

10. Development is not a single process, but the result of many interdependent economic, social and technical forces within a country. These interdependent forces must be considered if industrial research is to support the development process effectively. It is pointless, for example, to develop an industrial process that industry cannot use because of social or technical limitations. An integrated approach to research, which combines the talents of researchers with various technical backgrounds, can make possible the careful consideration of the multifarious forces at work in a developing nation.

11. This balanced approach to problem solving could be provided by staffing the research institute with economists, scientists, engineers and technicians, and co-ordinating their skills on individual projects through team-work. This would give the research teams a broad perspective on how specific problems relate to other phases of industrial development. The need for detailed technological and economic studies prior to any intense research cannot be over-emphasized. It is essential, if industrial research is to prove effective, that potential projects be scrutinized with the greatest of care before any hard research is undertaken. Further, it is equally imperative that the research teams examine the industrial potential of their nation or region in terms of already developed activities in other countries. To a large extent, their job would be to adapt the vast technologies of the rest of the world to their particular sector - not to re-invent the wheel. The job of these teams would be to find analogies in the industrial complex of the world economy to specific raw material, process and market situations in their own country. In the established research institutes of the developing countries, such an approach has been the most fruitful. Communication among the various disciplines in such teams would provide a stimulating environment in which to work and should result in more creative solutions to problems.

B. Organizing for effective research

12. The organization, administration and staffing of a research institute must be designed specifically to help the institute meet the requirements for effective industrial research in a developing economy. This must take into account available resources, economic needs and longer run training requirements. The integrated-team approach to industrial research has already been mentioned. To set the stage for the way the institute should be organized, the specific kinds of tasks such an organization could undertake will be described. Thus, by understanding the end results expected from a research institute, it becomes possible to develop an ideal organization.

What the research institute does

13. There are three critical activities in any research laboratory: project selection, problem solving and the translation of problem solutions into economic

results. Each stage would benefit from the integrated approach to research. Figure II illustrates the critical steps in integrated research activity.

Selecting projects

14. Project screening and selection must be carried on within the framework of the objectives of the nation and the institute. The development of objectives should be the responsibility of the director of the institute, since these objectives must primarily reflect the needs of the country, in terms of resources available to the institute. In determining the needs of the country, the director of the institute should work closely with the Government and with industry. Once objectives are determined, projects should be evaluated according to how well they serve the country's industrial requirements and how effectively they utilize the institute's own resources. An essential part of project screening is the evaluation of alternative proposals and the priority ranking of those proposals selected as projects. Since technical and scientific resources are scarce in developing nations, the utmost consideration should be given to putting those resources to use where they will bring the greatest possible return to the specific industry and to the nation as a whole. (Specific considerations in over-all evaluating of project proposals are discussed more fully below.)

Solving problems

15. After projects were selected, research teams would carry them out. Team members should be selected on the basis of the specific technical requirements for the project. The team, aided by technical and non-technical support service groups, should be responsible not only for research on the project, but also for helping industry to use results. Institute management would work with the team in its contacts with industry. The team's co-operation with industry in implementing new techniques should extend to active assistance in industry planning. Every technological innovation must have the support of management. The services of the institute should therefore include educational and management consulting assistance, as well as technical research on the nation's industries. A problem cannot be considered solved until industry is actually using research results.

Transferring results to industry

16. Since successful research projects result in continual change as progress is made, a final step for ensuring the maximum use of institute capability would be a review and integration of research results and the proper transfer of results to industry to ensure effective implementation. In this way, the institute would be able to communicate the benefits of its accumulated knowledge and experience - not just the results of one specific project - to industry. By organizing to accomplish these critical steps in the research activity, the directors of an institute would be able to use the resources of the institute to the greatest advantage for the nation's industry.

Ideal organization for a research institute

17. The organization of the research institute should be designed not only to carry out the basic steps in research activity, but also to keep a project moving

through the institute from the time it is first suggested to the time when, if undertaken, it is finally implemented. Figure III presents an ideal organization designed to fulfil these needs. This plan of organization includes:

(a) The director of the research institute, who would have over-all responsibility for the institute;

(b) Three staff groups, to provide institute management. The policy and project planning group, and the funding and financing group would provide the staff services essential for optimum planning, direction and control of the institute. The administration and non-technical services group would provide the day-to-day management and services required for efficient functioning of the institute;

(c) Four major research groups, organized according to the technical skills required for industry research in developing nations. These are the research group, the development group, the economic analysis group and the operations research group. Although these skills would be integrated through team-work on individual problems, departmentalizing the disciplines would permit specialization of researchers within each skill and would provide an organized base for each field of research. As the titles of the major research groups suggest, the main emphasis should be on development work or research designed for immediate application in industry. The development, operations research and economic analysis groups would be concerned with these industrial application problems. The fourth group - research - would be concerned with basic research and applied research relating to specific problems unique to the country's industry;

(d) Two supporting service groups, to support the work of the four major research departments. A significant advantage of a research institute is that it is practical and financially feasible to have a centralized technical support services group. Adequate support services promote efficient research activity. The other staff group is the industry and Government liaison group, whose main responsibility would be maintaining contacts with research organizations throughout the world. Since most research work performed by an institute would be development work and adaptations of proven technology, the institute should have an efficient organization to gather and utilize information on established technology and keep informed of new scientific developments in other countries.

Policy and project planning group

18. The policy and planning group would be responsible for both long-term and short-term planning of the operations of the research institute. Another key responsibility of this group would be project initiation, evaluation and review. In essence, then, this group would be responsible for the over-all research programme, including the selection and control of projects, the measurement of results and the provision of both internal and external support services for the institute. This would include responsibility for manpower planning and utilization within the institute and such key personnel responsibilities as recruiting, staffing, and developing and motivating personnel within the institute.

19. Since the key to the success of a research institute lies in effectively performing the right projects, projects should be evaluated and selected with care. Each project should be considered from three points of view: (a) its effect on

the national economy; (b) its effect on the particular company or industry; and (c) its effect on the research institute. Both long-term and short-term effects should be considered.

Effect on the national economy

20. How does the project rank with others in importance to national economic development plans? Is there a reasonable choice between developing local industrial production and importing the goods, and what are the relative costs of each? Does the project increase or decrease employment of nationals? What skills and training are required? Do the supporting industries required to carry out the project exist? Will the project stimulate related and supporting industries? How long will the project take? What guarantee or other financial commitments may be required?

Effect on the company or industry

21. How do expected increases in productivity compare to expected costs and feasibility of carrying out the project? This question entails those given below:

(a) Firstly, what are the potential cost savings or the potential increases in output? Will the project lead to additional possibilities in this or other sectors for improving productivity?

(b) Secondly, what will institute services cost the industry? Will industry have to invest additional capital to use research results? How do expenditures for new plant and equipment compare to expected profit from the new product or process envisioned? How long will the payback period for these investments be? How much time and manpower will be required to ensure the continuing implementation of research results transferred to industry?

(c) Thirdly, is the project feasible? Are the necessary management skills for carrying it out available in industry? If not, can they be developed? Are the needed resources - technical equipment, raw materials, supplies, skilled workers, power supply and transportation facilities - available? What is the market situation - potential demand, level of competition, established channels of distribution and consumer awareness?

Effect on the institute

22. Does the institute have the resources to carry out the project successfully? This involves the following questions:

(a) Firstly, does the institute have the scientific and technical knowledge and manpower necessary for the project? If not, can these capabilities be acquired through direct assistance or through co-operative work in external research organizations? What are the probable costs of carrying out the work?

(b) Secondly, are the proposed methods of attacking the project feasible and practical, considering the scientific knowledge available to the institute? Are the problems expressed clearly enough to suggest possible avenues of scientific investigation?

(c) Thirdly, are the institute's facilities adequate, both in equipment and supporting services?

(d) Fourthly, how does the project fit with the objectives of the institute and its current work? Will projects already under way help the proposed project in terms of technical approach, equipment available, or specific skills developed? Are the facilities, time and manpower required actually available, or are they being fully utilized on projects already in the programme?

23. Finally, in evaluating potential projects these three considerations - effect on the economy, effect on the company or industry and effect on the research institute - must be combined. The costs of the project in time, manpower and money must be weighed against the potential benefits to company or industry, the economy and the research institute. The time required to do the research and to realize the benefits is an especially important consideration in reaching a final judgement on the project. One other consideration should not be overlooked: the risk of the project or the chances of fully meeting the project's goals. It is critically important for a newly established research institution that the projects selected have as high a probability of both technical and practical success as possible. The institute must become an integral part of the nation's industrial complex. Its valuable contribution must be made evident to industrialists, entrepreneurs, financiers and Government planners. The key to this demonstration is, firstly, a careful selection of projects that can make a contribution relatively quickly and, secondly, the careful development of effective working relationships in the key sectors of the industrial economy.

Funding and financing group

24. The funding and financing staff group would have three key responsibilities. Firstly, it would be responsible for the development of financial plans and funding operations - that is, for securing adequate operating funds for the institute, predicting and budgeting the need for funds, and accounting for funds. Its second responsibility would be that of financial evaluation, which would require working with the policy and project planning group on matters of economic and financial feasibility in project selection. Thirdly, it would be responsible for financial relations - that is, for maintaining relationships with existing and potential industry investors both within the country and in other countries. Thus, the funding and financing group would co-ordinate financial planning and management of institute activities with the long-range and short-range plans of the policy and project planning group.

25. Since even the most modest integrated institute would require a substantial income to maintain a satisfactory scale of operations and growth, careful financial planning is of the essence. Once the initial plans are developed - and they should include a budget for a five-year period showing proposed expenditures and expected and alternative sources of funds - the funding and financing group should develop ways to make the institute's growth self-supporting. This could be done through proper charges to the Government, industry and external groups for services rendered, and through the expansion of demand for the institute's valuable services both internally and abroad. Judicious and careful establishment of fee structures for services rendered could do much to encourage and increase the utility of the institute to the developing nation's economy.

Administration and non-technical services group

26. The administration and non-technical services staff group would be responsible for the day-to-day administration of the institute and for the provision of such services as accounting, personnel, purchasing and general office management. Accounting includes general accounting, cost accounting, planning and budgeting, internal auditing, and systems and procedures. Personnel includes terms of employment, wage and salary administration, industrial relations, organization planning and development, and such employee services as personal services, safety, and protection and security. Purchasing involves securing the materials, supplies, services and equipment required in the operation of the institute. General office management includes the maintenance and engineering services required for the physical facilities as well as the management of materials, supplies, security and miscellaneous services. Thus, this group would complete the management requirements of a research institute. The group should not be large, but its efficient operation would be of great importance to the over-all research activity.

Research group

27. The function of the research group would include both basic and applied research. The extent and type of basic research should be suited to the country's needs, but would generally include long-term exploratory research in such fields as chemistry, physics, geology and biology, on problems uniquely important to the country. Applied research utilizes the results of basic research to provide specific commercial applications in terms of process designs and product specifications for application to specific industrial problems by the development group.

Development group

28. The development group would be responsible for using existing knowledge, either available from technologies of other countries or developed within the research group, to create products or processes new to the country's industry or to modify existing ones. Such a group would have seven key functions:

(a) Preliminary development: the development of technical process designs or operating models to demonstrate working principles of prospective products or processes;

(b) New product and process development: the design of products and processes new to the nation's industry (manufacturing systems, operations and facilities), based on studies of analogous raw materials and agricultural and manufacturing resources in other nations;

(c) Product and process improvement: to improve yield, performance and so forth, of existing products and processes in the economy and to solve technical problems of local manufacturers;

(d) Product and process redevelopment for cost reduction: the reappraisal and redesign of materials, appearance, performance and manufacturing requirements of products, to reduce costs and improve quality, and to meet export requirements or internal needs;

(e) Product and process engineering: specifying, interpreting and modifying the design, performance and quality characteristics of existing products and processes, for manufacturing and marketing purposes; testing products and processes for compliance with established standards of quality, performance reliability, manufacturability and serviceability; and helping local manufacturers meet external competition;

(f) Industry follow-up: to provide the required engineering assistance to industries and companies to eliminate manufacturing difficulties;

(g) Sales engineering assistance: to provide technical aid to industries and companies in adapting products and processes to customers' end-use requirements.

29. In summary, the development group would emphasize product and process development and improvement. Specific studies on cost-reduction methods, better utilization of existing facilities and ways to make economic use of by-products and local materials are the types of industrial research studies that would benefit developing nations by increasing efficiency and creating new opportunities for further technical and economic growth. Each economically successful technical step forward would pave the way for an increasing number of such steps, not only in terms of satisfactory financial balances, but also in terms of trained and experienced industrial development manpower.

Economic analysis group

30. Economic analysis should be responsible for conducting basic research on the nation's development needs and for contributing economic knowledge to the industrial research studies of the institute. The economic analysis group would undertake the following types of studies:

(a) Economic development planning, to study the critical factors required for national industrial development. These studies would consider government development plans and the interaction of economic factors required for accelerating industrial growth, and would attempt to pin-point those industrial possibilities that might serve as key links contributing to the future growth rate of the economy;

(b) Resource analysis, to study the nation's economic resources, including natural resources that offer economic potential and research opportunities, characteristics of the labour force and extent of managerial resources,

(c) Geographical development analysis, to provide a refined analysis of the unique industrial development problems in each geographical area of the country;

(d) Industry sector analysis, to develop a framework for understanding the most critical problems facing the nation's major industries, including agriculture;

(e) Foreign trade and exchange, to develop an understanding of the nation's industrial economy in relation to the world economy and to analyse requirements of foreign trade for industrial development;

(f) Money and credit, to analyse the nation's money and credit needs in the process of industrial development and to relate these needs to the industrial research activities of the institute.

31. In general, then, the economic analysis group would develop a framework for evaluating the critical economic and technological requirements in industrial development. The research of the group should contribute to the background information required in determining project priorities. The group should also consider the economic feasibility of carrying forward industrial research activities in the light of the resources available and those required to complete a project. This group would thus play a key role in the institute's successful application of technological understanding to industrial development. Working in close co-ordination with applied scientists and engineers in project teams, they would aid in combining the understanding of technology, production costs, alternative processes, potential and actual raw materials, and manpower resources to provide national and international financial institutions and individual investors, as well as institute research planners and industrial enterprise directors, with the confidence that projects had been adequately thought through and planned. The ability to undertake these kinds of analyses is perhaps the greatest single advantage of the integrated institute.

Operations research group

32. Operations research is a relatively new addition to the kinds of activities that should be undertaken in the integrated industrial research institutes of developing nations. Operations research is an approach to the problem of getting the best results from the use of scarce resources. Since this is a key problem for the developing nations, the addition of an operations research group to the institute scientific staff would constitute a significant step forward in the integrated approach.

33. The operations research group would be responsible for studies and analyses of the costs and benefits that are likely to result from various alternative management decisions with respect to individual manufacturing enterprises or industrial sectors of the whole economy. The results would provide the executives or policy makers with information on maximum effectiveness and recommendations to assist them in making optimal decisions. For example, the costs and benefits of partial processing of an export raw material, along with the decision alternatives, might be studied by the operations research group to provide the decision makers with a clear indication of the consequences of the various choices before them. The distinctive operations research approach is to study problems of the executive, business manager, or policy maker who is responsible for integrating functionally distinct organizational components. Teams of scientists and engineers would examine all aspects of a problem, drawing from a wide range of scientific concepts, methods, techniques and tools those most applicable to the problem at hand. This integrative and synthesizing research would provide an objective basis for making decisions and establishing policies that would best serve the nation as a whole.

34. The operations research group would have three key functions:

(a) Developing and improving methods of long-range and short-range industrial forecasting;

(b) Providing technical leadership and assistance in the application of integrated scientific approaches to problems of: (i) inventory controls; (ii) production scheduling; (iii) pricing decisions; (iv) allocation of resources to production, personnel, and capital requirements; (v) sequencing of production, hiring, training, and transportation activities; and (vi) acquisition of raw material, production equipment and personnel resources;

(c) Developing and carrying out programmes designed to acquaint personnel in the institute and in the industrial sector of the economy with the applications and potential of operations research and computer-based analyses and problem solving.

35. In general, then, the studies of the operations research group would be concerned with maximizing the efficiency of the operations of the industrial sector, an industry, or a firm within the framework of the national economy.

Industry and government liaison group

36. The industry and government liaison group would be responsible for ensuring that appropriate relations and liaisons were developed and maintained with scientific, technical and economic communities, both within the country and throughout the world. This group would also assign responsibility within the research institute for maintaining communications with these communities. Since much of the industrial research activity of the institute would involve utilizing known technology, this liaison group would provide information vital to the main activity.

Technical support services group

37. This group would be responsible for providing appropriate staff services to the four research groups of the institute. Specific services required would vary with the needs of individual research institutes. However, the following types of support would generally be required: library research, information retrieval, chemical and physical analytical services, instrumentation development and maintenance, pilot-plant operations, and engineering assistance (depending on the industrial emphasis of the country - civil, mechanical, chemical, mining, electrical, metallurgical and industrial).

C. Conclusion

38. The basic organization outlined is designed specifically for the needs of a central research institute using the integrated approach to research in a developing country. The divisions within the organization are designed to complement one another and to help the institute produce effective research. The organization is intended to promote effective research activity in three ways: by gaining maximum research results from limited and expensive research people; by gaining economies in financing the research effort; and by minimizing the time required for research benefits to be realized in the nation.

Research personnel

39. Developing nations should have some means of training and encouraging their scientific and technical talents and having those talents work efficiently to promote progress. This could be accomplished through a centralized research institute organized to foster team-work while concentrating on the nation's critical industrial research problems. Experience indicates that the chances for effective research are enhanced by concentrating, in a single location, the various technical skills required, rather than having them scattered throughout the country. Thus, the centralized institute, organized in the manner described, should be most effective. It also would make support services possible, since the research activities of the institute would be broad enough to warrant such services.

Financing of research

40. Financing industrial research activity in a centralized institute avoids duplication of research facilities. The organization, designed to ensure concentration on the most critical problems of industry in developing nations and co-ordination of the various technical talents to solve those problems, would foster the needed research work. Such work, in turn, should bring substantial financial or economic return to the nation, and these results should justify the cost of the research institute.

Rapid realization of benefits

41. Integrated research through an institute would lead to the selection of those projects most important to economic development and thus would use the research resources of the nation to the greatest advantage. The co-ordination made possible through the institute would promote the quick completion of projects. The institute would also be a centre for communication on industrial research activities with the rest of the world.

42. The optimum use of people, money and time made possible through the well-organized, integrated industrial research institute can yield maximum technical benefits to developing countries.

FIGURE I

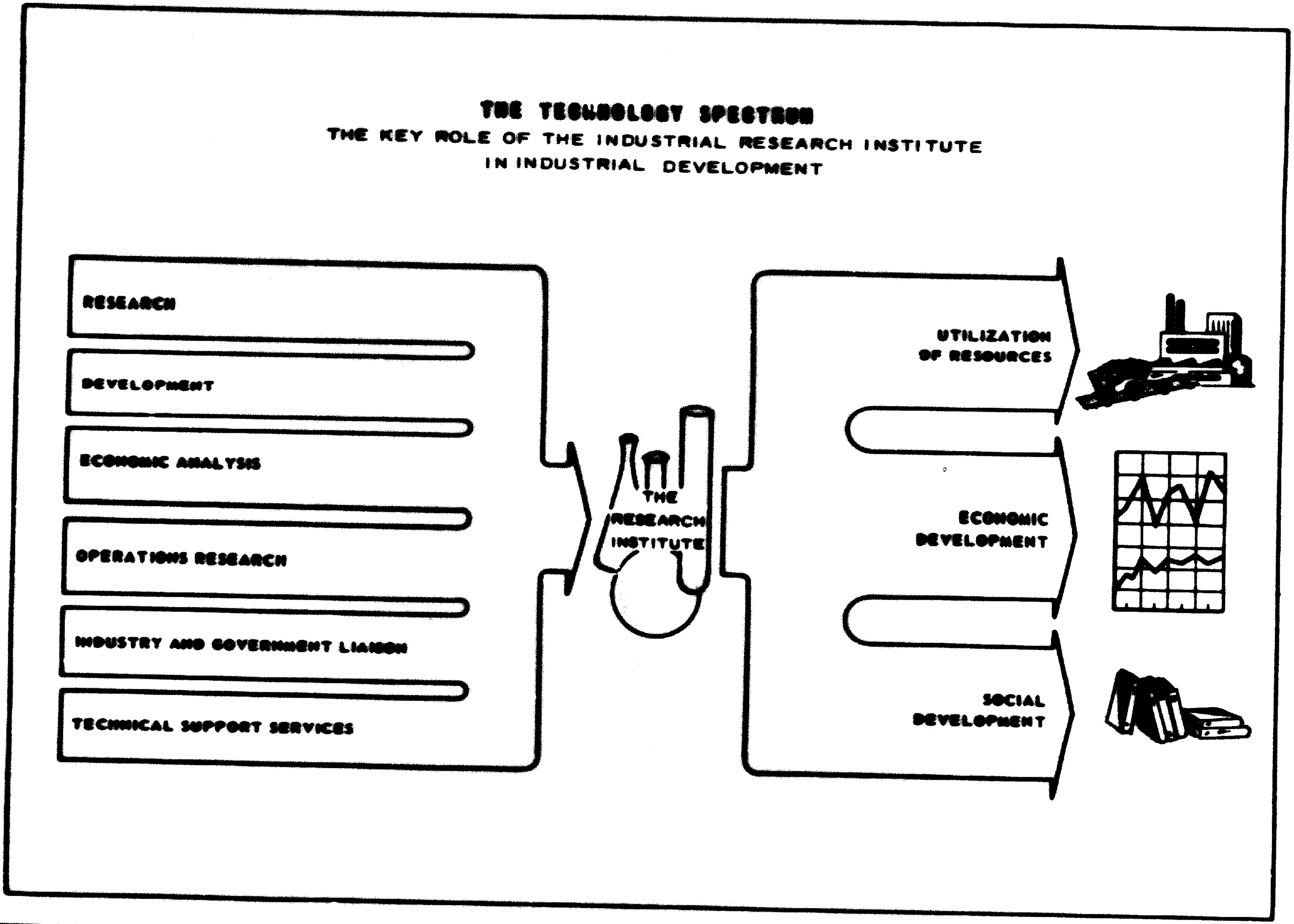

THE TECHNOLOGY SPECTRUM
THE KEY ROLE OF THE INDUSTRIAL RESEARCH INSTITUTE
IN INDUSTRIAL DEVELOPMENT
RESEARCH
DEVELOPMENT
ECONOMIC ANALYSIS
OPERATIONS RESEARCH
INDUSTRY AND GOVERNMENT LIAISON
TECHNICAL SUPPORT SERVICES
THE RESEARCH INSTITUTE
UTILIZATION OF RESOURCES
ECONOMIC DEVELOPMENT
SOCIAL DEVELOPMENT

FIGURE II

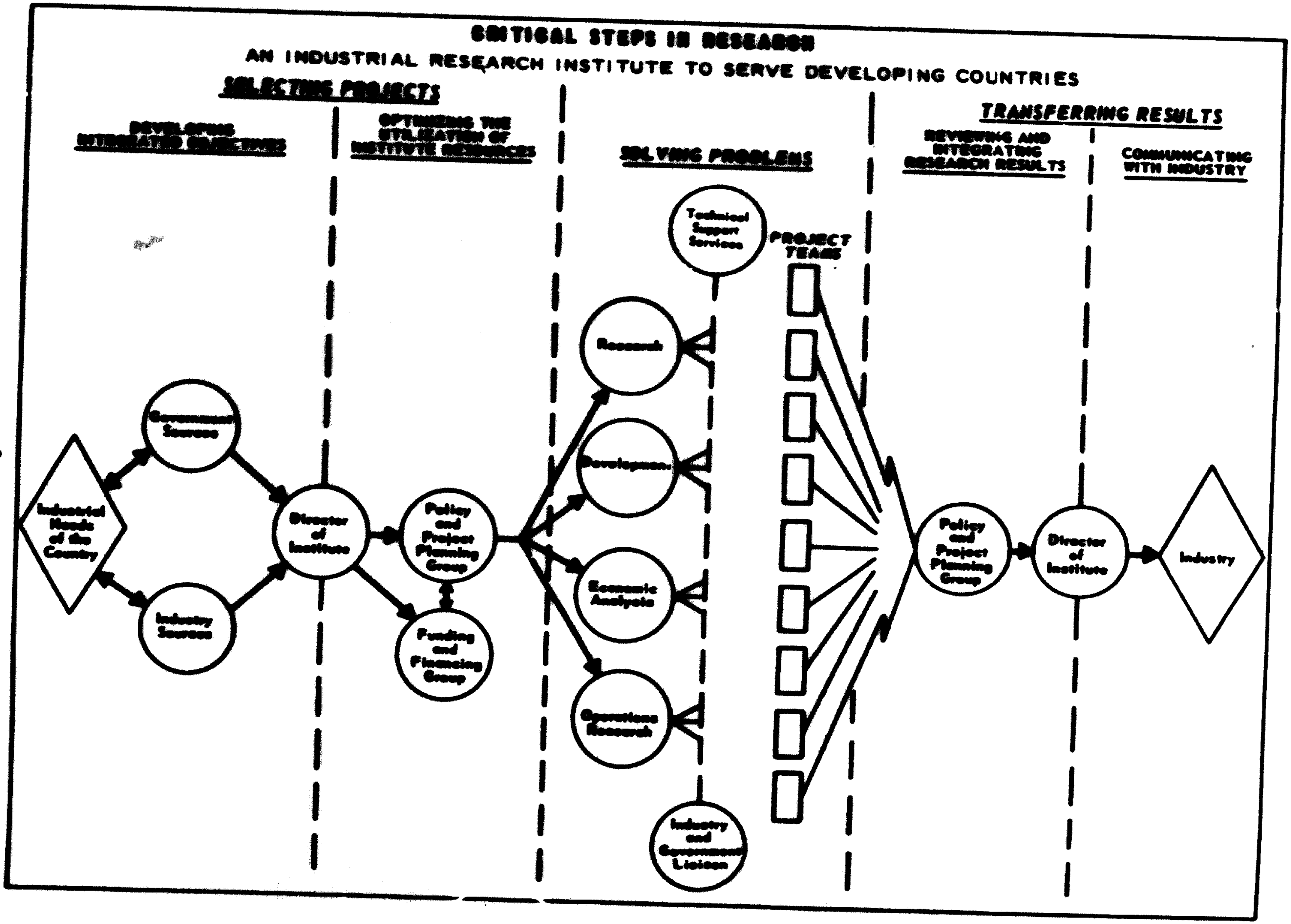
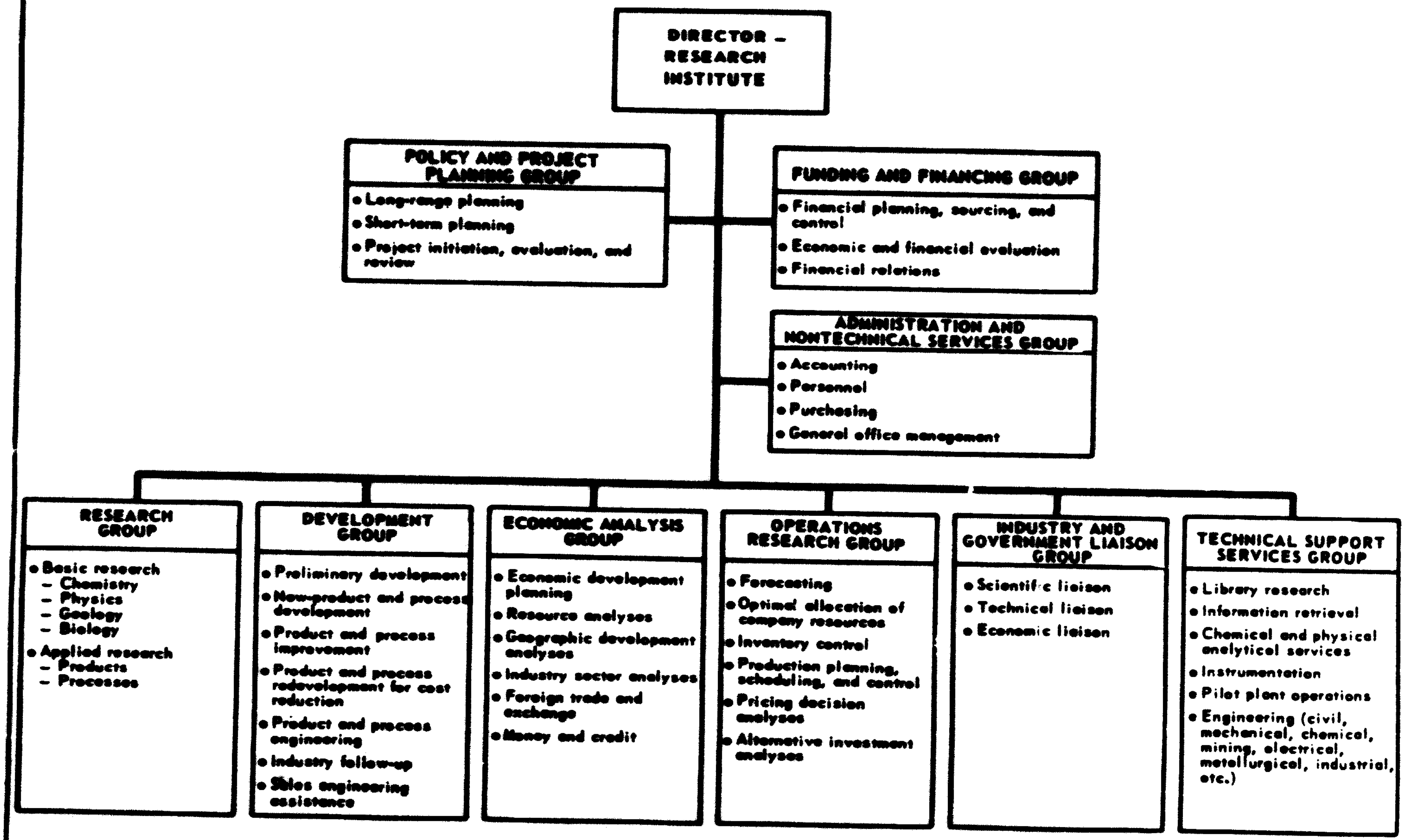

CRITICAL STEPS IN RESEARCH
AN INDUSTRIAL RESEARCH INSTITUTE TO SERVE DEVELOPING COUNTRIES
SELECTING PROJECTS
DEVELOPING INTEGRATED OBJECTIVES
OPTIMIZING THE UTILIZATION OF INSTITUTE RESOURCES
SOLVING PROBLEMS
TRANSFERRING RESULTS
REVIEWING AND INTEGRATING RESEARCH RESULTS
COMMUNICATING WITH INDUSTRY
Industrial Needs of the Country
Government Sources
Industry Sources
Director of Institute
Policy and Project Planning Group
Funding and Financing Group
Research
Development
Economic Analysis
Operations Research
Technical Support Services
Industry and Government Liaison
PROJECT TEAMS
Policy and Project Planning Group
Director of Institute
Industry

FIGURE III

IDEAL ORGANIZATION AND KEY FUNCTIONS

INDUSTRIAL RESEARCH INSTITUTE FOR DEVELOPING COUNTRIES



IV. INDUSTRIAL RESEARCH AND DEVELOPMENT IN THE UNITED KINGDOM

Prepared by the United Kingdom Department of Scientific and Industrial Research

A. Distribution of scientific effort in the United Kingdom

1. Scientific research and development in the United Kingdom of Great Britain and Northern Ireland is conducted in six separate types of organization, as follows:

(a) Government laboratories;

(b) Public corporations;

(c) Private industry;

(d) Co-operative research associations;

(e) Universities and technical colleges,

(f) Sponsored research institutes.

2. In 1961-1962, the total expenditure on research and development in the United Kingdom was £634 million, of which £246 million was government defence expenditure, leaving £388 million, or 1.5 per cent of the gross national product, as the civil expenditure on research and development. The breakdown of this annual expenditure, excluding defence, between the six categories of research organization is approximately as shown in table 1:

TABLE 1

Expenditure on scientific research and development (excluding defence) in the United Kingdom 1961-1962

(millions of pounds)

Research organization	Total expenditure	Government expenditure
Government laboratories (excluding defence laboratories)	83	77
Public corporations	20	-
Private industry	209	20
Universities and technical colleges	32	27
Co-operative research associations	10	2
Sponsored research institutes	2 a/	-
Totals	356	126

a/ Approximate figure.

Note: The balance of £32 million to give the total civil expenditure on research and development of £388 million is mainly derived from non-defence expenditure in government defence laboratories and by government grants to research institutes not covered by the categories above.

3. The work carried out in each of these organizations is briefly described below:

(a) Government laboratories: A large proportion of the expenditure in government laboratories is for nuclear research by the United Kingdom Atomic Energy Authority. Also included under this heading are the laboratories of the Medical Research Council, the Agricultural Research Council, the Nature Conservancy and the fifteen research stations of the Department of Scientific and Industrial Research (DSIR). The DSIR stations cover a wide field of research, which lies clearly within the responsibility of the Government - building and roads, water pollution, coastal erosion and fire protection. They also contribute to the efficiency of industry as a whole by their work on standards of measurement, mineral resources and properties of materials. Finally, the DSIR stations work in such specific fields as radio research and the preservation of fish, both of which could lead to new developments of national importance;

Public corporations: Research carried out by the publicly-owned (i.e. State-owned) corporations is mainly in the fields of fuel, power generation, and transport and communications;

(c) Private industry carries out, in its own laboratories, the major proportion of research and development work in the United Kingdom. Most of the research expenditure is by four groups: the aircraft industry, electrical engineering and electronics, the chemical and oil industries; and mechanical and marine engineering, including shipbuilding. All other industries, including food, textiles and clothing, motor vehicles, the manufacture of metals, scientific instruments, and construction, have a combined annual research and development expenditure of about £60 million in private laboratories;

(d) Co-operative research associations. More than fifty research associations, which are co-operative research organizations carrying out work for individual industries, are in operation in the United Kingdom. Most of these research associations were set up with government assistance and are still receiving government grants. In the main, the research associations serve the industries outside the four major research and development groups listed in (c) above, so that although the £10 million spent on co-operative research for industry is only a small proportion of the total industrial research and development expenditure, the research associations make a substantial contribution to research and development in the older craft-based industries and in certain heavy industries, like iron and steel;

(e) Universities and technical colleges: work here is almost entirely of a fundamental or long-term nature and is not intended to be of immediate interest to industry, but rather to increase the fund of human knowledge;

(f) Sponsored research institutes form a small but growing proportion of industrial research and development effort in the United Kingdom. These laboratories usually specialize in one branch of science or technology, and carry out work on a confidential contract basis for industry. Some sponsored work for industry is also carried out by research associations and by government laboratories.

B. Categories of industrial research

4. It is possible to distinguish three broad categories of industrial research:

(a) Research that the individual company finds it profitable to undertake wholly at its own expense, either in its own laboratories or sponsored on a confidential basis elsewhere;

(b) Research and development that is of value to an industry as a whole but is only economical on a co-operative basis. Such work may lie in a fundamental study of the materials or processes used by an industry; in a survey of the comparative efficiency of production units in individual companies in the industry; in the formulation of standards, standard testing procedures and instruments for the industry; the study of problems common to an industry as a whole - such as effluent treatment, health and safety of workers, and improvement of productivity; the evaluation of new materials available to the industry; and the application of automation techniques;

(c) Research that is the special interest or responsibility of the Government, either because it is of direct bearing on the health, welfare or safety of the population as a whole, or because it is fundamental to a range of interests wider than any individual industry.

5. The research work that is largely supported by the Government in the United Kingdom has already been outlined above [para. 3, (a) and (e)]. Unless industries are State-owned, there is a limit to which a Government can go in getting research results applied in industry. In the United Kingdom a National Research Development Corporation (NRDC) has been set up by the Government to support, develop and apply research in industry.

6. In general, the larger and more technologically complex an industry is, the more it will find it necessary to carry out its own research and development work. On the other hand, industries that are mainly composed of small units may find it difficult to carry out sufficient research except on a co-operative basis. The United Kingdom Government has, for nearly fifty years, fostered and encouraged co-operative research by industry, originally as a means of bringing science and industry together, and more recently to ensure the more efficient use of scientific manpower and to bring about technical advances in industry as rapidly as possible.

7. It is suggested that since the developing countries, by definition, have few large and technically complex industries, the pattern of co-operative research may be a suitable one for expanding and developing their industries. The system of co-operative research in the United Kingdom is described in some detail in the next section.

C. Co-operative research associations in the United Kingdom

8. Research associations are independent bodies, each governed by a council whose members are mostly drawn from the industry served by the association. Legally, these associations are non-profit corporations and their incomes are exempt from taxation. Membership by companies from the industry is voluntary and the research associations derive the greater part of their income from voluntary membership subscriptions. However, at the request of their industries, a few have their industrial income collected in the form of a statutory (i.e. legally enforced) levy

on all firms, whether members of the association or not, in the industry served. Grants are paid by the Government, through DSIR, to most research associations, in proportion to the income raised from industry. The DSIR grant is normally higher in proportion to industrial income for a new research association than for a well-established one, and additional grants are available for capital purposes (buildings or major items of equipment). Special "earmarked" grants for specific projects are a recent feature of DSIR support of research associations.

9. In 1964, fifty research associations were serving industries in the United Kingdom and were receiving grants from the Government. A list of these associations is given in annex I. Most of the research associations were established by the trade association of the industry concerned, with the DSIR support coming either at the stage of initial formation of the research association or at a later stage when research was already being carried out. There are several co-operative industrial research organizations which, although similar in most respects to other research associations, have never become part of the government scheme.

10. The research programme of a research association is the responsibility of the Research Association Council, which is advised by the director of the research association and a research committee. A balance has to be made between six types of work at these associations:

(a) Fundamental research on the raw materials processes or products of the industry;

(b) Applied research on technical problems;

(c) Development work, either on a pilot-plant scale or on a factory scale, in members' works;

(d) Studies of industrial operations to improve efficiency;

(e) Library and technical information services;

(f) Technical liaison and trouble-shooting for members.

11. Many research associations also carry out contract work, which may be for Governments (United States of America or United Kingdom), for the North Atlantic Treaty Organization (NATO), or on a confidential sponsored basis for industry.

12. Membership in a research association was originally restricted to United Kingdom concerns only. Since 1932, however, research associations have been permitted to admit Commonwealth organizations into ordinary membership and there are currently about 500 Commonwealth members; since 1960, subject to certain safeguards to protect United Kingdom industry, foreign manufacturers have been admitted to non-voting membership in those research associations who wish to recruit them. Twenty-nine research associations currently admit foreign members and the total membership by foreign companies is about 130 and is growing fairly rapidly, but mainly by applications from companies in the more advanced countries.

D. Some achievements of the research associations

13. The achievements of the research associations cover a very wide field, as would be expected from the range of industries served, and include both outstanding scientific achievements and resounding commercial successes. It should be borne in mind that, in addition to the major achievements listed below, which are clearly worth while, thousands of smaller technical advances have been made in industry through the work of the research organizations, and it is this steady unspectacular advance on a wide front which is probably the greatest benefit of the co-operative research scheme. Achievements of the research associations may be divided into several categories (brief examples of the work are given) which are outlined below.

Development of new processes

14. The baking industry Research Association has developed a process for bread-making which does not require yeast; this new process is suitable for continuous bread-making and close control of quality is possible. Many years ago, the wool Research Association invented a process for the dry chlorination of wool, which doubled its useful life. In another direction, the ship Research Association is working with the United Kingdom Atomic Energy Authority in the application of nuclear power to merchant ship propulsion.

15. An example of an outstanding scientific achievement is the work of Dr. Martin and Dr. Synge in developing at Wool Research Association the technique of partition chromatography, for which they were awarded the Nobel Prize for Chemistry in 1952.

Improvements to existing processes

16. The iron and steel Research Association developed a method for automatic control of the gauge of steel strip from rolling mills, where formerly as much as 5 per cent of production was rejected for being off-gauge. The potential savings are about 300,000 tons of steel per annum in the United Kingdom alone, and many installations have been made abroad. The motor Research Association collaborated with London Transport in an investigation of lubricating oils, resulting in a specification for the optimum viscosity of oils which has led to fuel savings of £4,000 per year by London Transport. The Electrical Research Association, by a thorough study of the current carrying capacity of buried cables, has saved about £500,000 per annum in installation costs of such cables.

17. Many research associations work closely with their industries on the reduction of fuel consumption, leading in many cases to substantial economies.

Improvements in health and safety

18. The shoe Research Association has made a study of children's feet, with the result that most children's shoes are currently designed correctly and made on lasts approved by the retail association. This retail association also does valuable work in the design and testing of safety shoes. The cotton Research Association has developed a system for eliminating most of the cotton dust produced on cotton cards; over 8,000 of these systems have been installed and this has helped to overcome an occupational lung disease, byssiniosis.

Other work

19. Many retail associations carry out fundamental investigations into the materials and processes of their industries, much of their work being openly published in scientific and technical journals. Another important achievement of retail associations has been in the field of technical training of staff at all levels for industry. Direct services to industry, which include library and information services for all research associations, in many cases extend to a valuable and effective trouble-shooting service which can solve an individual company's particular problems rapidly.

20. One additional useful function of the research associations is that they give expert technical advice to the Government on many problems within their wide field of interest.

E. Summary and conclusions

21. This paper shows that, in the United Kingdom, the major part of research and development, excluding defence, is carried out by private industry in its own laboratories and that of this the bulk is carried out by the four major science-based industries. In the other industries, private research is supplemented to a significant extent by co-operative research, supported by the Government. A brief description of the research association scheme has been given, together with some of its achievements. The advantages of co-operative research may be summarized as follows:

(a) It can bring the benefits of research and development to all companies in an industry at a relatively small cost to each company, and is an efficient way of utilizing scarce scientific resources;

(b) Co-operative research institutes are well suited to provide training for the staffs of members to meet the special technical needs of their industries;

(c) Companies participating in co-operative research become more technically minded and by pooling ideas can plan research programmes more effectively.

22. The Government of the United Kingdom assumes responsibility for a number of industrial research and development activities (in addition to defence, medical and agricultural research), where these are of fundamental interest or concern to the country as a whole rather than to one specific industry. An interesting case is the United Kingdom Atomic Energy Authority, which is, in effect, an attempt to develop a new industry in the national interest and is largely Government supported.

23. For developing countries, it is suggested that co-operative research may be a method of strengthening and developing existing industries: for the setting up of new industries it is likely that imported capital and know-how, or full government control, would be more effective.

ANNEX

GOVERNMENT-SUPPORTED CO-OPERATIVE RESEARCH ASSOCIATIONS IN THE UNITED KINGDOM

Food

British Baking Industries Research Association

British Food Manufacturing Industries Research Association

Research Association of British Flour-Millers

Fruit and Vegetable Canning and Quick Freezing Research Association

British Industrial Biological Research Association

Textiles

Cotton, Silk and Man-Made Fibres Research Association

British Hat and Allied Felt Makers Research Association

Hosiery and Allied Trades Research Association

British Jute Trade Research Association

Lace Research Association

British Launderers Research Association

Linen Industry Research Association

Wool Industries Research Association

Engineering

Civil Engineering Research Council

File Research Council

Heating and Ventilating Research Association

British Hydromechanics Research Association

Machine Tool Industry Research Association

Motor Industry Research Association

Production Engineering Research Association

British Scientific Instrument Research Association

British Ship Research Association

Water Research Association

Metals

British Cast Iron Research Association

Drop Forging Research Association

British Iron and Steel Research Association

British Non-Ferrous Metals Research Association

Spring Manufacturers Research Association

British Steel Castings Research Association

British Welding Research Association

Materials[a]

British Ceramic Research Association

Coal Tar Research Association

Gelatine and Glue Research Association

British Glass Industry Research Association

Research Association of British Paint, Colour and Varnish Manufacturers

Rubber and Plastics Research Association of Great Britain

Timber Research and Development Association

Welwyn Hall Research Association (Chalk, Lime, Whiting and Allied Industries)

Energy

British Coal Utilization Research Association

British Coke Research Association

Electrical Research Association

Consumer Goods[a]

British Brush Manufacturers Research Association

Cutlery and Allied Trades Research Association

Furniture Industry Research Association

British Leather Manufacturers' Research Association

British Paper and Board Industry Research Association

Printing, Packaging and Allied Trades Research Association

Shoe and Allied Trades Research Association

Information and Industrial Psychology

Association of Special Libraries and Information Bureaux (ASLIB)

National Institute of Industrial Psychology

Commonwealth Mycological Institute

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a/ Some of the research associations listed under Materials are also concerned wit Consumer Goods and vice versa.

V. THE ROLE OF INDUSTRIAL RESEARCH INSTITUTES IN UNDERTAKING TECHNOLOGICAL RESEARCH AND FEASIBILITY STUDIES IN DEVELOPING COUNTRIES

Prepared by N. Tanyolaç*

1. The writer, as the title indicates, mainly attempts to explain the functions and types of industrial research institutes and the basic considerations in preparing research programmes.

2. The possibility of utilizing industrial research institutes in feasibility studies and in the preparation of industrial standards, and the use of institute laboratories for specific laboratory testing purposes are discussed.

A. Technological research

3. Economic development in any country is possible if some of the basic missing elements in that country are provided. Two most basic elements of development are technical knowledge and capital.

4. Both in developed and in developing countries capital is important, but it has a limit; the scientific and technical skills have no limit and development both in developed and in developing countries depends mainly on scientific and technological research. It is possible to borrow capital and also to borrow science and technology from developed countries. If the borrowed capital and the resources of a developing country are not used as the technological research in the country indicates, even the capital will be harmful for the country.

5. Investment in a paper manufacturing plant or paper bag plant using high-cost imported raw materials and chemicals, or investment in a caustic soda plant to take care of the total demand of the local textile, paper and soap industries without establishing a local market for the by-product, chlorine; or investment in an electrometallurgical industry without having electricity as low in cost as that in developed countries, can be a real burden to a developing country.

6. Science being universal, it is possible to teach it to people, but to have good scientists is not always possible. To teach people technology is difficult, but not impossible; however, to use them in a given country and obtain the same result as in developed countries is one of the most difficult tasks. It is possible for developing countries to set up institutions and organizations and technological services similar to those in developed countries, but if they are not adapted to the local conditions and needs they will hinder rather than help the development of the country.

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* Director, Robert College Research Centre.

7. Research in the developing countries with their own proper organization is the best and shortest means of economic development. During this Inter-regional Seminar on Industrial Research and Development Institutes in Developing Countries, the details of institutes and their activities will be explained by representatives of participating countries. In this paper, the main emphasis will be on the types of industrial research and the specific problems of industrial research institutes.

8. Before defining the types of industrial research, a general definition of research will be given. "Research is the application of human intelligence in a systematic manner to a problem whose solution is not immediately available." 1/ This indicates that research involves original work rather than the mere exercise of personal opinion. It is also clear that research does not always require an invention.

9. This broad definition makes the people working for Governments, for educational institutes, for industry, for business and, in general, for all kinds of economic activities, research workers if they do their work systematically.

10. Industrial or technological research refers to the applied and development research carried out in industry, or in industrial research institutes for an industry. One of the definitions of applied research is the extention of basic research (fundamental and/or background research) to the determination of generally accepted principles with a view to specific application, generally involving the devising of a specific novel product, process technique or device. Industrial development research is the adaptation of research findings for experimental or demonstration purposes, including experimental production and testing of models, devices, equipment, materials, procedures and processes. Developmental research differs from applied research in that the work is done on products, processes, techniques or devices that have previously been discovered or invented.

11. In some developed countries, large industrial companies finance or even conduct basic research in their own industrial research institutes, in addition to applied and developmental research, as part of their industrial research programmes.

12. Industry is one of the most complex and advanced economic activities, compared with agriculture, commerce and transportation. In the manufacturing industry, the major functions are purchase, sale, planning, production, transportation, and control and elements used are men, materials and machinery. Industrial research involves all these activities. Market research, raw materials research, product research, waste utilization research, process research and operational research are types of applied and developmental research to be carried in industry.

Market Research 1/

13. Customer requirements on quality, quantity and styling of a product are determined by market research. The need, the market and the future demand for improved products and for new products, and the testing of consumer reaction to new products are part of market research. A modern plant with a product of very good quality, but without customers to buy the product or with a limited number of customers, has a real problem.

1/ Eugene W. Scott, ed., Applied Research in the United States, (Washington, National Academy of Sciences - National Research Council, 1952), 90 p. (Publication 210).

14. A market-demand estimate based on per capita consumption in developed countries, without consideration for the buying power of the people, the customs of the people, and the lack of adequate transportation and communication in the country, may create sales difficulties. Statistical data, and other background facts and publications dealing with market research that are available in developed countries may not be available in developing countries; therefore, extensive field study and interviews might be very helpful. Even the method of market research for developing countries should be different than for developed countries.

Raw material research[1]

15. The objective of raw materials research is, in general, to improve the quality, reduce the cost and increase the source of supply of the raw materials used in an industry. Result of the research may be the substitution of a new, better and cheaper source of material.

16. In a developing country, a cotton and/or a wool textile industry might be possible. The cotton and/or wool may be locally available or be partly imported. Continuous research on producing better and cheaper cotton and/or wool would be needed. This could lead to the possibility of growing better cotton and also of bringing a special breed of sheep to the country, as is done in Turkey. Mixing the cotton and wool, or other synthetic fibres, in textiles is also part of raw materials research. Raw materials research on clay to be used for bricks, tile and ceramics requires local geological surveys, and various chemical and physical analyses. Improving the quality and continuation of the production of canned food for the local or export markets requires continuous research on the raw materials of the country. Local research on the proper sand for the glass industry has been responsible for the establishment and success of a new window-glass plant in Turkey.

Product research[1]

17. This is usually involved with process research and the aim is to improve the quality of the existing products or to develop new products. Product research is usually based on market research, which indicates the consumer demand for quality with regard to the improvement of old products or the development of new ones.

18. It is not the best quality, but the customer quality, which has the largest market. Product research geared to the market demand on quality and quantity would be the main function of engineers in the plant. The aim of product research is not only quality and demand, but also a reduction in the cost of manufacturing. The competition of local or imported products is the main incentive for product research.

Waste utilization research[1]

19. The object of this type of research is to find uses for the waste products of a process or to reduce the percentage of waste as much as possible. In some cases, the disposal of waste may be costly or it may even involve some health and social problems in the community. The most effective waste utilization research would be that which transforms the nuisance into a source of profit.

20. Owing to the lack of experience and training of the workers, the percentages of waste in industries recently established in developing countries are higher than in similar industries in developed countries. The possible uses of the waste products are usually geared to other industries which may not be available in developing countries. Therefore, waste utilization research in developing countries faces different problems, and their effect and contributions will be greater than in developed countries. One of the examples of transforming a nuisance into a source of profit is the use of cinder from the coal-power plants in making cinder-blocks for the construction of buildings.

Process research[1]

21. It may involve either a specific step in a process or the complete manufacturing processes. This type of research involves a great deal of scientific and engineering work, and requires highly qualified research workers. The result of process research is always great saving; either in material, in labour, or in improvement of quality.

Operational research[1]

22. Its objective is to analyse the many factors that affect the income of the company and to find out what combinations of these factors will give the maximum profit. Operational research requires the team-work of scientists, engineers, mathematicians, and social, economic and financial experts.

23. Research on personnel and labour relations in the plants, relations with government competitors and customers; and research on changes of import and customs regulations are part of the operations research of a company. Customs regulations, the political system of a country, and the financial means and sources of a country will have great influence on the methods and types of operational research.

Industrial research laboratories

24. Industrial research laboratories in industry may be classified in three groups

Testing and control laboratories[2]

25. They are used for analytical, chemical, metallurgical and physical testing, and control over materials, processes, and products. Practically all manufacturing companies, depending on the type and amount of their product, should have a testing and control laboratory facility.

Development laboratories

26. They are used to decrease the cost of production and to develop new products or improve the existing products, by process and product research. The procedure in development laboratories is to collect ideas from all sources, conduct the research and find the methods and process to apply them to the manufacturing stage

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2/ C.E. Kenneth Mees and John A. Leermakers, The Organization of Industrial and Scientific Research (N.Y., McGraw-Hill, 1950), 383 p.

This means that the new idea with applied research, trial and error, and scientific investigation, may result in a new technical method of production or a new product. After this step, models and a pilot plant may be built, and a small-scale use of the method in the plant or he use of the product in the market on a small experimental scale tried. The manufacturing scale can be adapted to the product and/or process if the result is successful. Practically all companies of moderate size and the large ones in developed countries do have such development laboratories attached to their research departments.

Scientific research laboratories

27. Their aim is usually to find applications for scientific discoveries and also to carry out some background research on a specific discovery which may offer possibilities for the development of new industries. This type of research may not produce any applicable ideas or processes for a considerable period of time. Only the large specialized companies in developed countries have scientific research laboratories.

28. Industrial research laboratories in companies may be either convergent (unipurpose) or divergent (multipurpose) laboratories. In general, most of the industrial laboratories are initially the divergent type. They work on all research problems of the company. As the activities of the research laboratories increase, they tend to become more convergent; and a company may have several specific research laboratories under the direction of their research department or research centre.

29. It is interesting for developing countries to study the beginning of the organized research activities in those countries which are currently developed, but which were developing countries prior to the First World War. In virtually all of them, organized research was begun and supported by their Governments, and most of their initial projects were related to the national resources. Just after the First World War, these countries observed in detail the differences in technology among the nations and its great power for the development of a nation. They accepted the fact that only scientific and technological research could close the gap between the developed and developing country. Most of them organized laboratories for agriculture, food, mining, health, national defence and fuel research before establishing specific industrial research laboratories. The developing countries of the current period are very fortunate in that they can initiate and accomplish technological research in their countries in a much shorter time and with less effort than was possible some twenty years ago. It is easier to train their research workers and scientists in developed countries and in their own countries; furthermore, the information on scientific and technological research in developed countries is no longer kept secret, but is usually published and, in many instances, is available for the scientists and research workers in developing countries. However, these data have to be analysed and adjusted to the economic and technological conditions of the developing countries by their research facilities.

30. Research is the key to the economic development of any developing country and also is necessary to sustain the economic development of any country at an increasing rate. Economic planning and investments based on economic planning are wasted when they are not also based on the technological research of the country and are inefficient when they are not backed by technological developments

in other countries. Today no nation, whether developed or developing can afford to neglect scientific and applied research. A developing country cannot progress continuously and attain the level of a developed nation simply through the process of borrowing technological information from other nations.

31. The immediate questions are to determine the basic problems in setting up organized industrial research institutes and, once set up, how they can perform their functions in developing countries. The first step in establishing an organized research and development institute in a country is to convince the Government, the public and the business people about the needs and functions, and the long-range effect and initial high cost of such an institute.

32. There are always people who will say the country cannot do research; that it cannot afford to train scientists and research workers; that research is expensive and the country cannot wait for the results of research; and that what is needed is to take the technology as it is in one of the developed countries and to train enough technicians to operate and maintain the industry. Yes, science and basic technology can be learned from other countries, but to apply them and to adapt them to the needs and conditions of a particular country is another problem; this can be done only by the national research organization of the country.

33. It is up to the national research workers to find the best uses for their resources and the types of products and processes, as well as public services, that will be most suitable to their national conditions, national resources, and economic, social, geographical and political problems.

34. Assuming that the Government, the public and the business people are convinced of the need for and the long-range contribution of a research institute, a climate of opinion will be created for the acceptance of the need for industrial research and such an institute or institutes, can be established in a developing country. The immediate problems are how to operate such institute in the most efficient way, in order to obtain first results in a reasonable time, and how to give it the first impulse.

35. It is neither the creation of an organization alone nor the money provided for research that creates efficient research activity in a country. The trained research workers and the especially qualified managers of research organizations are responsible for the success of industrial research and development in a developing country. The major functions of managers of research organizations are the selection of research workers and their proper training, the provision of freedom for research workers to pursue their investigations to a practical conclusion without interference from any source, the provision of adequate facilities for research work and the provision of good compensation for their work.

36. Modern research involves the team-work of research workers with the same and with different scientific and technological education and training. An individual worker in research is only one member of the team. Scientific and technological development, and economic and social development are closely related. Thus, it is not enough to have engineers, economists, and medical, social and legal research workers to work closely in the same research institutes. Research institutes of different fields should have close co-operation and co-ordination among themselves. Thus, a co-ordinating body for all research activities in a developing country would be very valuable. Although research is a collective,

creative effort, the research worker prefers to work by himself and would like to have freedom from rules and regulations; he does not want to be supervised and controlled. Special management and organization principles must be applied in research institutes. The co-ordination and co-operation between research institutes also requires a very special method of management and organization principles. Thus, a co-ordinating organization of research institutes should help only to promote and co-ordinate research activities in a country; it should not be considered an organization designed to administer and direct research activities.

37. The national industrial research institute should be an independent organization with its own board of directors representing the Government, educational institutes, industry, commerce and agricultural organizations. Its budget should come directly from the parliament rather than from any one ministry budget. It should be independent from the control of a particular government department. Its administration should have freedom in establishing the salary scale of research personnel and in purchasing equipment and machinery without the hindrance of bureaucratic red tape.

38. In most of the developing countries, it is a problem to convince government officials and even the parliament that the Government should give money to a national research institute without having the privilege of controlling its activities, that is, controlling the appointment of personnel, the expenditures and the programmes of research, and evaluating the results of the research work.

39. The success of a research institute with proper administration depends upon, firstly, the quality of the research scientists and engineers; secondly, the availability of equipment and facilities; and, thirdly, its library.

40. Research cannot be done by average men. It requires men of independent judgement, initiative, imaginative minds, curiosity and the ability to accept responsibility for attaining solutions of the research projects and to penetrate beyond the known. The number of qualified and experienced research personnel is very limited in every country. The wage policy of the research institute must be designed to attract and retain good research men for the institute. If the institute is not an independent organization, it is a real problem in developing countries to establish salaries which will differ from those of other government personnel and be adequate to attract and retain the nation's best minds in science and technology. Many scientists and research workers of developing countries are either going to other countries to work or leaving their fields of research for more highly paid employment; this is even the case in some developed countries in Europe.

41. The usual red tape involved in the expenditure of approved government budgets, the difficulty of obtaining adequate foreign exchange and the customary delays in the procurement of necessary equipment, supplies, periodicals and books are frustrating to the scientist and increase the time required for research projects, which means an increase in the cost of, and a loss of interest in, research.

Programmes of industrial research and evaluation of research results

42. These are another critical problem in the management of research institutes. The creation of an institute with physical facilities, money and freedom of operation is not sufficient to have a successful industrial research institute.

Firstly, the trained research personnel; and, secondly, a good programme are the factors which make an institute an efficient and a successful organization. The research scientists and engineers, with the director of research, should initiate the programmes. One of the characteristics of a successful research scientist is his ability to select the proper research subject and define its objective. The programme should be related to the needs and resources of the country, and to the available or obtainable facilities of the institute.

43. A new research institute should not plan an ambitious programme for the first five, or even ten, years. Programmes should be realistic and flexible; changes should be foreseen and accepted as the research develops. Projects for programmes can originate either in the institute or in external government or industrial organizations.

44. Short-term projects related to the immediate needs of specific industries in the country should have priority. The percentage of long-term projects can be increased in time, as the research workers in the institute gain experience and the attitude of the public towards research changes. In developing countries, it may be difficult at the beginning to select the proper projects if the research scientist and engineers do not have opportunities to visit the industrial plants and government organizations, and to talk with their technical people about their problems.

45. Regular meetings of the research personnel to discuss their projects, their ideas and the results obtained would provide opportunities to explore new possibilities for projects and programmes.

46. Proposals from government organizations and from industries should be given priority in setting up the programmes.

47. A good short-term development project for inclusion in such a programme would be one for which the personnel, facilities and time requirements, as well as the total cost, could be reasonably well estimated.

48. It is difficult to have a basic method for the rejection of a proposed research project, especially when the proposal is within the broad definition of the objectives of the research institute, or is a long-term project.

49. It is both important and difficult to decide when to stop a project. The specific personnel requirements, and the great difference between the time estimated to achieve results and actual time spent up to that day, may be major factors in the decision.

50. It would be advisable to review the research work with the chiefs of projects at regular intervals and to have them prepare a brief written report about the development up to the reporting date, and their ideas and approach for the future work and conclusion, indicating if the work is developing along the lines established by the proposed objectives. A regular conference attended by research workers would also be useful for evaluation of individual projects and the exchange of ideas and information between research workers. In this type of conference, the experimental results and theoretical background and the direction of the future experimental programme could be presented and discussed. It is also good practice to set up a special project evaluation committee, which would make the final recommendation to the director of research for final decision.

B. Industrial research institutes and feasibility studies

51. There is currently a common agreement between the political, business and technological leaders of the developed and developing nations that industrialization is an essential factor and the means for achieving high standards of living. Agricultural development alone, regardless of its scope, cannot achieve the desired level of economic development for a country. Industrialization and agricultural improvement complement each other and a neglect in either will limit the other. Industry and agriculture together offer the best prospect of a continuous advance in living standards.

52. It is also understood that industrialization can increase a nation's real income only when it is properly carried out. Industries that are not properly selected and adapted to the nation's circumstances, either in terms of the market demand, the resources required, the economic scale of operation or the timing, will become a waste of capital, and a disappointment both to the investor and to the country.

53. It is possible to have some kind of an economic development plan for developing countries involving figures in the millions for capital investment, and assumed or estimated figures for production, consumption and even export based on these investments. In each case, however, it is the feasibility study which will have the main influence on the investment decision. The definition of a feasibility study, and the requirements for and the function of research institutions in, such studies are defined below. 3/

54. Here feasibility studies for industrialization will be discussed only for the manufacturing industries. These are preliminary studies with sufficient data to appraise the economic merits of an enterprise, but without the detail necessary for its execution. All feasibility studies require both technical and economic phases, which are closely related and require team work between engineers and economists.

55. In developing countries, feasibility studies for manufacturing industries can be classified in three groups: (a) national; (b) regional; and (c) local. The first two groups are usually carried out by the Government in relation to the over-all or regional economic development programmes of the country; the local studies are usually requested by private investment groups who would like to set up a specific industry in their city.

56. In general, each country must co-ordinate the growth of investment in manufacturing industries with the development of other sectors of the economy. The lack of capital, technical knowledge and entrepreneurial ability are the main factors affecting the rate of industrialization in developing countries. To select the proper investment at the proper time is much more important in developing countries than in developed countries. For example, an investment in a flour-mill, a brewery, or an automobile assembly plant might be more profitable than an investment in a fertilizer plant, an oleomargarine factory, or an agricultural equipment and tractor plant.

57. The profit to the investor in a fertilizer plant or in an agricultural equipment and tractor plant might not be as high as in the case of the brewery and the automobile assembly plant, but the contribution to the national economy and, specifically, to the saving in foreign currency would be higher.

3/ N. Tanyolaç, "How to create industrial climate?", Turkish Economic Review, 12.12, 1955; "How our industrial development can be successful", Factory, August 1955, and "Where and what industry?", Factory, August, September and October, 1955.

58. A basic policy to help establish the priority list for investments is necessary in developing countries. 4/ This means that experts must undertake feasibility studies for every investment. Engineers, economists, sales experts, and financial and legal experts have to work together in conducting feasibility studies. They must have up-to-date technological data about the raw materials, machinery, equipment, processes, energy, production and labour requirements; and the relation and contribution to other industries of the specific investment, both in other countries and in the local market. They must be able to forecast the present and future demand for the product in the national market and for export. They must be able to estimate the necessary fixed capital and working capital, to indicate the possible sources of capital and to calculate the net return of the capital. They must know the basic investment policy of the country and its import, export, customs, sales and labour regulations.

59. In a feasibility study, two main conditions for an industry have to be considered. First, the requirements of the market and the resources must be well suited to the conditions of the country. Secondly, general requirements which affect the successful operation of manufacturing industry have to be considered.

60. In conclusion, the influence of the following groups should be considered: Government agencies and their policies for the development of industry in the country; private firms or entrepreneurs in the country and in other countries who have trade relations with the country; and such inter-governmental agencies as the International Bank for Reconstruction and Development and the United Nations Technical Assistance Administrations. Special aid agreements with some foreign countries should also be considered.

61. It is important to indicate that the general requirements in a country for any industrial development, that is, utilities and services, development of natural resources and development of human resources, may not be sufficient to justify a manufacturing industry, when the conditions of same industry are compared with the conditions in a developed country. This should not be considered a main criterion for the decision. Similarly, the market demand may not be sufficient to take care of the minimum economical production based on the experience in a developed country. This also should not be considered a major criterion for the final decision.

62. In a feasibility study, the partial lack of general requirements, and the partial lack of market demand and resources should be used in setting up a priority list of manufacturing industries, rather than as final criteria for rejection or recommendation of an industry in developing countries.

63. The following additional factors have to be evaluated before final decisions are made:

(a) Net return in terms of national product and in terms of the profit to the investor;

(b) Its outlook for long-range expansion;

(c) Its contribution to the total development plan of the country;

(d) Its effects on the balance of payments in the country;

(e) Its social, military and political effect for the nation.

4/ N. Tanyolaç, "Where and what industry?".

64. Some of the major factors to be considered in feasibility studies for developing countries have been emphasized to indicate the necessity of special methods and techniques, and special training of experts. Foreign experts alone cannot carry out an effective and efficient feasibility study in developing countries.

65. In developed countries there are usually consulting firms specializing in feasibility studies. Most developing countries, however, do not have consulting firms experienced in feasibility studies, although they usually have experienced people who can work as a member of a team in such a study. The development of local consulting firms for feasibility studies requires considerable time and depends on the attitude of payment of the private investors and even on the government agencies for such studies. Detailed information on national and local resources, manufacturing facilities and especially on future developments, demands and investments is not usually made available to private consultants, either local or foreign.

66. A national or local institute recognized by the government agencies can carry out the feasibility studies in general and, with the help of specialized foreign consulting companies, can carry out the feasibility studies with all technical detailed data. It is important that such an institute should be independent both from the political influence of the Government and from the influence of existing manufacturing companies. Such an organization was organized and administered by the writer in 1954, in the Union of Chambers of Commerce Industry and Commodity Exchange in Turkey. This organization, called the industrial assistance commission, carries out local preliminary feasibility studies with its specially trained personnel, with the help of local chambers of commerce and chambers of industry and with the help of foreign experts and foreign consulting companies for their detailed final feasibility studies of industries where the investment is large and is on a national, rather than a local scale.

67. In countries where feasibility studies are not assigned to an agency, they could be assigned to industrial research institutes. It is important to indicate that engineers working on applied research and development research can give specific and detailed technological information and, in particular, the new trends in production techniques and processes for specific industries, which are very valuable for feasibility studies. Specially trained teams consisting of consulting engineers, economists, market analysts, sales experts, transportation experts and legal experts could be formed in the industrial research institute, as an independent group for feasibility studies on both a national and a regional scale. They should have all the information facilities of the industrial research institute and also the technical advice of the research engineers. If a national planning organization is available, the industrial research institute and the planning organization should work in close co-operation, especially in setting up the basic investment policy of the country.

C. Laboratory testing and standards

68. The testing laboratories of manufacturing companies (used to test the materials they purchase and also their products), the laboratories of trade associations or private independent organizations, and government testing laboratories are important parts of the industry in developed countries. They help to maintain the high quality of the manufactured products and to encourage fair competition and help to settle disagreements between buyers and sellers.

69. The cost of testing equipment and the cost of maintenance and operation of laboratories are, in general, high if the equipment and personnel are not fully utilized.

70. In developing countries, industrial research institutes initially can help industry and the Government with their laboratories for only special tests which cannot be carried out anywhere else in the country. This is usually the case for the testing laboratories of universities and higher technical institutes in developing countries. This type of test, if carried too far, would be very dangerous for the research programme of the industrial research institutes. Industrial research institute testing laboratories can be used to train technicians for the regular testing laboratories of the industry.

Standards

71. Classical publications on industrial standards indicate that, directly or indirectly, standards improve supplies and services for the consumer, pave the way for better and cheaper goods, and lead to a higher standard of living. Standards help the economic development of a country by a better utilization of its resources. One of the indirect, but very useful, contributions of national standards of a country is to encourage the development of industry and protest the national industry from the unbalanced competition of the importers of foreign goods.

72. The importance of standards for developing countries have been realized and most of them have some kind of organization to prepare their national standards for industrial and agricultural products. Before making any comments about the possible activities of industrial research institutes in preparing standards, it is appropriate to indicate the distinguishable types of standardization work and some of the very important aspects in preparation of national standards in developing countries. There are basically four different kinds of standardization work:

(a) Manufacturers' (company) standards: standards made by the company for their own products;

(b) Branch standards: standards made by some of the companies of the same products for their products;

(c) National standards: standards made for use throughout the country by a national standard organization;

(d) International standards: standards made by the International Organization for Standardization (IOS) or the International Electrotechnical Commission (IEC).

73. Some people in developing countries would like to have all the standards made compulsory and to translate the standards of another country and adopt them as national standards.

74. The first attitude has two major dangers for the development of the industry. One, control of compulsory standards entails sufficient well-trained technical personnel and laboratory facilities, which are usually not available in developing countries; and it is a very expensive operation. Two, standards must be dynamic; acceptances of technological development for improvement of products and production possibilities of cheaper and better products would be difficult.

75. The second attitude usually comes from the importers and they prefer the acceptance of the standards of the country from which they import their goods. This would create a real economic dependence of the developing country on one developed country; it also would create a very weak position for the developing industry in the country in competition with the industry of the developed country.

76. The recommended practice for national standards is an independent institute with a general council and board of directors consisting of one third from government representatives, one third from scientific and technical institutions and one third from commerce and industry. In general, standards should be non-compulsory and should be improved in time as the industry develops. However, standards of safety and health can be compulsory.

77. Turkish and Indian standards institutes are good examples to be studied by the developing countries.

78. The nature of the standards and the techniques of preparing various types of standards indicate that national standards should be prepared by the special institute of the country. If special research is needed in preparing a national standard and if the laboratories of the national standards organization cannot handle it, the industrial research institute should help them. The industrial research institute should be represented in the general council of the national standards institute, and comments and recommendations on final drafts of standards of industrial research institute should be available to the national standards institute.

79. It is quite possible that some of the standards preparation may lead to data for background research. In these cases, to avoid duplication, both institutes should follow their publications and in specific work use the expert advice of the others.

80. Industrial research institutes may be more helpful to the specific industries in preparing their company standards, especially when they have done specific product development research for that industry.

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VI. FORMULATION AND SELECTION OF PROJECTS FOR A NATIONAL INSTITUTE OF INDUSTRIAL RESEARCH

Prepared by A. Sundralingam*

A. Industrial Research in the United States of America

1. In the last thirty years, industrial research has grown from a little-understood field of activity in the United States of America, to a $US 10 billion industry employing over half a million people. The 1950 edition of the directory, Industrial Research Laboratories in the United States lists some 2,845 laboratories. 1/ During the last ten years, this industry has tripled in size and is growing at the rate of 12 per cent per year. 2/ This spectacular growth is obviously owing to United States industry recognizing the challenge of an expanding economy and meeting such a challenge by voluntarily spending large amounts of money on enlarged research programmes. It follows too that this policy has paid ample dividends by way of new technologies and new products which have met their immediate or long-term development plans. Most of the laboratories referred to are parts of industrial concerns and considerable literature has been published on the organization, operation and management of such institutes. The responsibilities of such a research organization for a company are:

(a) To determine what technology is needed and the discipline involved;

(b) To create the needed technology;

(c) To assist in the effective utilization of that technology;

(d) To assist in the operation of the company by quality control of its products and by the prevention and solving of its production problems.

B. Europe follows

2. Against this background of the phenomenal growth of industrial research in the United States grew the firm belief that research and industrial progress were indivisible. The industrial concerns in other developed countries followed the example of the United States, although there were also several university and government research institutes in the basic sciences, which had been established

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1/ United States of America, National Research Council, Industrial Research Laboratories of the United States, including Consulting Research Laboratories., 9th ed. (Washington, 1950), Bulletin, 120.

2/ National Industrial Research Conference, 1956, sponsored by the Armour Research Foundation of the Illinois Institute of Technology (Chicago, 1956).

many many years earlier. In this context, industrial research was thought of as an essential complement to fundamental or basic research and as an indispensable tool for industrial development. It is pertinent to mention here that Europe had led the rest of the world in its advancement of science and the search for new knowledge, and this had resulted in economic development and higher standards of living in the eighteenth and nineteenth centuries, but the application of the results of research to production had been slow during the twentieth century, while the newer countries had forged ahead in this particular field.

C. The emerging nations

3. The emerging nations which have become politically independent have watched the spectacular strides made by the developed nations in their economic development and have come to associate this rapid development with their successful industrialization based on the results of industrial research. They also have noted that nations which only recently were under-developed have become industrialized nations in a period of twenty to forty years. Both the Union of Soviet Socialist Republics and Japan are examples of countries which have established a lead in science and in industry within three or four decades. The key factor in development has been research and this acceptance led to the establishment of national research institutes in the developing countries. The emergence of industrial research institutes sponsored by the Governments of these new developing countries as essential organizations for their industrial development is of more recent origin. Consequently, there has been a paucity of literature and know-how on the organization, operation and management of such institutes. This assembly of Directors at this Seminar is a clear indication of the need to exchange experiences and views in this field of activity so vital to the developing nations.

D. The dilemma of developing countries

4. This paper deals with the formulation and selection of projects for a national institute in a developing country, with poor resources of scientific manpower and no tradition of industry. The assumption is also made that the capacity of such a country to find the financial resources to equip and run an institute is limited. A further assumption is made that a national institute with responsibility for industrial development will have wider objectives and policies and a larger spectrum of disciplines involved. The technological needs and the adaptation of existing technological requirements would also be larger by comparison with company-oriented research establishments. The last condition would require for its rapid solution the harnessing of extensive resources in manpower and finance. Yet, it is in these specific areas that there is considerable limitation. This conflict has to be resolved and the challenge posed by the need for development must be faced. The thoughts that follow are an attempt at bridging this inexorable gap between requirements in development and the severely limited means available to the developing countries.

E. Pre-conditions for formulation and selection

5. It is necessary to state (a) the functions of industrial research for a national institute; (b) the objectives in relation to national economic plans; (c) the mineral, agricultural and power resources available; and (d) the identifiable needs of technology to meet the industrial plans of the country before formulating the projects which would form the programme.

6. The next step would be a consideration of the limitations enforced by finance and manpower and the priorities already set by the economic plans of the country. The final selection of projects would be based on predetermined criteria including, among others, the technological requirements of industries already planned and in existence.

F. Functions of industrial research

7. The functions of industrial research are to create the necessary technology, to adapt existing technology to a particular set of conditions and to maintain the chosen or created technology at maximum effectiveness. The research component includes basic and applied research. Basic research has been defined by the Department of Defence as "that type of research which is directed towards the increase of knowledge in science". The basic research for industry also attempts to increase knowledge, but only in areas that can be expected to provide new knowledge whose application will contribute to new wealth. Hubert P. Buetow expressed the difference between basic and applied research in the following terms, "Knowing how to make things stick - for example - that's applied research. But knowing why they do - that's fundamental". 3/ There was a recent example in Ceylon when the Ceylon Institute for Scientific and Industrial Research (CISIR) undertook a project on the manufacture of instant tea directly from green leaf. 4/ It involved a choice of conditions in each of the operations and processes, such as withering, rolling, fermenting, extraction and drying, and consideration of the variations in quality of leaf at different seasons, altitude, humidity and temperature. A set of conditions was established to obtain a product superior to any other known. The experimentation involved in arriving at this product is applied research, but because we know so little of the mechanism of reactions involved in the traditional processes of withering, bruising and fermentation, and the biochemistry of tea, the advance now achieved has been made without a full understanding of the reactions; consequently, there is no certainty that optimum conditions and quality have been reached. The long-term investigations into these processes, and the chemistry and biochemistry of tea will be basic research. It is, however, oriented in that the new knowledge gained will be applied towards determining the optimum quality attainable and in attaining such quality.

8. Unlike the situation in basic research, there has been no ambiguity regarding the definition and scope of applied research in industry. It is scientific research directed to the solution of a problem of practical significance in industry and includes the development of a process or product through pilot scale work and design, product evaluation, utilization studies, economic studies, process design and market research.

9. It will be apparent that industrial research is no test-tube affair but a practical exploration into industrial development through all phases except production itself. 5/ It should be able to provide full information on the process machinery to be employed and the technique of manufacturing.

3/ Ibid.

4/ Ceylon, Institute of Scientific and Industrial Research, The Manufacture of Instant Tea Directly from Green Leaf, by A. Sundralingam (Colombo).

5/ United Nations, Economic Commission for Africa, Standing Committee on Industry, Natural Resources and Transport, "A report on institutes of industrial development and research on sub-regional basis for Africa" [by A. Sundralingam] (E/CN.14/I&NR/41, 27 November 1963).

10. Technology is often thought of as a primary resource for the reason that it has no value unless it is used. The creation of a technology produces a potential, but the realization of this potential only comes through effective exploitation. There is a fallacy that once a new technology has been announced, industrialists will hasten to use it. On the contrary, there is a normal reaction to change and a new technology has to be sold even in the industrialized countries. In the developing countries with little or no entrepreneurial talent, the task of selling presents greater difficulty and involves added assurance of continuous and direct assistance. This area of assistance would include industrial testing, quality control, efficient maintenance, trouble-shooting, industrial engineering, etc. These are essential elements of service if research results in the developing country are to be extended to production and accelerated industrial development generated within the country. 5/

G. Research in relation to economic development

11. The role of a national industrial research institute is that of active assistance to the nation in implementing its industrial plans in all its phases. This role it can effectively play only if it provides technology of the right amount and the right kind at the right time. Research should therefore be directed towards meeting established and planned needs of the country. To discharge this responsibility, it must be in the hub and counsel of planning and development. It cannot operate in an ivory tower apart from the country's policy makers and planners. 6/ Research is an integral part of planning and development. The research organization can only meet its responsibilities towards the nation by being fully associated with the industrial development objectives and plans of the country. To this extent, its programme should reflect the co-ordinated thinking on the country's needs of the planning departments, government agencies connected with industrial policy and the scientists.

H. Resources

12. The resources of a country and their optimum utilization in industry are key factors in development. They are consequently of vital importance in research and in determining the programme. There are two distinct ways in which the subject of resources and industries can be handled. One is the descriptive method, which is a description of the mineral, agricultural, and energy resources known and available, and the other is the functional method. 7/ The descriptive method gives a detailed picture of the nature, quality and quantity of a resource. The functional method places the emphasis on analysis, correlation and appraisal. For the purpose of project formulation, it is necessary to use both methods. One would therefore catalogue the resources to the extent that such information is available through geological and other surveys, and would also apply the technique of analysis and questioning in order to elicit the problems associated with the resources.

6/ Ceylon, Institute of Scientific and Industrial Research, A Review of the Applied Research Problems in Ceylon and a Research Programme for the CISIR, by A. Sundralingam (Colombo).

7/ Erich Walter Zimmermann, World Resources and Industries: A Functional Appraisal of the Availability of Agricultural and Industrial Resources, rev. ed. (N.Y., Harper [1951]).

13. It is necessary to know the quality of the resource to determine whether beneficiation is likely to enhance the quality to the extent desired for use within the country or for export. One would question why a particular resource is either not exploited or under-exploited, either unutilized or under-utilized. A material similar to a local resource in use in a process or industry already existing would suggest an investigation into that resource. Lowering of quality in the final product by use of the local resource would again suggest a project on the pre-processing of the resource or adaptation of the technology used in the particular industry or process. Some minerals and most of the agricultural resources provide by-products often going to waste because no immediate use is found in the area; investigation into finding uses for these can be rewarding and fruitful.

14. The developing countries of Asia, Africa and Latin America have primary product economies where agriculture is dominant. The crops include the major food crops like rice and wheat, many and varied subsidiary food crops, and the agri-industrial crops like sugar, cassava, vegetable oil seeds and palms, besides primarily industrial raw materials such as fibres, rubber, essential oils, cinchona, pyrethrum and forest products. These agricultural economies are increasingly using modern machine-intensive methods and large acreages are now being cultivated on plantation scales, utilizing fertilizers, tractors and harvesters, in order to increase both the yield per acre and per person employed.

15. Very few products are exported in the form they are harvested from the land. Some processing, if only for preservation and storage, is almost always necessary. Coconuts as husked nuts will not keep for more than three to four weeks. Consequently, the conversion of kernel to dried copra and then to oil arose, and with it a number of subsidiary fibre products, desiccated coconut, shell dust, etc. Tea is not exported as green leaf, but is processed in a factory; the black tea thus produced is the export product. Coffee beans are cleaned, fermented and dried for the market. Rubber is extracted from the tree as latex and either concentrated or processed into sheets, <u>crêpe</u> or other special forms. Cassava is made into starch and pearl tapioca. Sugar is made in factories by crushing the cane, concentrating the juices and crystallizing; of the by-products, molasses is converted into alcohol and the bagasse is either used as fuel or made into paper or board. This interdependence between agriculture and industry finds infinite examples and because of such correlation a host of applied research problems will present themselves.

16. Minerals are non-renewable resources and their exploitation by mining would present problems of beneficiation, refining, purification and preliminary processing if the country is to obtain maximum value for them. Such energy resources as coal, petroleum and peat would suggest a number of chemical processes and by-products for investigation. The water resources are modest in most countries, but are essential for agriculture and the source of hydroelectric power. The optimum utilization and conservation of water is therefore of vital importance to the economy.

I. <u>The industrial plans and identifiable needs of technology</u>

17. A new country passes through three stages of economic development: the exploitive stage, the stage of industrial development and the stage of industrial maturity. Most of the developing countries were until recently exporters of the

products of agriculture, mining, fisheries and forestry. They have, however, a long tradition and experience in the processing of their primary products for export. Since the Second World War, many countries have embarked on planned industrial development and if these plans have been based on sound economic decisions, each country will have built its industry largely on the strength of its basic resources - agriculture or mining. 8/ Basic industries for the manufacture of fertilizer will have evolved from the availability of oil or large reserves of forests, plywood and newsprint from forest timber, iron and steel from iron-ore deposits, chemicals from salt and other deposits, aluminium from bauxite, copper wire and plate from ores of copper sulphide or oxide, cement from limestone and clay, etc.

18. Besides these basic industries, which are generally planned and have specified targets of completion and initial production, there is a large area of secondary industries producing consumer goods. The secondary industries are mentioned only briefly in most plans, to the extent of indicating the over-all investment and employment desired. The basic industries, because of their size and complexity, often have built-in technical and managerial arrangements included in the cost of the project. On the other hand, the large number of secondary industries usually found in the private sector are not so provided for and entrepreneurs are expected to obtain such assistance as they can within the country.

19. Added to this disadvantage is the lack of specific information in most plans of the number and nature of these secondary industries. The countries' industrial policy statement, together with the approvals already granted for new industries, would then have to be studied in order to determine the adaptation of technology, the raw material substitution and the processing problems of these industries.

20. Furthermore, existing process industries, as well as basic and secondary industries, would have to be listed, and their raw materials and the processes in use closely examined to reveal those problems which required immediate or future solution.

J. Over-all programme to preliminary selection of projects

21. The over-all programme would be an inventory of projects resulting from an analysis and appraisal of the needs of technology and technical services necessary for enhancing the resources and developing the existing and planned industries of a country. These projects could then be subdivided into basic and applied, and long-term and short-term, projects under product or subject headings.

22. At this stage, it would be necessary to consider the major short-term and long-term objectives of development of the country in relation to the financial and manpower resources available to the research organization.

K. Scientific manpower for industrial research

23. Stanley F. Teele stated, "I think that the premium on imagination, on flexibility, on the capacity to deal with questions that have never been asked

8/ Murray D. Bryce. Industrial Development (New York, McGraw-Hill, 1960).

before, will be very much more substantial than it has been in the past. I think that the capacity to deal with new knowledge effectively, new knowledge that is piling up at a rate that is hard to exaggerate, is of utmost consequence. It demands the capacity not only to acquire and use knowledge but also to discriminate carefully with respect to what does not need to be acquired and what should be avoided". 9/ The manpower for industrial research should possess the above qualities and it would be wrong to assume that a science graduate is a potential research man. The type of scientist acceptable for research would be an honours graduate in those disciplines most required, viz. chemistry, physics and engineering, with a post-graduate degree by research in an applied scientific field and at least one to two years in an industry of determined specialization or an industrial research institute.

24. A university post-graduate degree trains, without the limitation of time, finance or reward, in the fundamental techniques of research, and one would normally expect that a scientist trained in these disciplines would use the acquired techniques towards solving those problems which are of urgent importance to his country. The experience of the developing countries which have been fortunate enough to have such post-graduate men has been, however, most disappointing, as most of them insist that they should be permitted to work in the specialized abstruse fields which engaged their attention at the university and in which a school of research existed under a particular professor. Any project assignment with industrial associations is looked down upon as being materialistic and against the university philosophy of knowledge for knowledge's sake. 10/ Applied research differs from basic research in intent rather than in method and the applied scientist should have had prior university training in research methods and techniques. Yet the acquired background in a university atmosphere is itself a barrier. To overcome this it is necessary to expose the scientist to the industrial disciplines of time, money and reward.

25. When scientific manpower is selected on the above-mentioned specified academic attainments, training and attitude, only one in fifty honours graduates will be considered suitable for applied research. In countries where the output of honours science graduates is small, the staffing of an industrial research laboratory will cause insuperable difficulties. Quality and the right attitude necessary for applied research cannot be made up by quantity with lower qualifications and training and this alternative should be avoided at all costs. One of the means of overcoming this scarcity of scientific manpower is to have an extensive programme of overseas training of graduates for periods of four to five years included in the industrial research organization's capital budget, for manpower is its most important capital asset.

Finance

26. The next factor to be considered is the extent of financial support available to the research organization for its equipment, building, training and service

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9/ Stanley F. Teele, "Technological Planning on the Corporate Level" in Proceedings of a Conference sponsored by the Harvard Business School, 1961 (Cambridge, Mass., Harvard University, Division of Research, 1962.

10/ Handbook of Industrial Research Management, Carl Heyel, ed. (N.Y., Reinhold /1959/).

facilities, and for the cost of operation. Most developed countries are spending as much as 2 per cent of their national income on research and almost 0.5 per cent on industrial research. The developing countries tend, however, towards the belief that research is an idle luxury to be had only for prestige reasons. Recently the Governments of South African countries considered an expenditure on industrial research of 0.01 per cent of the gross national product per annum too high. Ceylon spends Rs. 1 million per year of a gross national product of Rs. 6,000 million, and this is considered inadequate to maintain the existing organization without expansion and without expenditure on overseas training for its staff. For developing countries, therefore, finance is likely to present as large a problem as the scarcity of adequately trained scientific manpower, and on both these issues the Governments should take the bold decision of spending adequate funds if the desired development is to be achieved in the expected time.

L. Preliminary evluation and screening

27. The over-all programme derived from a study of the resources and plans of the country would, as stated earlier, have to be classified according to resources and industry, and further subdivided into basic research, applied research and development. Because the institute serves an entire nation, which includes the private and public sectors of industry, the spectrum of disciplines and the possible number of projects would be extremely large. A preliminary evaluation and screening would then be necessary.

28. The projects formulated at this stage would represent ideas with, perhaps, concise information on the scope, disciplines, and state of existing knowledge. Preliminary evaluation, which may be done by a joint committee of the research staff and ministry officials, would consider the relative importance of a group of projects in a particular industry or on a particular resource, and would eliminate those which involved small gains in relation to research effort, those which required technologies that were scarce or unobtainable, those for which existing technology was satisfactory and which could be postponed for later consideration, and those on which outside knowledge had been found to be available and could be adapted at lower cost.

M. Information content of project proposals for final selection

29. Even for the projects submitted in the over-all programme, a certain amount of preliminary work must be done before the idea is reduced to writing. After the preliminary screening has been made, the projects remaining and therefore considered to have some merit or purpose would have to be prepared in some detail for the final selection.

30. The scope and object of the project and the specific problems to be solved by the project should be stated first. This would be followed by a brief summary of the literature search made on the particular subjects and the gaps in knowledge which the project is expected to fill. The institute library can play an important role in this aspect of the work by maintaining a good cross-referenced index of work the laboratory has previously undertaken, so as to exclude experiments which

have been made previously. 11/ It could also, as part of its service, maintain a similar cross-referenced index of papers, journals or patent information on areas and subjects in which the institute is likely to be interested. The value of adequate literature and patent search cannot be over-emphasized. It often happens that lack of library information has led to projects which attempted to rediscover what was already known and published. Apart from the savings in cost, it saves even more in valuable manpower.

31. The utility factor should be presented next. A basic research project to provide new knowledge towards the solution of other applied problems has utility, even though it would be difficult to estimate in advance the time required for completion of such a project and hence the cost. In applied research the utility factor can be more specifically stated as a new or better raw material, an improved product or process or operation or a new product. At best, the time, cost and magnitude of the attack on such a problem can only be an intelligent prediction based on previous experience with similar problems. Research is essentially an exploration into uncharted areas and therefore defies more definite estimates. What is presented as time and costs are notional probabilities.

32. In the case of development projects which involve pilot-plant operation, determination of unit costs, market research and evaluation of final product, it would be possible to determine more closely the utility and usability factors and to predict within close limits the results that would be achieved, in a particular time and at a particular cost.

33. In addition, certain other factors, such as specialized equipment and specialized skills and their availability or procurability, should be stated. Also of great importance in the selection would be the considered view of the director and technical staff of the chances of successful attainment of the objectives of the project and whether the project was of importance to existing industrial plans.

N. Final projects - selection and priorities

34. When the projects had been prepared by the research director in the detail and form given above, they would be subject to further scrutiny by a committee as before or by a research advisory group to select the final projects, establish priorities and determine the projects for implementation over a period of five years.

35. There are two approaches to selection - one is the systematic formula method and the other is based on individual or committee judgement with weightage given to service and the person or persons involved in execution of the project. Blake favours the informal committee approach because a group can make two important contributions: (a) the establishment of technical chances of success; and (b) a review of the literature and other information contained in the proposal. 12/

11/ R.N. Anthony, Management Controls in Industrial Research Organizations (Boston, Harvard University, Graduate School of Business Administration, Division of Research, 1952).

12/ Walter T. Blake, Project Selection, (Madison, University of Wisconsin, Engineering Institute's Industrial Research Organization, 1956).

36. The simplest formula devised by an industrial research institute, as an index of net probable return on investment, is $I = \frac{PN}{C}$, where I = index of relative worth, P = over-all probability of attainment of goal, N = estimated net return for an arbitrary five year period and C = estimated research cost. The organization which developed this formula gives priority and emphasis to projects with larger indices.

37. The ideal approach would probably be a combination of both and the final selection would represent a certain number of projects to be established. A more detailed consideration in relation to existing and proposed plans of economic and, particularly, the industrial development would suggest the priorities for a specified period of, say, five years.

Research capacity

38. The final selection of projects with its own priorities established for the whole programme and inter-group would represent the research capacity that the institute should possess to meet the targets of development. This would require balancing and phasing and, in that form, could be evaluated in terms of disciplines, scientific manpower, equipment and facilities, and cost of operation.

39. If existing personnel are insufficient to carry the priority projects selected, the following steps should be taken:

(a) Seek outside organizations within the country, such as universities, departments of the Government, etc., which employ scientific research trained personnel to carry the basic research programme;

(b) Seek the help of scientists from friendly nations and international agencies to work in the research organization, as supplementary staff on determined projects;

(c) Establish an extensive programme of training both within and outside the country in order to develop the total manpower required within a specified period of time.

40. While this approach can be made to overcome manpower shortage, it is only possible if sufficient funds are made available. Finance is therefore a critical factor, and it is urged that developing countries which are establishing institutes should make adequate provision for recurrent expenditure. At this late stage in the race for technology, it is the considered view that the extent of annual finance should be 0.1 per cent of the gross national product of the country. It is no longer a question of whether a country can afford it, but whether it can afford to be without it.

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VII. APPLIED RESEARCH, DEVELOPMENT, TESTS AND STANDARDS IN THE DEVELOPING COUNTRIES

Prepared by D. Zanobetti*

A. Research and Development

1. The Centre for Industrial Development of the Economic and Social Department of the United Nations should be complimented on its timely decision to hold the Inter-regional Seminar on Industrial Research and Development Institutes in Developing Countries, since it has been proved that these institutes are the fundamental instruments for the industrial development of all countries, whatever the stage of industrialization they may have reached.

2. The reasons for this obviously stem from the complexity of current industrial research, the very high cost of instrumentation and the need for a concentration of material and human resources.

3. A confirmation of the usefulness of concentrating developments and research efforts in a centralized organization is the fact that they are adopted not only by Governments - who are generally accused of having centralization tendencies - but also by private industry; in the highly developed industrial countries one finds laboratories are established jointly by corporations which, moreover, may even be extremely competitive.

4. The United Kingdom is perhaps the country in which this pattern has reached the greatest generalization, and in which one can also see the very interesting process by which large research associations, that were at the outset purely private enterprises, have gradually become of interest to the governmental agencies and have grown into semi-governmental bodies.

5. Examples of governmental initiatives for the same purposes are too numerous to mention, so that a developing country wishing to follow examples of joint co-operative efforts in research and development has only the difficulty of selecting the best model, i.e., the one best adapted to its particular case. Whatever the formal organization, the basic elements - the laboratories - should be studied first, and in this, one may find the complete range, of which it may be useful to examine the two limit cases.

6. Firstly, one may consider the case of a country just beginning its independent development: this situation is common following recently acquired political independence.

7. Up to the time of their independence, such countries may have relied entirely on the industrial organization of the colonizers. Sometimes their only economic resources are based on agriculture or, still worse, on monoculture and the only research laboratories they possess may be those created by foreign private companies for the sole purpose of their commercial activity.

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* United Nations Educational, Scientific and Cultural Organization.

8. In these cases, the task is that of creating a basic technical infrastructure: a place, a laboratory, where the newly established activities may find help in the form of advice and general facilities.

9. A chemical laboratory should provide means of effecting analysis for various purposes; a building laboratory should help the private- and public-works activities and provide means of testing materials; an electrical and mechanical laboratory should permit measurement of a certain precision, and the repair and calibration of measuring instruments, etc. All these should serve both government bodies - the Customs, the Post-office, the Ministry of Public Works, etc. - and private enterprises, farmers, miners, manufacturers, etc.

10. A problem is, of course, to select the facilities in relation to the country's primary requirements and lines of development, but perhaps the most serious problem is that of staffing.

11. When the country possesses a technical school or a university, the laboratory may be linked with it in order to share both the equipment and the staff: this is, in general, the best solution and one that has prevailed in all the currently industrialized countries up to very recent times.

12. When the country does not possess any technical school, the problem is undoubtedly more serious, but since the urgency of technical education and development activities have the same order of priority, a school and a laboratory should be started together. In this case, a fellowship scheme to be carried out abroad should prepare the technicians and the teachers to staff the school and the laboratories and to replace foreign assistance.

13. A paper by R.A. Krause, contributed to the United Nations Conference on the Application of Service and Technology for the Benefit of the Less Developed Areas (UNCSAT) deals with the problem of co-operation between universities and research laboratories, and relevant parts of it are reproduced in annex I to this paper.

14. At the other extreme, there is the case of countries which have an advanced stage of development, where research and development laboratories have reached a high level of specialization. However, there remains the problem of a common denominator to all this activity, which takes the form of a national standards laboratory for the execution of the highest precision analysis and measurements, to which not even a developed industry may devote the very large financial investment required.

15. An example of a national laboratory of this kind is the National Bureau of Standards of the United States of America. The role of such a laboratory is described in annex II, by A.V. Astin, its director.

16. The concept of a national laboratory exists more or less in all the industrially developed countries, though, of course, historical reasons, industrial patterns or simply governmental structures may influence its set-up.

17. As an example, in Switzerland, the Federal Bureau of Weights and Measures is a body of the Ministry of Finance, since an important part of its early activity was the enforcement of the law on weights and measures. However, it is also a place where original and independent metrological research is carried out and where type testing of a highly refined nature may be executed.

18. In annex III, L. Ragey gives a description of the activity of the National Testing Laboratory of France, together with its historical background. This shows very clearly how a national laboratory was involved in the industrial development of the country, from the start of the industrial revolution up to the present, adapting itself to the national necessities and always providing those services which other organizations with more limited or more specific interests could not provide.

B. Tests and standards

19. Standardization goes hand in hand with progress and development. It began as a necessity felt by the users and it continues as an essential means of simplifying production and giving common reference to every trade and activity.

20. However, standards may have many meanings and include many concepts:

(a) A common definition of measurement units;

(b) A standardization of basic elements, from threads and railways gauges to transistor sockets;

(c) Standards specification for quality, covering raw materials, agricultural produce and industrial products;

(d) Code of practice for the most important industrial activities concerning public use (construction, erection of electrical lines, food conservation, etc.).

21. These activities are quite distinct from one another but they have in common a specialized knowledge and the necessity for instrumentation and, as a consequence, research and development institutes should be concerned with all of them.

22. The definition of measurement units implies the maintenance of legal standards, but this activity has currently become much easier than it was in the past. Relatively moderate-priced standards of good precision are available and transport has reached such a high degree of speed and safety that the activity of calibration against highest-precision standards maintained in reference laboratories abroad, permits the elimination of the very expensive and time-consuming work which used to be coupled with the maintenance of national standards.

23. The standardization of the basic elements only requires the adoption of standards already in existence; practically the only decision is that of deciding between the United Kingdom system and the metric system, and there is no doubt that the trend is towards the general adoption of the latter, notwithstanding the fact that it will take a considerable number of years before it is universally adopted.

24. Much more complicated is the problem of standardizing products. It is true that most developed countries have large collections of standards, such as those of the United Kingdom and of the United States of America, but in many cases, these cannot be adopted readily. As an example, there is no doubt that the specification for butter in Scandinavian countries or in Canada cannot be adopted in Nigeria.

This requires the study of special standard specifications for each country, though joint activities permitting the preparation of regional standards are often much preferred.

25. The same consideration applies to codes of practice and in both activities there is ample scope for the international and regional organizations in establishing co-operation among the interested countries to issue common documents.

26. That is why, whenever one speaks of industrial research and development institutes in developing countries, one should always include, as a fundamental part of their activity, "tests and standards", meaning that their facilities should also be used for the activities described.

ANNEX I

EXCERPTS FROM ROLE OF A RESEARCH INSTITUTE

by Ralph A. Krause*

I. INTRODUCTION

1. Developing countries have a shortage of scientific and technical personnel at a time when the need for them in government, industry and education is critical. Scientific, engineering and testing facilities are needed for instruction, industry development and government functions. Facilities are expensive and should be available on a basis ensuring efficient use. Often, industrial and governmental leaders lack staff assistance with the technical and scientific background and experience so essential to realistic planning for the use of research relevant both to managerial decisions and material development.

2. Some assistance can be provided by the technical staff of the university or technical school and by such local consultants as may be available. Assistance can be given by foreign experts or organizations. Such assistance, while important, is difficult to arrange, is not continuous, lacks local laboratory facilities, is often quite expensive, and does not serve to build a strong scientific and technical resource for a country.

3. A central organization designed to provide technical assistance to each segment of the economy, staffed with scientific and technical personnel, adequately equipped with laboratory and supporting facilities and suitable directed or motivated toward serving the government, industry and business of the country, can be a major asset in the development programme. Such an organization - a research institute - can have several important functions. It will emphasize one or more of these functions in accordance with the need of the country, the particular abilities of the staff and the direction of its leadership.

9. In addition to conducting research into new products or endeavours for industry, the research institute provides many technical services. It makes its staff available for visits to industry to discuss technical operating problems, to conduct on the spot "trouble shooting" and testing, or to advise on suitable materials or processes to improve the production of the industry. In a more formal manner the research institute establishes technical standards for industry, distributes suitable standards for industry use and provides a standards checking service. Similarly, it works with industry in establishing testing procedures and provides materials testing facilities and service at its own laboratory. It may, in addition, at government or industry request, serve as a standards and quality control testing and inspection facility.

10. In general, the role of the research institute in supplementing the industries' activity is to provide services which each industry needs but cannot provide within itself on an efficient basis. It provides a manpower and facility resource which can be called upon as needed and which can, because of the interests of the staff, keep industry abreast of new developments and assist in their adaptation.

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11. Certain additional services given to industry, such as the training of personnel who eventually are employed by industry, the upgrading of industry personnel, and liaison with the world's technology and with foreign experts will be mentioned later.

12. There are many examples of research organizations providing the above services to industry, such as the Instituto Mexicano de Investigaciones Technologicas and the Industry Institute of Lebanon. The Instituto de Investigaciones y Ensano Materiales associated with the University of Chile provides such services with emphasis on industry standards, testing and quality control.

III(C). Improving the Scientific and Technical Manpower Resource

17. A less easily recognized role of a research institute concerns the development of an adequate resource of scientists and technical personnel and the facilities to make them effective. The institute calls on the staff of universities and technical schools for assistance in its studies. This makes the services of such personnel available, on a part-time basis, to the development programme and, at the same time, enhances their income and provides research facilities and technical challenges to them. By providing a source of employment for technically trained personnel, it establishes a motivation for students to undertake scientific and technical careers. It can assist in the training of students by providing facilities for graduate research and by providing fellowships for studies in foreign research organizations.

18. Many of the staff of the research institute eventually become attracted to technical positions in the industries of the country or are called upon to serve in technical or administrative positions in government. This turnover provides experienced, technically educated, personnel to the industrial development programme or to government policy positions and at the same time opens up opportunities for younger personnel to join the institute for research and training. The research institute encourages industry to send its technical personnel to participate in the research project undertaken by the industry in order to assure efficient transfer of the research results to the industry and to provide training for the participants. In addition to this technical upgrading of industry personnel, the research institute conducts formal meetings, seminars or special courses for the education and training of industry personnel either through a formal productivity programme or in connexion with its research activities.

19. The research institute gathers scientific and technical publications of the world and maintains a library available to its staff and to members of industry and government. It has library exchange relationships with the foreign sources of information and can thus obtain the publications needed by its staff or by industry.

20. The resource institute seeks to make scientific and technical information available to government, industry, and educational organizations through its publications. These include abstracts or reviews of scientific developments, reports on research results, proceedings of meetings and seminars, or scientific papers of its staff.

21. The research institute arranges for and hosts meetings and seminars which are attended by interested persons from all segments of the community and in which local and foreign experts participate. Conversely, the members of the staff are

encouraged to attend and participate in international scientific, industry or development meetings.

22. The research institute, in its relationship with the academic community, in its training programme, in its acquisition and dissemination of information and in its sponsorship of meetings is performing the important role of helping to establish the framework for a national scientific and technical self-sufficiency of the future and the prestige of the nation in the scientific community of the world.

ANNEX II

EXCERPTS FROM THE ROLE OF THE NATIONAL LABORATORY

by A.V. Astin*

The Founding of National Laboratories

6. Concurrently with the growth of firm ties between science and technology, technological developments in transportation and communication, focused international attention on the need for compatible measurement techniques based upon internationally accepted units and standards. International exhibitions, demonstrating the marvels of new inventions and scientific discoveries, led to an awareness that further progress would require international accord on a world-wide system of measurement. Such a system would be particularly important if scientific data were to be reliably exchanged among scientists of different nations, if the application of scientific data by technologists were to be facilitated, and if international commerce in the products of the new technologies were to prosper or grow efficiently. Such considerations led to the formal signing of the Treaty of the Meter in 1875 which in turn provided for the establishment of a permanent International Bureau of Weights and Measures at Sèvres, near Paris.

7. Although the creation of the International Bureau of Weights and Measures was a significant step in international scientific co-operation, and in providing a logical and physical basis for scientific, technological, and commercial exchange, it was only a beginning. Means had to be provided for the dissemination of standards within nations including standards for measuring thermal, electrical, optical, chemical, and mechanical properties. These needs led to a realization that central facilities for the comparison, verification and calibration of measuring instruments were essential. At about the same time several thoughtful scientists and engineers realized that a well equipped laboratory devoted to the systematic measurement of important physical constants and properties of materials would facilitate the work of scientists and technologists generally. These multiple needs first crystallized into a practical plan in Germany. The Physikalische Technische Reichsanstalt (PTR) was established in 1887 to provide instrument calibration and research and testing on standards, instruments and materials important to the science and industry of Germany.

8. The immediate acceptance of the PTR soon led to efforts to establish similar national laboratories in other countries. Following closely upon the pattern and objectives of the PTR were the National Physical Laboratory (NPL) established in England in 1900 and the National Bureau of Standards (NBS) established in the United States of America in 1901. The prescribed functions of each of these three national laboratories were remarkably similar. All were charged with (1) the establishment of measurement standards and the verification of instruments based upon such standards, (2) the determination of important properties of materials,

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and (3) research on problems of a major nature that required the availability of nationally furnished facilities and resources. In addition, these laboratories and similar ones established in other countries have provided focal points for the co-ordination of precision measurement activities among nations, primarily through the International Bureau of Weights and Measures, but frequently through direct exchange.

9. In the more than seventy-five years that national laboratories have been contributing to scientific and industrial progress their programmes have expanded substantially, more or less paralleling the tremendous technological growth during the same period. During this same period, the range of functions has tended to enlarge and a better appreciation has evolved concerning the nature and importance of the original measurement functions. We shall proceed next to examine in some detail these functions.

Modern Functions of a National Laboratory

10. Standards for Physical Measurement. A major purpose in providing standards for physical measurement is to assure uniformity and compatibility in all activities in commerce, industry, and science that involve physical measurement processes. In the exchange of data among scientists it is essential that the quantities and units in which a scientist's data are expressed be the same as the quantities and units used or understood by other scientists. In turn it is essential that all engineers who design materials, structures, or devices by quantitative methods employ the units and quantities that are the same as or compatible with those of the scientists whose data he uses. A standard provides a physical means of representing a unit or quantity so that it will have meaning and stability from place to place and from time to time. Measurement standards thus provide a cornerstone upon which basic scientific information can be applied to useful purposes.

11. The traditional role of measurement standards, in the area familiarly known as "weights and measures", has been primarily concerned with assuring reliability and fairness in commercial exchange. In the buying and selling of commodities, mutual agreement on the actual amount of a commodity that is exchanged depends upon accurate, stable, and honest weights and measures. The function of establishing and disseminating reliable standards for weights and measures has long been a responsibility of government. In commerce between nations, however, the attainment of the necessary confidence requires the means of relating one nation's standards to those of other nations. Although this can be done by direct bilateral negotiation between governments, it has proved much more effective to have national laboratories work through the International Bureau of Weights and Measures.

12. Measurement standards also provide a basis for the exchange of components within an industrial system. The importance of this exchange derives directly from the importance of the concept of interchangeable parts. The achievement of today's interchangeability requires first that there be adequate capability to measure properties wherever there is a requirement to control properties, next that the measurement techniques for different types of properties that must be controlled within a single assembly be consistently related through a logical measurement system, and finally that the standards upon which the system of measurement is based be adequate to the range and tolerance requirements for interchangeability.

13. In its simplest form interchangeability requires only a measurement standard applicable to a single production line. In the next stage the measurement standards are applied to different production lines within a single plant. From this phase we go to the need to assemble components made in different plants, first in different parts of one nation and then in different parts of the world. In order to assure interchangeability under these expanding and more extensive conditions, measurement standards must be increasingly available and on an international basis. Increasing the accuracy of measurement raises the level of sophistication of the interchangeable parts concept. The reliability and efficiency with which parts can be mated through controlling dimensions by a standard increases only as dimensional control itself becomes more accurate. Modern industrial efficiency depends to an appreciable extent upon the phenomenal increases in our ability to control dimensional accuracy.

14. A still higher degree of sophistication in the evolution of interchangeable parts involves the measurement of properties other than dimensional, such as thermal, electrical, optical, and chemical, together with an assurance that components not only fit together but operate together to a high degree of reliability. Coupled closely with this is an increase in the number of individual components involved in modern complex devices. Interchangeability reaches its most advanced stage in the assembly of devices for space exploration. Here, the requirements for interchangeability may be imposed on hundreds of thousands of components or many thousand distinctive types, with scores of different controlled properties. Measurement standards for all of these properties must be available.

15. A very important aspect of effective interchangeability is found in the problem of maintenance. Many of the devices and materials of technology require periodic maintenance if reliable performance is to be obtained or if long life is desired. Maintenance frequently requires that measuring instruments to determine critical properties be available, and that there be a supply of replacement parts. In order that testing instruments and replacement parts be compatible with the original equipment we again must depend upon measurement standards. The test instruments require calibration against the same or compatible standards from which the original equipment was built. The properties of the replacement parts must have been similarly controlled. This aspect of the availability of measurement standards becomes of considerable importance in extending technology from a few nations to many others. Here we have a situation where the most complex technological devices are fabricated in a few countries but where their use is world wide.

18. Engineering standards. The degree of involvement of different laboratories with engineering standards varies widely from country to country. Standards of technical practice generally include procedures established by authority, customs, or general consent, such as models, sizes, tests, levels of performance, and quality. Such standards have also been frequently defined as model means of performing a repetitive task or providing a repetitive item. Standards of technical practice are of substantial importance to manufacturing processes, and in technological and commercial exchange. In the building construction industry, for example, the availability of standard sizes for such things as masonry units and lumber facilitates substantially the design of structures, the erection of structures, and their maintenance. Similarly, in the mechanical industry, standard sizes for nuts, bolts, screws, pipe, sheet metal and many other items facilitate all aspects of commerce in these products.

19. Mass production industries with their extensive dependence upon interchangeable parts require not only reliable measurement standards but also standard sizes, modules, sub-assemblies and performance characteristics. In this area, as was the case in the measurement standards area, the range of applicability of standards of practice increases the range of usefulness of the interchangeable concept. Standards applicable to a single plant will permit internal production efficiency but if products are to be used in conjunction with other products, if the maintenance and repair of equipment is to be facilitated, then engineering standards must be widely accepted and used.

20. In general the importance of engineering standards increases as technology becomes more widespread and as the diversity and complexity of technological products expand. Without a reasonably high degree of standardization of sizes, varieties and operating characteristics, modern technological economies would collapse.

21. A systematic concern with engineering standards is extremely important in extending technology from the more advanced nations to less developed areas. Although standards applicable within a single country or even a single firm may take care of all major problems of internal production efficiency, the exportation of technological products to other countries where they must be operated and maintained requires the availability of standards accepted and understood in the importing countries. The development of international standards, so important to international trade and commerce, is centred in the International Standards Organization (ISO). There must, however, be affiliating organizations within each member nation of ISO. These affiliating organizations are frequently governmental organizations, sometimes private organizations and sometimes quasi-governmental organizations. Sometimes a national laboratory or its equivalent may assume full responsibility for the engineering standards work within a country but this is by no means essential. There are many ways, however, in which a national laboratory can and does contribute to the advancement of engineering standards activities. Let us examine a few of these briefly.

22. Most meaningful safety codes require some quantitative knowledge of the properties of materials and the limits of operating conditions to which a material or device may be subjected. Building codes, for example, require a knowledge of the strength of building materials and a knowledge of the range of loads to which the building is apt to be subjected. From such quantitative information meaningful building codes can be developed.

23. In the development of specifications for the purchase of materials or devices for specific application it is again necessary to have available relative and quantitative information about the materials and devices, as well as about anticipated operating or use requirements. In addition, it is essential that meaningful test techniques be devised in order to assure the compliance of a product with a specification. National laboratories with their inherent skill in physical measurement techniques have made substantial contributions to the development of standard test methods as well as in providing data on the properties of materials essential to the development of a useful specification.

24. In nations which depend extensively upon the importation or exportation of fabricated products or raw materials, it is essential to have useful standards for both quality and quantity. Only when such standards are available can there be confidence in the value of commodities purchased or in the fairness of reimbursement for commodities that are sold. National laboratories can exercise one of their most useful functions in providing the technical expertise for the development and application of such standards.

ANNEX III

THE NATIONAL TESTING LABORATORY OF FRANCE

by L. Ragey

The French Testing Laboratory was founded in Paris in 1901 at the Conservatoire des Arts et Métiers, since it was here that the first measures of inspection and industrial output had been studied and here too that the International Metric Commission had been based, under the leadership of General Morin.

As long ago as 1863, the engineer Tresca - Assistant Director of the Conservatoire des Arts et Métiers - set up a small polyvalent laboratory where, for the benefit of inventors, he measured the performances of very widely varying machines: hot air machines, gas driven motors, fans, various steam machines, hydraulic motors, automatic steam pumps, machines to bore or cut hard stones, water-meters, hydraulic rams. For public and industrial services also, Tresca determined the properties of materials or of installations: the resistance of window glass, stone pipes, lead pipes, steel wire, silk ropes, the ultimate strength of rubble-work and other types of floors, the iron roofing of the North Station in Paris, the degree of elasticity of aluminium bronze, the efficiency of heating installations of blasting machines, of various kinds of pumps, etc.

Eighty reports of these tests were published between 1862 and 1879 in the Annals of the Conservatoire - one of the rare scientific and technical journals of those days. Thus, in the second half of the nineteenth century, the basic idea of industrial testing - whether it concerned the inspection of a machine or the exact measure of a property of any given material - was spread by men who put to use the experience gained in the metrological work at the Prototype Office of the Decimal Metric System.

It is from these origins that the Testing Laboratories have acquired their dual character of centres of metrological work on the one hand and, on the other, centres open to anyone desiring the most exact measurement possible, in order to testify to the quality of a product or a construction. It is evident that, depending on the country and on the moment in history, one or other of these two characters may predominate. Here, we give a description of the French National Testing Laboratory.

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At the time of its foundation in 1901, the role of the Testing Laboratory was confined to measurements of properties and to "physical, chemical and machine" characteristics. Therefore, everything to do with biological properties (toxicology, etc.) was implicitly excluded.

It was only in 1925, after the reorganization of the Bureau of Metric Standards at the Conservatoire des Arts et Métiers, that the Testing Laboratory also became the Centre for Research and High Precision Metrology. From 1943 onwards, it was designated National Laboratory, and was entrusted with representing France in all international metrological commissions.

During the first thirty-odd years of this century, the Laboratory equipped itself to deal with requests for tests of the most varied nature, sent in by manufacturers and public services. Chemical analyses, particularly those to do with minerals, including fuels, together with the measurement of the usual properties of metals and materials (resilience, elasticity etc.), constituted the main activity. Special installations permitted the observation of the breaking-strength of cables, the ultimate strength of ceilings and building materials, and the resistance of walls to the transmission of noise or heat.

It was natural that, at a time when industry, with the exception of heavy industry, still retained so many vestiges of the old crafts, not every factory possessed a laboratory or a section for the inspection of its products. As an example to manufacturers, the measures set up at the National Laboratory gave information on the manufacture or reassurances on the nature of the products used. Fortunately, however, industrial development was to point out to the manufacturers the fundamental importance of these data, and recourse to the Testing Laboratory gradually stimulated business to set up measurement sections. Thus the incoming work was soon limited to inspections of an official nature which could be contested in a court of law.

Even today, the French Laboratory is still the only one qualified to draw up reports in the name of the State of all the various measures - physical, mechanical or chemical - that are required in an industrial country. In spite of the exclusion of biological measures, the field is immense. It is extended still further by the institution of a label indicating conformity with standards established by the State and entrusted to the French Standards Association, which calls in the Testing Laboratory in the event of disputes with those requesting this label.

The exceedingly wide range of measures naturally led to seeking the collaboration of the large specialized laboratories which, in the field of their particular specialization, could delegate others to act on their behalf, subject to scientific inspection: thus it is that reports countersigned at the Testing Laboratory are issued in respect of measures made, for example, at the Institute of Optics, the Institute of Oxy-acetylene Welding, the Central Electricity Laboratory, etc.

There is an agreement with each of these bodies for the improvement of equipment and working conditions. In view of the limits on the expansion of departments imposed by the financial structure of the National Laboratory (which will be described at a later point), it would undoubtedly be worth while to increase the number of such agreements.

Other effects of technical progress have altered the activity of the Laboratory considerably. At first, the gradual working-out of industrial standards demanded the assistance of specialists in control-work, since the standards would be useless unless they also included means of verification. The Testing Laboratory therefore appoints a delegate in most of the numerous commissions for the study of standards.

At the same time, the experience acquired by these specialists, the ingenuity and the sense of precision applied to the realization of measures to which they are accustomed, has naturally led manufacturers to apply to the Laboratory for the solution of hitherto unsolved problems concerning methods of testing or new methods of control and inspection.

Thus, it is that real applied research is entrusted to the Laboratory. As an example, we quote some of the contracts of recent years:

- The study of thermo-elastic constraint on the casing of a nuclear reactor,
- The study of the mechanical properties of concrete for nuclear application;
- Tests of anti-condensing materials,
- Gauging, under an outside pressure of 5,000 metres of water, for the study of ocean depths;
- The measurement of inertia-time of a jet blast-pipe;
- Investigation of the rubbing factor on underground piping;
- Studies of air pollution in the vicinity of power stations;
- Acceleration of the setting of concrete by drying out (for underground railways).

Furthermore, the increasing use of radio-elements has obliged the Laboratory to set up, with the scientific collaboration of the Atomic Energy Commission of France, a section for the measurement of radioactive power (calibration of sources and titrating of radio-elements).

Thus, the Testing Laboratory offers to industry:

(a) The means of measurement and inspection according to industrial standards, especially when litigation demands a sure and official measurement;

(b) The means of perfecting exceptional measures, whether or not involving the prior search for a new method.

Hence it is a national service, which saves manufacturers from having to install costly and non-paying equipment that would bring in no profits, not being required in the usual way, and offers them work of indisputable scientific quality, resulting from the advice of the Scientific Corps of the Conservatoire des Arts et Métiers and from the experience of specialized experimenters.

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Depending on its nature, work requested from the Laboratory is allocated to the following sections:

PHYSICS

Acoustics

Electro-acoustics: Study of transmitting equipment, receivers and sound recorders.

Architectural acoustics: Study of levels of noise and vibration, of reverberation in rooms, of transmission factors through walls and floors.

Supersonics: Industrial applications.

Radioactivity: Logging of radioactive sources and titrating of radio elements.

Heat:

Calorimetry.

Measures of thermal conductibility.

Tests of central heating radiators.

Studies concerning: Industrial combustion methods.
Heat exchangers.
Mechanical deformation through the action of thermal gradients.

Spectrophotometry, in ultra-violet, visible and infra-red.

Calorimetry; preparation of white standards.

Radiocrystallography: X diagrams of powders.

Industrial dusts and air pollution:

Tests of dust filters.

Analyses of industrial atmospheres.

Aerosols and very fine granulometry.

Study of pollution in the vicinity of factories.

Plastics

Measurement of mechanical and thermal properties, in particular for the Quality Label department. This department works in close co-operation with the Plastics Research Centre.

Miscellaneous measurements

Barometry, manometry.

Analogue computation

METALLURGY

Industrial dynamometry; standardization and calibration of machines.

Various mechanical tests of metals. Measures of hardness.

Non-destructive inspection.

Optical and electronic metallography.

MATERIALS

Mechanical, thermal and technological tests on:

- Non-metallic minerals (stone, sand, cement, concrete, plaster, bricks, refractory materials, glass, etc.)
- organic materials (wood, cork, paper, leather, rubber)
- paints and varnishes
- products for heat and sound insulation
- protective garments (helmets, aprons etc.)

Tests of behaviour at high temperature and to withstand fire.

Climatic tests.

Photo-elasticimetry.

Granulometry.

Acceptance tests (buildings and public works).

MACHINES

Various tests on motors and machines, in particular:

- internal combustion engines
- brakes
- transmission gear

Extensometric measures.

Tool tests.

Hydraulic tests on valves, taps, pipes, etc.; measures of loss of heat, of resistance to internal or external pressure, etc. Aerodynamic tests (in wind tunnel).

CHEMISTRY

Mineral analyses:

- metals, metallurgical and mineral products
- soil, sand, cement, ceramics, glass and refractory materials
- water
- gas

Physico-chemical and technological analyses and tests on various industrial organic products:

- coal
- petroleum products (petrol, paraffin, mineral oils)
- solvents
- various paints and varnishes

Standardization of branded liquor.

Corrosion tests.

It should be noted that tests concerning radio-electricity and electrical properties of materials are passed on to the Central Electrical Industrial Laboratory, in accordance with the agreements mentioned earlier. Those concerning optical properties are in the same way passed on to the Institute of Optics, and those concerning welding structures to the Institute of Oxy-acetylene Welding.

The person requesting the tests receives from the Laboratory a report of the measures taken, accompanied where applicable by a report on the research carried out. These documents are the property of the person who made the request and enjoy full professional secrecy.

In consequence, every test or item of work is subject to payment, the financial equilibrium of the Laboratory being dependent on this income which, next year, will represent about 40 per cent of its working budget.

So far, we have not touched upon the metrological role of the Testing Laboratory. It should be stated right away that a metrological section is at the service of industry for high precision standards:

- measuring rulers, gauges, not-go-gauges
- sets of weights
- calibrated glass
- liquid or platinum-resistance thermometers
- thermocouples; optical pyrometers

- photometers, secondary-standard lamps

High precision densimetry

Industrial photometry, particularly in the case of optical devices (e.g. reflectors) used in road signals.

It should be added that French law has entrusted the Laboratory with the compulsory inspection of medical thermometers, alcoholmeters and densimeters. However, the main role of the Laboratory in the field of metrology is the same as that of the big national laboratories, the national counterparts of the International Bureau of Weights and Measures. Thus, the Laboratory has to take part in the work of defining units of measurement and the setting up of the appropriate standards. It must collaborate in the work of comparing national standards and in conferences on metrological methodology.

This purely scientific activity naturally implies a heavy workload for the metrological section and it is not helped by the semi-industrial set-up that may obtain in other sections. In spite of the unceasing efforts of the head of the metrology section, the participation of the French Laboratory in the work organized by the International Bureau during the last few years has not been as great as one might well have expected from the country which invented the decimal metric system.

The Government, under the guidance of the Conservatoire des Arts et Métiers, is at present examining a reorganization of the Laboratory that will lead to an expansion of the metrological activity, with the aid of a fuller budget.

VIII. SOME ASPECTS ON RESEARCH AND TESTING LABORATORIES AND STANDARDS

Prepared by R. Vieweg*

A. Concepts

1. Among these concepts, there are several which need to be explained and even to be defined in order to avoid misunderstanding in the following explanations. It should be stated more precisely not only what is meant by "research" and "development", but also what is meant by "standards", as for this term also there is no clear and unanimous conception of meaning.

Research

2. Research occurs always, and only when a scientific problem is approached with the aim of advancing into unknown fields, the task being completed in a scientific way with scientific methods, by adjusting the whole to a greater context and publishing the results in a scientific manner. This definition tells one that research represents one intellectual-cultural unity including all disciplines. Therefore, it does not, in principle, matter which science provides the object, be it Sanskrit or geology, theoretical physics or a field of medicine, economic rationalization or international law. In the separation too of the so-called philosophical and natural sciences there should not be any valuation. Likewise, it is of no importance whether, starting from a given scientific law, something new is found, or whether some question of application or an industrial problem has given rise to the research.

Development

3. The concept of industrial "development" work may well be distinct from that of research, although they often appear to be combined. "Development" as in "developing" country is not considered here, this being a matter of politics; this paper is limited to questions of sciences and techniques. Industrial development usually indicates some improvement in solving a task of manufacturing, of a product or of a process, that means industrial progress. Research in the sense defined in this paper, i.e., science in methods, results and publication, need not necessarily be discussed. It very often happens that tasks of development originate from research, and the boundaries between the two fields cannot always be well-defined, as in modern life orders often overlap.

4. In this connexion, it is very important to point to the increasing infiltration of science into the whole of life and especially into all industrial activities. In every field of economy and techniques the results of research are present, from the large plant down to the small, simple part. In every bit of provisions, one will find some application of botany, physiology, and agricultural chemistry; every piece of metal requires some knowledge of scientific metallurgy,

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physics and chemistry; for each apparatus, standardization and automation, as well as electronics and chemistry, are needed. No book could show its modern form without the progress of research in engineering for printing it, research in chemistry for stamping, colouring and gluing it. Modern medicine depends to a great degree on physical and chemical knowledge, on expedients and apparatuses in diagnosis, surgery and therapy. And Governments and municipalities rely upon telecommunication that is perfectly designed through science.

Standards

5. The third concept which needs explanation is that of "standards". There are several rather different meanings, though they all are connected with the same fundamental conception. Standards are fundamental magnitudes and units, as well as their realizations by so-called etalons. In the United States of America, for example, the name of the National Bureau of Standards hints at such "standards", without exhausting the tasks of this authority. Standards are also the unifying rules, often called norms, concerning dimensions, as well as the testing and quality of technical objects. The British Standards Institution furnishes by its name an example of such tasks. When one speaks of the "standard of living", one thinks of a certain level of living - as it is, for instance, attainable for the mass of inhabitants in a country. A "standard work" is simply a fundamental book for a certain field. In the sense of this seminar, "standard" is used in the first two meanings, as the basis for measures and measuring, and for marking quality.

B. Standards and testing

6. When seeking reasons for the rapid progress in sciences and techniques during the last decades, one soon finds that measuring and measuring techniques have shared in it decisively. Measuring, i.e., to express some magnitude by measure and number, is a basic part of all exact sciences and of techniques which profit from scientific methods. To find quantitative coherence is always the aim of the efforts of sciences. There is no scientific progress conceivable without highly developed techniques of measuring. Many important discoveries have been made possible only by refined measuring instruments and methods.

7. Measuring also is an indispensable part of industrial production. The quality of industrial products depends to a high degree on the level of measuring techniques. Industry needs units of high precision and measuring methods which permit an easy use, not for itself, but for reasons of practical exigencies. There are many branches where it is necessary to measure lengths with a precision of 1/1000 millimetre. In addition to the increased need for accurate measuring methods in the precision instrument and optical industries, it is also essential that the deviations of a precision-tool machine - for instance, of a milling-machine - concerning the straightness of the guide-rail, should not exceed 1/1000 millimetre. It is quite obvious also that the cylinders for motors in cars are now produced with a tolerance of less than 1/100 millimetres. In electro-industry, capacitors must be constructed with 1/10,000 of the capacity value; and in frequency, there are even more rigid requirements. With the modern elements of amplifiers, dimensions of 1/1000 millimetre and less are extremely important.

8. Guaranteed units are the preliminary condition of precision production, and further, of highly developed and precise, though robust, measuring instruments and

methods. It becomes evident that industry depends on the fabrication of qualified measuring instruments, which itself is dependent on scientific measuring techniques. Control of industrial production by physical measurements will even increase in the future because of the fact that wherever transition to automatic processes is possible, techniques of high precision measurements are more and more necessary.

9. It is obvious that measuring also is very important in every day life. At the filling-station, gasoline must be measured accurately up to fractions of a litre; a clinical thermometer must be exact within the scale of 1/10 degree. Of all goods for which one has to pay with money, one demands the correctly measured countervalue. The qualities of all materials, whether for architecture or for other construction and articles, mechanical solidity in particular, but also the elastic and other constants, are of great consequence. They are tested according to standardized methods.

10. In the modern world it has become general judgement that to offer exact measures for citizens and for industry and to secure them by law is one of the obligations of the Government. The State has first to be sure that all important magnitudes and constants can be measured correctly with all just available precision, and, secondly - in certain situations - that they really are measured exactly in praxis. These two basic trends of modern measuring and testing are to be realized.

11. The implication that wherever anything is measured, it can be measured correctly, comprehends presentation, maintenance and development of physical and technical units and basic magnitudes, and provision for uniformity of measures in the whole country. Immediately connected is scientific development of measuring techniques in all fields of physics.

12. Where there is special need for protection of citizens, for example, against being cheated in economy, or against risks of health, or where - for instance, among economic partners - decisions are needed in dubious measurements, there must be assurance that the measuring is correct. Therefore, beyond those above-mentioned conditions for measuring as a whole, the Government orders exactness and official testing of certain measuring instruments and methods. These are chiefly instruments that are used "in public business for the determination of the extent of services", as it is expressed in German law. It concerns, for instance, commercial scales, counters for gas and electricity, taximeters for motor-cars, and volume-meters for filling-stations and other purposes, all belonging to areas where the reading of an instrument finally determines the prices of goods. Certain substandards also and some measuring instruments for medical inquiries, for purposes of revenue offices, and for traffic control are due to official testing and inspection.

C. Material testing and laboratory techniques

13. As previously mentioned, a special testing task concerns all problems connected with materials. Architecture furnishes an instructive example. Safety and durability of constructions depend on knowledge of the qualities of materials and on their testing. In the construction of concrete buildings everywhere, the composition of mixtures and the stability of test specimen, which are made on the spot, are superintended.

14. Outside the field of architecture, qualities of materials are extremely important for technical constructions. Beyond mechanical qualities, chemical compounds and structure of materials are of consequence. Protection against corrosion and other attacks influencing the duration of objects is of the greatest economic importance. Seeking faults often is an urgent task; in order to solve this problem, methods of non-destructive testing have been widely introduced. As an example of this application, one may mention the safety of boilers. The task of non-destructive testing currently entails very different procedures: for example, irradiating with X-rays, especially for metallic parts, and measuring the di-electric losses of insulating materials, which has become very helpful in the area of electrical high voltages.

15. It is quite evident that for those problems uniform procedures and clear demands are important conditions. Testing materials therefore depend on rules of testing and on standards, and there exists great interest in their elaboration, and permanent improvement and adaptation to the most modern situation.

16. Modern testing machines, which are highly developed and often are furnished with recording apparatus and automatic controls, are used to their full extent when the samples to be tested are conditioned in a suitable manner. The components of climate, temperature and humidity, and often pressure also, must be available in special chambers variable within a wide range to guarantee complete and reliable results of the experiments. Of course, cultivated laboratory techniques also are indispensable for the standards mentioned in paras. 6-12.

D. Guarantee of quality

17. The quality of technical objects of all kinds, as well as provisions and other goods that are offered to customers in the market - be it a market in the narrow sense or a commercial action in the wider sense - is often unsatisfactorily determined. The purchaser has to have confidence and to trust; disappointments often occur too late for amends to be requested, especially when the damage cannot be clearly defined for lack of distinct demands. In recent years, this widespread situation has brought about fixed quality claims in several areas, often by unions of purchasers and often with the participation of judicious and willing producers. This can be done in quite different ways: by describing determination, by testing samples, by placing a mark as a sign of certain tests. It is characteristic for all such trends to arrive at a guarantee of quality, that they do not depend so much upon measuring exactly in numbers and constants, as upon statements of the general appearance which concern form, colour and practical behaviour. To be sure, it is necessary that the objects be expediently designed and manufactured without fault. The bases of such demands are, of course, those exact measurements which have been dealt with in paragraphs 13-15. Their results only indirectly enter the evaluation summarized as "guaranties of quality".

18. Here also standards are often cited and the meaning is, for instance, with provisions like butter, that the delivered package must correspond in every way to a certain fixed minimum quality. It is much the same with other agricultural products, e.g., with fruits, where demands are made according to size, colour, taste, and absence of spots from pressure and rottenness. Analogous considerations are valid for entirely different products, textiles and so on.

19. Problems of guaranteeing quality are best handled by chemists, whereas the testing of materials is the field of the engineer and the fundamental magnitudes belong to the physicist. The reason why this question of competency is touched only now is that, considered as a whole, the co-operation of all disciplines counts most. When guaranteeing quality plays a greater part, it may be that a biologist also should be given a share, but this report will not go into these details.

E. Standards, testing rules and documentation

20. Standardization is a very important condition of industrial work. Any large production which occupies many machines would prove quite irrational if its elements of construction deviated from one another. Every little defect would entail the making of spare parts. Therefore, standardization has long been established for frequently used construction elements, e.g., for screws, bearings, cog-wheels, etc., that means to determine a limited number of types in their dimensions.

21. Naturally, the problem of standards, as well as that of physical and technical units, surpasses the needs of single nations. In the field of standardization, there is the International Organization of Standardization (ISO), with headquarters in Geneva. Associated with it is the International Electrotechnical Commission (IEC), which specializes in standards and testing rules in the electrotechnical field. In the many member countries, both organizations rely on the national committees.

22. These organizations for standardization have long been occupied not only with the standardization of dimensions, i.e., the sizes and distances and other exterior relations of objects, but also have tackled the uniformity of tests in determining properties. The target is, of course, that national standards and rules conform to a high degree with those accepted internationally, and that they show deviations only when dependent upon a special situation in the respective country. The work of standardization is an important assistance to the exportation and importation of goods.

23. For units and fundamental magnitudes and for the public inspection service there are international arrangements, which are regulated by treaties of the States. In 1875 the International Meter Convention was concluded; forty countries currently belong to it. The aim of the convention is to define the fundamental metric units, to secure and to develop them, in particular the established "international system of units" (SI) for length, mass, time, electric current, temperature and intensity of light. The International Bureau of Weights and Measures at Sèvres, near Paris, disposes of laboratories for the fundamental magnitudes and is the centre of co-operation of the national laboratories in this field. Characteristic of the metric system are - except for the time unit - the decimal multiples and submultiples which have proved of great use in daily life as well as in science.

24. For the inspection service. i.e., for those fields where measurements and measuring techniques are regulated by the Government, the International Organization for Legal Metrology (OIML), was founded in 1956 with the administrative seat at Paris. It does not run a laboratory of its own, but functions entirely as a centre of co-ordination. The number of member States nearly equals that of the Meter Convention. The OIML aims to determine internationally the requirements for measuring apparatuses that are used in trade

and traffic - scales, counters, measuring transformers, medical syringes and many other objects - in order to avoid obstacles in the exchange of goods as could arise under different gauging rules in different countries.

25. Measuring and testing have gained such significance, nationally as well as internationally, that the reference of competent literature has become very important too. An institute of industrial research and development therefore not only needs a library with the standard works on the fields discussed, as well as the very numerous periodicals pertaining to the service, but also it should obtain the documentation needed to answer quickly and correctly all questions concerning the tasks of the Institute.

F. Scheme for an institute

26. Having given the interpretations in the foregoing sections, it is now possible to draw the frame of an institute for industrial research and development in developing countries. According to those explanations, it is quite evident that the Institute should be entirely, or at least to a high degree, a public institute, i.e., a national one. The tasks of industrial research and development may originate from the fields of labour of the institute itself, or they may be given to the institute by public organs or by industry. Apart from the directorate of the institute, there should be a board of trustees, consisting of prominent personalities representing the State, the sciences, and consumer and producer groups.

27. In sketching this frame, the problem of maintaining the institute is solved in advance. Firstly, it is an obligation of the State to provide for the uniformity of measurements in the country and to use the beneficial efficacy of the institute for the common weal of the country. Therefore "full payment" for services of the institute should not be discussed, but only "fees" which can be easily adapted to changing needs and which represent a type of "payment of acknowledgement". Of course, this does not exclude the possibility that in cases of bulk articles which are dispatched in a routine way, small fees may recover the expenditures of the institute.

Tasks of the institute

28. The tasks of the institute are those of a central institute that takes upon itself scientific investigations, developing labours and testing tasks for industry, as well as for other employers, concerning the fields of physics, chemistry and techniques, and which exercises even governmental duties in these areas if necessary. The title "Central Institute" has a double meaning: in case of a large country, it is the top institute to which smaller regional institutes may be subordinated. If distances and industrial needs are more complicated, it could even be possible, that under the top institute, institutes of medium range may follow, to which in turn local institutes are subordinated. Thus, there would be pyramidal structure with the small institutes forming the base, the medium-sized institutes in the middle level and the central institute at the top.

29. The problem of the simple services in the country can be briefly illustrated by the example of the inspection service. In every developing country, technology and industrialization serve as the means of providing the masses with goods that need to increase even more rapidly than the population. Every citizen of the

country is meeting these great, and previously unknown, problems. Then it is important that the sense of right and justice expands and that a corresponding praxis makes way. How should such thoughts better intrude upon the conscience of all, than by dint of correct measuring in trade and traffic and every-day life. Therefore, next to the public schools, which should be given top priority, in order to avoid illiteracy and to promote the spread of fundamental education, a measuring and inspection system is most important. The central institute must ensure the uniformity of this basic service and must perform all arising higher duties. It is indispensable for the fruitful development of the inspection service that the organization does not grow torpid, but remains adaptable to respond to new, scientific knowledges and to the constantly changing demands of industry and economy.

Organization of the institute

30. The organization of the institute follows easily from the main groups of tasks:

(a) Department for fundamental magnitudes, units and constants. The sphere of duties of this department covers the maintenance, presentation and development of etalons to the praxis of the inspection service. Divisions can be marked by the main branches of physics: mechanics, electricity and magnetism, heat and pressure, acoustics, optics and atomic physics. There need not at once be laboratories at disposal for all these branches. But the whole should grow following the requirements and possibilities;

(b) Department for material testing. The general sphere of duties was described above (paras. 13-16), and becomes clear by the following divisions or laboratories: concerning materials for constructing, metallic materials, non-metallic materials (organic, ceramic and others) and finally those concerning safety tests, which deal with technical gases, in particular with compressed ones, and further with inflammable and explosive agents;

(c) Department for guarantee of quality. The name was chosen to avoid the ambiguity of the concept "standard". The objects were explained above (paras. 17-19). Possible divisions are: guarantee of quality for agricultural products, in particular, provisions; industrial products, e.g., textiles; for implements for daily use; and for the products of mining and metallurgy, e.g., metals, ores, minerals;

(d) Department for standards, testing rules, and documentation. The necessity and tasks were sketched above (paras. 20-25). Here the title indicates the three divisions to be formed. Their mutual co-operation, as well as that with the previously mentioned departments, is decisive for success;

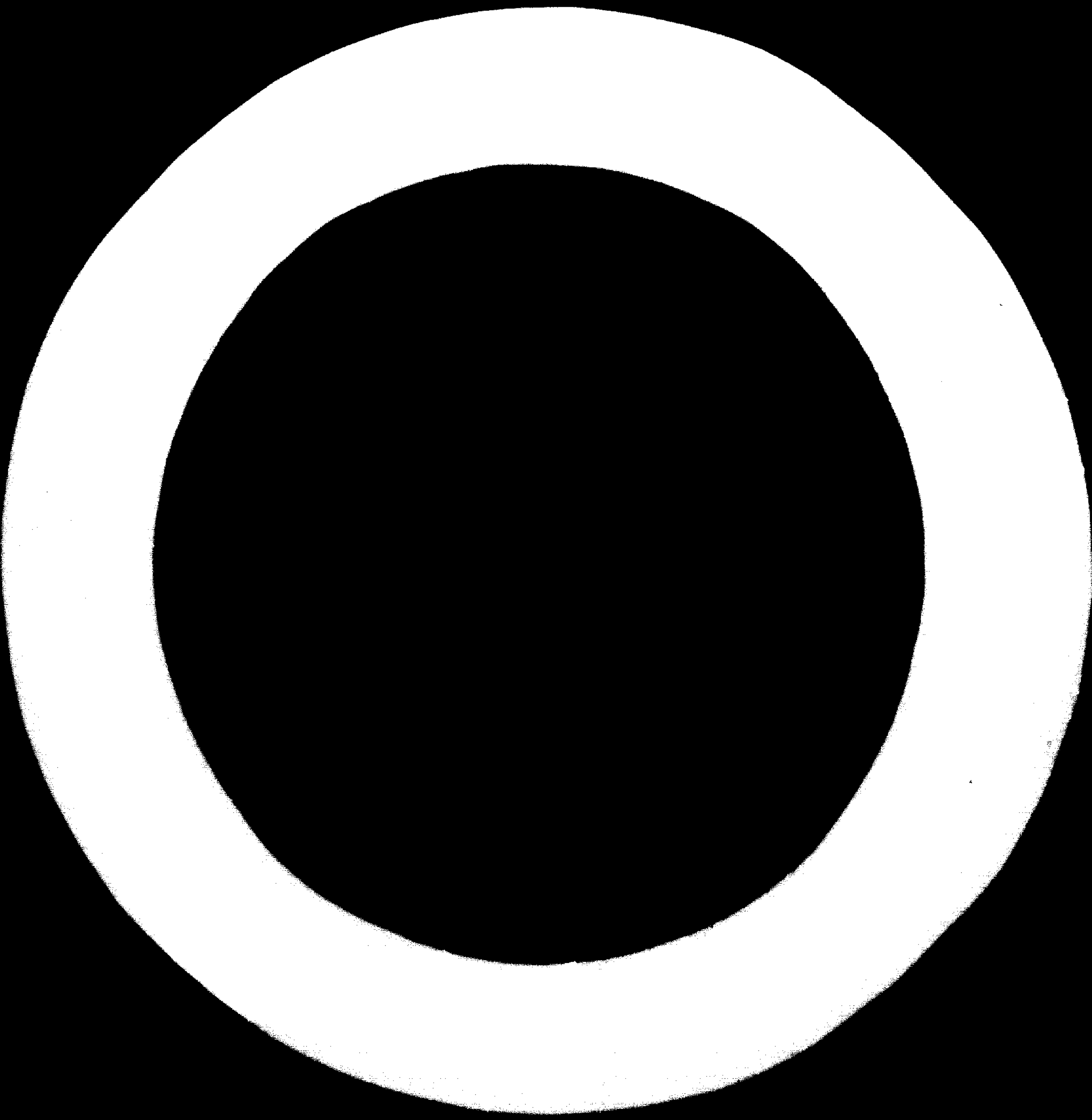
(e) Department for general services. For completion it should not be omitted that for technically and experimentally working laboratories an efficient workshop is a very great help. A well-organized energy supply also plays a dominant part in the whole. Last, but not least, the institute needs an administration which serves it best and which allows a frictionless functioning and the synthesis of official affairs.

Official position of the institute

31. With respect to the eminent importance of research, the rank of the institute within the whole of the public organization has to be considered seriously. In some highly industrialized countries, the organization of research was not assigned to an existing ministry - for example, to that of economy - but there was created either a special research ministry or some group which was placed directly under the cabinet or the prime minister. In developing countries, also, a prominence of such kind would prove useful, inasmuch as it corresponds to the superior services which are expected of the research institute. Research means indeed to doubt what was formerly valid and to advance to better solutions of a problem. It would be of value to interest pupils in such ideas and their practical realization, both at least in the primary stages, to waken the first inclinations of youth to research and to create understanding for the efficiency of research to the advantage of all.

G. Summary

32. This paper attempts to describe organization and activities of a central institute for industrial research and development in a developing country. The institute is thought of as a combined one, to serve the manifold tasks of industry as well as the public demands of the State itself, and whose equipment in personnel and apparatus therefore could be utilized to a high degree. Owing to the brevity intended, it was impossible to go into details, all the more since the conception of a developing country differs so very much by size, structure and needs. This paper, therefore, outlines a loose frame that will in principle fit all. It is adequate to the best experiences made in highly industrialized countries, both large and small. The completion of the framework must be left to special studies concerning practical examples. Co-operation with expert consultants is always recommendable in order to transform projects into useful actions.



Part Three - Industrial extension services

All papers in this part of the Seminar proceedings, other than that prepared by the United Nations Educational, Scientific and Cultural Organisation, are published as presented by the author with such editorial modifications as were considered necessary. They express the authors' views and not necessarily those of the United Nations.

CONTENTS

I. THE ROLE OF RESEARCH AND DEVELOPMENT INSTITUTES IN APPLYING SCIENCE TO INDUSTRY

Prepared by B.R. Williams*

A. Definitions of terms

1. To reduce the risk of a misunderstanding of what will be said about industrial research and development institutes, the writer will first attempt to make clear:

(a) What is meant by such terms as science, research, technology, and* development;

(b) The writer's attitude to their roles in economic growth.

2. By science is meant the sum total of systematic and formulated knowledge about the natural world. Research is an activity directed towards extending this sum total of knowledge. Industrial research is an activity directed towards increasing that part of scientific knowledge likely to have application to industry, whether in the form of new (or better) products or processes.

3. Sometimes the new knowledge yielded by industrial research can be applied directly to industry. Thus, a manufacturing fault may be referred to the research scientists who may be able to provide an explanation and a solution. For example, in early graphite-moderated gas-cooled nuclear reactors, the graphite gave trouble from the outset. In certain reactor conditions, distortion of the graphite's crystal structure can seriously alter its dimensions and lead to internal stresses which can be involuntarily released with evolution of heat. Once scientists came to understand this phenomenon, it was possible to rearrange reactor design to avoid the difficulty. 1/

4. Frequently, however, the results of research cannot be applied directly to industry. A further example from the same graphite-moderated gas-cooled reactors will make this clear. At high temperatures and under neutron irradiation, graphite is chemically attacked by the carbon dioxide used as a coolant. The problem may be solved by making the graphite moderator part of the fuel element, in which case the moderator would be replaced and renewed with the fuel, or by using heavy water as the moderator. In both cases, research is involved, but the passage to successful application cannot be either direct or certain. Technical development is the process of building and testing scaled-up models of processes used in laboratory research, or prototypes based on design research. It is because the application of science to industry often contains a strong empirical element (the "suck it and see" approach, as engineers sometimes call it), that one has to make this distinction between research and development. In general, the greater the extent to which "practice runs ahead of theory", the greater the cost and time

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* Professor, University of Manchester.

1/ Sir Christopher Hinton, "Nuclear Power", Three Banks Review, 1961.

involved in development. This is fairly obvious in both aircraft and atomic reactors. Of course, in these industries, without a very strong basis of theoretical knowledge, development scientists and engineers would have to guess wildly about what to try, and the chance of getting a profitable technological development would be small.

5. Technology is the sum total of formulated knowledge of the industrial arts. Development, which adds to this vast stock of knowledge, has two aspects. The first is purely technical. It consists of testing whether the technical performance of something developed in a laboratory is affected by "scaling up" and perhaps the use of different materials; or whether something "built off the drawing-board" operates as predicted.

6. But development cannot be purely technical. Some new ideas are not worth getting ready for production, simply because no one but a commercial idiot would want to invest in them. This would be so with a possible new product for which there was too little demand, or a possible new process more costly than an existing process. It is an important part of the development process to get a very much better idea of market and cost conditions than is possible at the research or design stage. Sometimes demand and cost studies make it clear that projects should be dropped. Sometimes it will be thought that redesign is called for. Such redesign as the facts become clearer is a typical part of an efficient development process. Sometimes redesign will entail further research; sometimes simply the use of cheaper materials and components or a less cautious approach to capacity limits. Neglect of the commercial aspect of development can lead to investment in projects which have to be abandoned; or, at least, to premature, and therefore needlessly costly, investment decisions.

7. An interesting example both of commercial pressure to adopt a less cautious approach to design limits and of premature innovation, at least as judged by many economists, is provided by the United Kingdom's nuclear power programme. In a Government White Paper of 1955, it was argued that the costs of nuclear and conventional power were about equal, and nuclear power-stations were commissioned in the expectation that they would in time produce cheaper power than conventional stations could. In fact, nuclear power has proved to be more expensive. Because the capital cost per unit output is very much higher in nuclear stations, the Government's calculation was very sensitive to the assumed rate of interest. The assumed rate of interest proved to be much too low. Furthermore, no allowance was made for improvements in the design of conventional stations, whereas capital costs per unit of "sent-out" capacity fell 50 per cent. In reaction to this (and helped, of course, by continuing research and development work), capital costs in newly designed nuclear stations have been reduced by the same percentage. This has involved building reactors with an output capacity very much larger than those which have been tested. According to Sir Christopher Hinton, these rapid advances were less supported by industrial experience than the wise engineer would wish, and were not without hazard. 1/ But the competitive position of nuclear power could only be maintained by accepting these risks.

B. Development gaps

8. Obviously the use of science to change technology can be a very difficult and complex matter. When science is not used sufficiently to change technology it may be said that there is a development gap. A development gap, as usually defined,

exists when there is a failure to develop usuable research discoveries (or when one country's research results are developed in another). But since research is simply a process of adding to the vast stock of scientific knowledge, it is better to say that there is a development gap when the bridges from science to technology are inadequate.

9. Because it is possible for research institutes to increase the development gap, an analysis of the possible reasons for development gaps should be a useful introduction to the role of such institutes.

10. Development, as discussed here, has two parts - technical and economic. When, however, the failure, or alleged failure, to apply science to industry is explained in terms of a development gap, the discussion generally goes beyond the relation of science to technology and introduces a new part of the problem - namely, a decision to use a new technology. Development has been defined above as a process of finding out whether a proposed new technology is of technical and economic value. The decision to adopt a development is another matter, which may be defined as an innovation. It follows that the explanation of development gaps is a matter both of development and of investment in innovation.

11. In highly developed countries, failure or slowness in applying science to industry may be owing to:

(a) A shortage of qualified scientists or engineers engaged in development relating to research. This shortage may be caused by an actual shortage of development scientists or engineers or by an unwillingness to invest resources in risky development projects. The cost of development is often very much greater than the cost of research and there may be a shortage of risk capital available for it;

(b) A failure to develop the right things. This may be owing to a concentration on the technical aspects of development at the expense of the economic. If the problems of development are not correctly stated, one cannot expect development departments to produce proposals that the production and finance departments will readily accept. Whether the problems of development are likely to be posed correctly depends in large measure on the communication network, in this case between people in the development, production, marketing and finance departments. 2/ An efficient network generally requires the employment of scientists and engineers outside research and development departments and of social scientists within them. This will make it more likely that the production, marketing and financial problems will be put in the appropriate manner to the development engineers, and that the development engineers will get the appropriate answers to questions about production and market conditions;

(c) An inability to make use of promising, even successful, proved inventions. This failure may be owing to the inability, or unwillingness, of existing managers and workers to cope with the new technology. This in turn may be owing to the absence of people with the required skills or to their employment in the wrong places. There is now a good deal of evidence that in the United Kingdom economy the application of science to industry could be increased by redeploying the scientists and engineers. There are too many in research, in relation to development in relation to production;

2/ See Carter and Williams, Science in Industry, (London, Oxford University Press, 1959), Part I and particularly chapter 3.

(d) A shortage of industrial risk capital. It should be made clear that this may be closely related to (a), (b) and (c). Among other things, the development process should eliminate a large number of unknowns and establish with much greater certainty the technical and economic potential. If there is under-investment in development, if development is not concerned with both technical and economic solutions, if the firm is not manned and organized to cope with changing technologies, then the risks of innovation will be needlessly high. The apparent shortage of risk capital may be largely a reflection of these other factors. 3/

12. The less developed a country, the less likely there is to be a development-gap problem, and the more is the problem of applying science to industry likely to centre round the supply of scientists, engineers and technicians. The key problem is to introduce a knowledge of existing science and of technologies that have been well and truly tried in richer countries. This does not mean that in making good use of science in industry there will be no need for any research and development. Research may be needed to produce more appropriate flora and fauna, or to establish the precise nature of local industrial materials. And development may be needed to adapt technologies to different operating conditions. Different temperatures, raw materials, relative prices of factors of production, ratios of skilled to unskilled labour, etc., may call for skilled development or redesign work. But, in the main, poor countries do not have to go to the expense of creating science and technology. What they most need already exists.

C. Priorities in the use of skilled manpower

13. It should be obvious that scientists, engineers and technicians can be used in different ways, and that making the best use of science and technology in industry involves making the best use of scientists and technologists.

14. The best use varies with the supply of scientists and technologists, the level of technology and (the partly dependent) industrial structure. 4/ If a country with a very short supply of scientists and technologists attempted to do much research and development, it would be unable to apply science to industry. In any case, with a poor supply of scientists and technologists the level of technology would almost certainly be low, and it would be possible and cheaper to advance by using technologies established in other countries. As the supply of scientific manpower and the level of technology rose, it would become economic to increase the proportion of scientists and engineers engaged in research and development. Within the field, there would also be a similar shift in priorities. The case for much research effort would first be weak, and then become stronger.

3/ The situation in the British economy is analysed in Carter and Williams, Industry and Technical Progress (London, Oxford University Press, 1957).

4/ Compare in this respect the economies of Australia and the United Kingdom. If, in 1961, Australia had spent on research and development the same over-all percentage of net output as the United Kingdom, expenditure would have been £70 million. But, on the basis of the same percentage of net output, industry by industry, the expenditure would have been only £40 million. The main reason is that the aircraft, chemical, electrical and precision-instruments industries are relatively less important in Australia. It is worth noting that the total Australian supply of scientists and technologists was nowhere near sufficient to manage a research and development effort of £40 million. The Australians have made up for their poor scientific manpower position by attracting chemical, electrical and automobile manufacturers from the United Kingdom and the United States of America. See B.R. Williams, Industrial Research and Economic Growth in Australia (Adelaide, The Griffin Press, 1962).

15. In 1960 the number of qualified scientists and engineers per 1,000 employees in industry was about thirty-four in the United States of America and twenty-six in the United Kingdom. In the United States of America, 45 per cent of them were engaged in research and development; in the United Kingdom, 38 per cent. Thus, the United Kingdom, with its less favourable manpower position and lower level of technology, used a smaller part of its qualified personnel in research and development. The Union of Soviet Socialist Republics had a more favourable manpower position, forty-three qualified scientists and engineers per 1,000 employees in industry, but a lower average level of technology. It used only 35 per cent of its qualified personnel in research and development. 5/ This is not the place for a detailed discussion of optimal distributions. Suffice to say that there is a good deal of evidence that the United Kingdom could raise its technological level faster with a smaller percentage of qualified scientists and engineers in research and development. 6/

16. In considering general research and development strategy, one needs to take into account more than the technological level and the percentage of qualified personnel. The absolute size of the economy is also important.

17. There is a threshold-effect in both research and development. A certain minimum scale of expenditure, which in some industries (e.g., aircraft and atomic energy) is very large indeed, is required for effective work. In a very large economy, such as the United States of America, it is possible to take on a very wide range of research and development problems without running the danger of spreading resources too thinly in them all. By contrast, the United Kingdom, the Federal Republic of Germany and France, with their smaller economies, cannot maintain an effective effort right across the board without an inefficiently thin spread of effort. In other words, the smaller the economy the more selective it needs to be, unless its smallness is offset by a very high ratio of scientists and technologists to the working population. The need for selectivity applies also within a chosen field. For example, if the United Kingdom tried to work in all the potentially interesting fields of nuclear reactor development, the work would be so diffused that results would probably not be obtained in any of them.

18. It follows that there must be economic gains to be made from international "trade" in science and technology. Most scientific results "trade" at very low prices in journal form. Much technology is traded in the form of new or improved products and machines. But some is traded in the form of licences to produce or receive know-how. In 1961, for example, the United States of America received from the sale of technological rights and knowledge $US577 million (equal to about one third of the United Kingdom's research and development expenditure) and paid out $US63 million. The Federal Republic of Germany, with its less favourable manpower position and lower level of technology, paid out about DM600 million and received DM150 million.

19. There is nothing inherently surprising in this. It is only to be expected that the principles of division of labour and specialization should apply to research and development. But the importance of international "trade" in science and technology has not received proper recognition. That economic nationalism is a significant

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5/ Some Factors in Economic Growth in Europe during the 1950's [1961 Survey: II] (United Nations publication, Sales No. 64.II.E.1).

6/ On the general possibility of excessive research, see F. Machlup, The Production and Distribution of Knowledge (Princeton, 1962), chapter 5.

force in research and development expenditures is owing partly to the tremendous importance of "defence" research and development - 50 per cent of total research and development in the United States of America in 1961 and 40 per cent in the United Kingdom - and partly to the widely held belief in "scientific circles" that the research and development rate determines the growth rate. It does not. 7/ Given the distinctions that have had to be made between science, technology and innovation, and the continuing differences in industrial structures and levels of technology, this is not surprising. In a general way, higher percentages of qualified scientists and engineers and research and development rates become more important conditions of growth as the gross national product *per capita* rises, but the present great differences between countries with similar levels of growth and income *per capita* are likely to persist. 8/

D. The organization of industrial research and development

20. Expenditure on industrial research and development should be thought of as inputs designed to produce useful outputs. In so far as they are useful outputs, they will become inputs in some production process. Now given the time lags involved, one should think of research and development as an investment process. Optimum allocation of resources therefore involves taking investment in research and development to the point where the marginal yields from it equal yields from alternative investments. Various calculations of yields to investment in research and development have been made. Almost ten years ago, R.H. Ewell estimated that for the economy of the United States of America the net yield to research and development was between 100 and 200 per cent *per annum*. Ewell's calculations were very crude - he used bivariate analysis in a multivariate system and did not attempt to calculate the marginal yields to investment in research and development. 9/ If one assumes that businessmen equate private rates of return on investment in research and development, and equipment from the known rates of return on capital investment, one may be confident that marginal private returns on investment in research and development are very much lower. A recent inquiry within Imperial Chemical Industries showed that for every £1 million invested in research, assessable yields were averaging £200,000 a year for ten years. 10/ With a time lag of two years, this implies a 10 per cent internal rate of return. 11/

7/ See E.F. Dennison, *The Sources of Economic Growth in the United States* (New York, Committee for Economic Development, 1962); B.R. Williams, *Investment and Technology in Growth* (Manchester, Manchester Statistical Society, 1964), and *Some Factors in Economic Growth in Europe during the 1950's* (United Nations publication, Sales No.: 64.II.E.1), chap. 5.

8/ In *Science, Economic Growth and Government Policy* (Paris, Organization for Economic Co-operation and Development, 1963), the relations between research and development rates and *per capita* gross national product are plotted. In Sweden, the Federal Republic of Germany, France and Australia - countries with similar *per capita* incomes, research and development, as percentages of gross national product, in 1961 were 1.3, 1.1, 1.0 and 0.6, respectively.

9/ See Machlup, *loc. cit.*

10/ Sir Ronald Halyroyd, Paper No. 637, Institute of Chemical Engineers, March 1964.

11/ Using the discounted cash flow formula:

$$C + \frac{Y_1}{(1 + R)} + \frac{Y_2}{(1 + R)^2} + \cdots\cdots + \frac{Y_n}{(1 + R)^n}$$

where C is the research outlay, Y the annual yield and R the internal rate of return.

21. If one looks at research and development in this way, there may seem no reason why it should be treated any differently than any other form of investment; no reason, that is, why, in a market economy, research and development should not be left to market forces.

22. However, it is necessary to look at what is counted in a market economy. Social yields to investment in research and development may be larger than the yields that accrue to the firms making the outlay. Yields to investment in research and development are not certain. Many projects do not pay off. Yields to research and development programmes are more certain, cet. par., the greater the number of projects. But only large firms are able to reduce risk by having a large basket of seemingly worth-while projects. Furthermore, it will generally not be possible for firms with successful research and development outputs to make other firms pay according to benefits received. There will, therefore, tend to be an under-investment in research and development in market economies, which will be greater the nearer one approaches the traditional model of perfect competition.

23. Where firms in a market economy are already undertaking research and development of the socially desirable kind, but simply not in sufficient volume, it is conceptually possible to use subsidies to lift research and development expenditures to the right levels. It is, however, difficult in practice to make subsidies sensitive to differing size structures and powers to appropriate the social yields from research and development. 12/ Where socially desirable forms of research (for example, basic research) are just not undertaken, the subsidy method is quite ineffective.

24. It is worth considering whether one could achieve the appropriate levels of research and development expenditure if the field were treated as a specialist central function. If it were undertaken by a vast research and development corporation with broad divisions reflecting the main fields of science and application, the corporation would be able to spread risks in a way that individual firms cannot. It would also be able to economize on scarce scientific manpower by avoiding competitive duplication 13/ and be in a position to reap the suspected economies of scale in research. 14/ But such a corporation could not put optimal research and development programmes on a self-financing basis. It would not be able, by selling research and development results, to appropriate the full yields from the work. For the research and development institute to work on anything like a proper basis, it would be necessary to give subsidies based on detailed cost-benefit analyses. Given the problems involved - the fact that current research and development will produce its yields in the future (if at all), the difficulty of determining appropriate time-discount rates to value contributions to yield in the future, the difficulty of isolating the effects of research and development in relation to education in relation to organization changes, etc. - it would be foolish to imply that one would be able to recognize the precise socially desirable

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12/ In both the United Kingdom and the United States of America, 350 large firms account for over 85 per cent of total industrial expenditure on research and development.

13/ Or, more realistically, "reducing competitive duplication". There is often secrecy and competitive duplication within firms and institutions.

14/ T. Marschak, "Strategy and Organization in a System Project Development", The Rate and Direction of Inventive Activity, (Princeton University Press, 1962).

research and development programme even if one met it. 15/ The difficulty exists, whatever the form of organization. But there are special difficulties relating to the proposal to centralize research and development. It was suggested above that there are economies of scale which such an institute could reap. This is probably true. But given the possibility of diseconomies of scale for other reasons, the real question is whether there would be net economies of scale.

25. The distinction between basic research, applied research and development is not always clear-cut. But often it does reflect differences in appropriate forms of organization. It is often said that research needs to be free of any external direction or organization, that the key to successful research is the unpredictable creativeness of individuals and that "in running a research establishment one is really running a gambling concern and taking incalculable risks for unassessable rewards". 16/ It is true that in basic research there can seldom be any question of organizing to create a particular result. This is a major explanation of the eminence of universities in the fields of basic research. But as one moves further through the stages of applied research and development, organization for a particular result becomes not only possible but essential.

26. Efficiency in industrial research is largely a matter of choosing the right problems. There are thousands upon thousands of possible research projects - the crucial task is to choose those few projects which are made relevant by the market position, the financial resources, the production problems and the management skills of the firms and industries.

27. In development, which is frequently many times more expensive than the preceding research, there is a still greater need to relate the choice of projects and the precise objectives of the development team to production problems, available finance and the market opportunities of the firms or institutions for which the invention is being developed. Here detailed team-work and organization are essential. "For instance, it is often true in the chemical industry that at the pilot-plant stage the main problems are already known, and the remaining work can be foreseen in fair detail. This makes it possible to organize a co-ordinated attack along several lines at once assigning workers their specific tasks. A tighter organization is also needed at the development stage to prevent waste of time later. The technical solution coming forward from the scientists has to be related to the production and marketing problems of the firm. Unless the production and sales staff have a chance to express their views during development, they may bring forward important new points when investment for full-scale production is in progress. There is a temptation for production engineers, if they have not been consulted earlier, to try to improve on the fully developed design, and this is a frequent cause of delay in commercial operation. 17/

15/ The difficulties come out clearly in E.F. Dennison's attempt to put numbers to the contributions of the various factors in economic growth. See Dennison, op. cit.

16/ J.D. Bernal, in The Direction of Research Establishments, (London HMSO, 1957) part A, p. 1; Mees and Leermakers, The Organization of Scientific Research, (New York, McGraw-Hill, 1950).

17/ Carter and Williams, op. cit., p. 48.

28. It is almost impossible for large research and development institutes to be close enough to production and marketing problems to conduct final development efficiently. Such institutes can very easily magnify the development gap problem.

29. Of course, where research creates the possibility of an entire new industry, the problem cannot be posed in this way. When the United Kingdom Government set up the Atomic Energy Authority it was entirely appropriate to ask it to take charge of the research into and development of nuclear reactors. But now that nuclear reactors have been put into commercial operation, the position has changed. To continue to centralize reactor development in the Atomic Energy Authority could lead to them spending vast sums on developing types of reactor design which are not appropriate to the plans of the Central Electricity Generating Board.

30. There is no reason to believe that there are net economies of centrally organized research and development and there is particularly little reason to believe so of development. Owing largely to problems of communication and differing objectives, there are economies of specialization within this vast field. But what of much more limited forms of specialization? This question will be approached obliquely through a brief outline and appraisal of the United Kingdom organization of research and development.

E. The United Kingdom case

31. The United Kingdom is a wealthy country, with a large supply of scientists and technologists and a distinguished record in scientific discovery. Yet, for the last sixty years, there has been concern about the alleged failure of industry to apply science. In 1900, the National Physical Laboratory was established "to bring scientific knowledge to bear practically upon our everyday industrial and commercial life, to break down the barrier between theory and practice, to effect a union between science and commerce." The National Physical Laboratory is now part of the Department of Scientific and Industrial Research (DSIR), which was established in 1916. To match Germany in applying science to industry it was thought necessary to have state assistance to promote and organize scientific research with a view especially to its application to trade and industry. At a time when industrial research and development hardly existed in the United Kingdom, DSIR was expected to: (a) encourage individual firms in science-based industries to do research; (b) help form and (until they were firmly established) subsidize co-operative research associations on an industry basis, where (because firms were too small to organize and finance a research department and/or the research required was too long-term) research would not pay individual firms but would pay the industry; and (c) undertake socially useful research which would not pay industry.

32. There certainly has been a tremendous increase in research and development conducted by individual firms - it now costs more than 3 per cent of industrial net output. In 1961, the United Kingdom's total expenditure on research and development was £634 million, of which 58 per cent was spent by private industry. However, 40 per cent of industry's research and development was financed by the Government, mostly by defence contracts of over £150 million. Private industry's self-financed research and development was only 33 per cent of total research and development, though 55 per cent of all that for civil purposes. As has been noted, most of this research and development is conducted by 350 large firms in a few modern industries.

33. There are now about sixty co-operative research associations. Fifty-two receive subsidies from DSIR, which, in total, provides 25 per cent of their income. The original belief that DSIR would only need to "prime the pump" proved incorrect. Grant aid is, however, given in proportion to the sums raised from industry.

34. Co-operative research is not restricted to small-firm industries: there is a Motor Industry research association, a Cement research association, an Iron and Steel research association, and (until recently when it was amalgamated with cotton and silk) a Rayon research association. But most are in the small-firm industries, such as pottery, wool, linen, lace, felt, glue, cutlery, etc.

35. The research associations have done very valuable work, though they are now responsible for only a very small part of industrial research and development - 3 per cent of civil research and development in industry, (compared to over 6 per cent in 1946). Whereas their expenditure increased 65 per cent between 1955 and 1961, private industry's (self-financed) research and development increased over 200 per cent.

36. Why has co-operative research not grown faster? In 1961, on average, their expenditure was divided as follows: 23 per cent basic research, 47 per cent applied research, 18 per cent technical liaison, and 12 per cent library and information. Research associations are most successful where they serve industries with relatively large firms, for such firms employ scientists and engineers who can develop the research association ideas for their own use, in contrast to many small firms which cannot even understand the concepts and terminology used in technical literature. Here the "communication loss" is a serious one. For the small firms, the most important thing is technical advice on the lines used successfully in agriculture. This underlines the points made earlier about the distribution of scientific manpower and the close relations between final development and actual production. But it should be emphasized that the research association movement has played an important part in inducing development work and, given that development is generally more expensive than research, the more successful it is in priming the pump in this way, the more will its share in industrial research and development fall. It should certainly not be thought that the research associations have failed because they have not helped to bring research and development, as a percentage of net output in old established industries, up to equality with the science-based industries. Equalization of marginal returns to investment in different industries will always leave big differences in research rates. 18/

37. DSIR now has fifteen research stations, which in 1961 spent, on basic and applied research, about the same amount as the sixty research associations. Their links with industry are less direct, but they are certainly concerned with the application of science to industry. The National Physical Laboratory (which conducts a wide range of basic and applied research in aerodynamics, metallurgy, radio, optics, mathematics, electronics, ship design and electrical engineering), and the Laboratory of the Government Chemist are older than DSIR. DSIR created the Building Research Station, the Road Research Laboratory, and the Water Pollution Research Laboratory between the First and Second World Wars. Since 1945, it has created several new research stations, most of which are concerned

18/ For the similarity in the relative research rates in the main industry groups in the United Kingdom, the United States of America and Hungary, see Some Factors in Economic Growth in Europe in the 1950's, chapter 5. See also Y. Brozen, "Trends in Industrial Research and Development", Journal of Business, July 1960, and B.R. Williams, "Variations par secteur dans l'effort de recherche-développement en Grande-Bretagne", Economie appliquée, 1961.

with engineering. Some of the research work has a very direct application to industry - e.g. the work of the Forest Products Research Laboratory on kiln seasoning, of the Torry Research Station on freezing fish at sea, of the National Physical Laboratory on the design of hulls and suspension bridges, of the Hydraulics Research Station on the location and design of viaducts - and even the measurable commercial yields to their work justify their existence. 19/

38. DSIR recently placed three civil research and development contracts with private firms making machine tools and electronics. This is an attempt to stimulate innovation by subsidizing neglected types of research and development, and getting them undertaken by firms with an interest in final production - a method that has worked well in defence industries. However, it will be more difficult to stimulate civil innovation in this way. In defence projects the Government is the sole buyer; in civil fields it is not. However, it is a sign of a further recognition of the need to keep final development close to production.

39. The National Research and Development Corporation (NRDC) - a public body founded in 1949 to deal with discoveries made in government research establishments and to secure the further development of new ideas coming to it - also gets private firms to complete development, sometimes with the encouragement of a development contract. It has so acted with electronic computers, fuel cells, Hovercraft, Dracones and hecogenin extraction for the production of cortisone.

40. The largest research and development institute is the Atomic Energy Authority, which spends on civil research and development alone more than three times as much as the research associations and DSIR research stations together. The Atomic Energy Authority put the United Kingdom first in the field in the commercial use of nuclear power. But given the recent rapid innovations in conventional power methods, design innovations are required to get nuclear power costs down. The segregation of development in the Atomic Energy Authority, away from the construction and use of power stations, is now beginning to be a serious problem.

41. The general position in the United Kingdom then, is that specialist industrial research bodies between them spend just under 20 per cent of total civil research and development. The DSIR and the research association laboratories do important work in applied research, some of which can be applied directly to industry. Where development work is required it is left to industry, though recently DSIR has begun a trial run with civil research and development contracts on the lines of defence contracts. Furthermore, both DSIR and the research associations exercised a pump-priming effect on development work in industry. Apart from the research institutes in agriculture (which have not been discussed here) the Atomic Energy Authority is unusual in that a high proportion of its expenditure goes for producing pilot plants. As pioneers this was inevitable, but the position is likely to change as the nuclear reactor industry becomes more skilled and powerful.

F. Special role of research and development institutes in developing countries

42. Science is imported more easily than technology, but for developing countries it is the technology that is crucial. The technology exists - it does not have to be created by a native research and development effort. But the form of the

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19/ See Sir H. Melville, D.S.I.R. Does it Pay Off? (Manchester Statistical Society, 1961).

technology used in richer countries - with their better supplies of administrators, scientific and technical manpower and capital - may be inappropriate. Even the Russians, who currently have a good supply of business administrators and scientific manpower, do not copy the techniques used in the United States of America, but take care to keep down capital cost per unit output. Where business administrators, technical manpower and capital are all in short supply, still different techniques may be appropriate. In some cases, they may prove to be what engineers would regard as very modern. But Mr. Leontief's general prediction that automatic factories will have a greater relevance in poor than in rich economies because of lower capital and skilled labour requirements per unit of output, leaves out of account the crucial importance of the large markets and the complex management skills required to make automatic factories economically viable.

43. Skilled manpower will be in short supply. It will be needed for both the adaptation and operation of technologies established in developed economies. The adaptation may require some applied research into the qualities of local materials, the effects of different operating temperatures and so on. But for the most part the need will be for development engineering. To ensure this, the essential research and development institutes will need carefully defined terms of reference. For, as has been said above, the main activity should not be research, but engineering development and technical information services.

44. To keep the correct emphasis in the research and development institutes, it would be wise to employ not only scientists and engineers to do technical development and information, but also social scientists to analyse costs and markets and to find appropriate means of "selling" the research and development outputs. Applying science for growth requires attention to the two faces of innovation - technical and social.

45. For the same reason, it would be wise to think in terms of institutes to serve (or create) particular industries. Because the range of outputs is vastly less in wheat, wool, milk, etc., than in the engineering, electrical and chemical industries (and the agricultural institutes can do satisfactory final development on their own experimental farms), a higher degree of specialization is required from research and development institutes in industry than in agriculture.

46. The appropriate procedure is to identify the industries in which investment in technological advance is likely to bring the greatest returns, and to create institutes for them with facilities for constructing prototypes and pilot plants. Once operational analysis, which would, of course, take into account the types of manpower required for production, showed that investment in a new technology would be sound, the institute would arrange for existing manufacturing firms (or firms created for the purpose) to use it. The institute would assist in, sometimes in fact run, the first production operations, and then continue in the role of technical consultant.

47. In the course of time, development work would be taken on by the manufacturing firms, but it might be generations before anything like the present United Kingdom balance between the work of research and development institutes and departments in firms emerged. The longer developing countries are in a position to adapt proven foreign technologies, the less there is rapid technological obsolescence in luxury industries; and the longer it takes for supplies of scientific and technical manpower to catch up with increasing demand, the more will it pay to concentrate research and development activities in institutes.

48. Research and development institutes are not the only way of introducing new technologies. Foreign subsidiary companies and branch factories play a very important part in diffusing technology. Hitherto such diffusion from developed to developed countries has been more important than diffusion from developed to developing countries. 20/

49. For a developing country, this way of acquiring new technology has great advantages. The foreign company relieves the state of excess demand for scarce resources by supplying the new technology, managerial skills and (generally) capital. However, if such firms rely entirely on the research and development work of parent companies and continue to use imported labour for key technical and managerial jobs, then they do little to create the conditions of self-sustaining technological change. But this does not create a good case for discouraging foreign subsidiary companies. Rather does it create a case for associating foreign companies with training programmes and for attracting them in those fields that will complement the work of the research and development institutes, established or about to be established.

50. The point about complementing the work of these institutes is an important one. Most of the developing countries are going to be short of high-quality scientific and technical manpower for some time to come. In the United Kingdom the minimum budget for an effective industrial research association is about £25,000 *per annum*, and where industrial development work is involved it is considerably higher. Some firms in the United Kingdom argue that the minimum cost of an effective research and development department is £100,000 *per annum*. The position in developing countries will, of course, be different, but they will certainly have to be very highly selective in their research and development programmes. Co-operation with rich countries and with other developing countries in the choice of research and development projects and in the exchange of knowledge should therefore be encouraged. At this Inter-Regional Seminar on Industrial Research and Development Institutes, it should not be necessary to labour that point.

20/ *See*, for example, J.H. Dunning, *American Investment and British Manufacturing Industry*, (London, 1958), and Williams, *op. cit*.

II. NETHERLANDS TECHNICAL CONSULTING SERVICE

Prepared by the Netherlands Development Centre, Delft

Introduction

1. For centuries the Netherlands has been famous as a commercial and agricultural country, yet there have also been industrial activities in the country ever since the Middle Ages, particularly in shipbuilding and textiles. About 1900, there were a number of large industries and a great many smaller industries and crafts. It was realized that the smaller industries would have difficulty in keeping up with technical development and that they should be strengthened and extended in the interest of the national economy. Accordingly, technical advisers were made available to the small firms and technical centres were set up for various branches of industry.

2. The Fibre Technical Centre, the Clay Technical Centre and others, which were originally concerned mainly with providing information, with documentation, carrying out check tests and developing check methods and apparatus, developed in the years between 1935 and 1940 into applied research institutes which proceeded to give more attention to applied research, too, with the object of inducing the branches of industry concerned to bring their technologies, methods and products up to date.

3. In 1914, a specific institute was set up at Delft (close to the source of technical knowledge, viz., the Technical University) to support the technical advisers for the smaller industries scattered throughout the country; its primary aim was to provide the regional consultants with documentation and information. The laboratory of this institute - the Development Centre - had facilities for testing tools and apparatuses manufactured by small firms, for issuing reports on performance and for demonstrating modern working methods and apparatuses. After the Second World War, when the industrialization of the Netherlands was being vigorously undertaken, both small and medium-sized firms felt the growing need for facilities for carrying out such development work as the building of prototypes, mechanization and automation.

4. This need for carrying out development work can be met in different ways. To avoid overlapping between applied research institutes and the Development Centre, this matter has been discussed at length in the Advisory Committee of the Centre. This discussion can be comprised into the following considerations.

A. Consideration of research and development

Consideration of pure research, applied research and development

5. In his opening address at the Technical University at Delft in 1948, Professor Tellegen gave some definitions on pure and applied research. He stated that:

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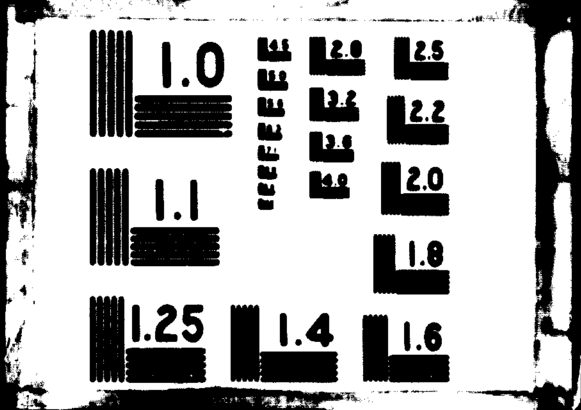

(a) Pure research wanted to know, applied research wanted to perform;

(b) Pure research led to discoveries, applied research led to inventions;

(c) The pure research worker wanted to understand: his task was an analytical one and his mentality basically philosophical;

(d) The applied research worker wanted to create: his task was synthetical and his mentality was related to that of an artist.

If one would like to add definitions on development work it could be put like this: Development work wants the techno-economic results of what is already known and invented, it leads to manufacturing. The development worker wants a practical solution, his task is executive and his mentality is related to that of a manufacturer.

6. When looking at the fields of action, the pure research worker is, generally speaking, bound to a certain branch of science, for instance, chemistry or electricity. The applied research worker is often bound to a specific material, for instance, metals, wood or plastics.

7. For development work, boundaries are less clearly cut. Primarily, what is needed is a collective approach on the part of experts in different fields: metalworking, designing and electronics. Results may be of use in different branches of industry with a possibility of grafting an idea in one branch of industry to other distinct branches.

8. If one would like to define the type of people one needs for pure research, applied research and development work, it could be tried as follows.

9. The pure physical researcher should be analytical, a good observer, with the talent of discernment and a high orderliness in thinking. He should be systematic, patient, objective and philosophical. It is accepted that he may not be interested in the material aspects of this world.

10. The applied physical researcher should have talents of association and combination. He should think synthetically with a creative mind, which should be used systematically and with patience. It is allowed that his interest be more drawn to the theoretical solution of a puzzle than to a practical application in manufacturing.

11. The development worker should select one solution, out of different possible ones, for application in manufacturing, based on a broad technical education and practical experience. In the first place, he should be practical and, secondly, have analytical insight and talents of association and inventiveness. He should have sufficient techno-economic feeling to pick a choice subjectively out of solutions which have been long known <u>or</u> which can be borrowed from results of applied research. He should have the determination to put his approach into actual use.

12. It is an advantage if there are good contacts between researchers and development workers. There certainly is an overlapping in the fields of action.

13. However, as development work may be based also on what has been known for a long time, and, furthermore, the goal is directed entirely to the actual execution in the plant, this type of work basically belongs to the plant rather than to the laboratory.

14. For small and medium-sized industries, however, this development work is hindered by the fact that staff members who could perform the work very well, in so far as knowledge, experience and inclination are concerned, have no time to spare to concentrate on it because the actual manufacturing takes all their time or interrupts them continuously. It is supposed here that the industry is of such a dimension that the plant cannot afford a separate development department.

15. From this point of view, an independent development centre on behalf of small and medium-sized industries is of great importance. Such a centre has, moreover, the advantage that it can use experiences in one branch of industry in other branches of industry, as already mentioned.

16. It is advisable to be aware of the differences in mentality between workers in these three fields of activities, for the group of workers in each of these fields should be homogeneous as to inclination and mentality and should be directed by a manager of the same type. As rarely as a technical managing director of a plant can act as the leader of a team of researchers, so rarely can a group of development workers be led by the head of a research institute.

17. At the end of the discussions in the Advisory Committee of the Development Centre, in which two top-level representatives of the applied research institutes took part, it appeared to be impossible to give a clear-cut theoretical definition of the field of action, but the Committee unanimously agreed on the following description of the duties of the Centre.

B. Duties of the Development Centre

18. The duties of the Development Centre consist in:

(a) Building prototypes of machines and appliances;

(b) Developing mechanization and automation devices for industrial processes;

(c) Advising entrepreneurs on problems of mechanization and automation in their factories.

These duties are mainly in the field of mechanical engineering, electrical engineering and electronics.

19. As a rule, this work is carried out on behalf of:

(a) Firms that do not possess their own development departments;

(b) Firms with development departments of their own that do not cover the fields in question (for example, a chemical firm with its own chemical development department that has an electronic problem to solve).

C. <u>Relationship between principals and the Development Centre</u>

20. Before applying to the Centre for assistance, a principal who wishes to introduce an improvement in his production apparatus and is not in a position to carry it out in his own factory generally asks himself the following three questions:

(a) Will the Institute be able to do the work properly?

(b) Will my original idea and everything that comes to light in the course of its development be reserved exclusively for my firm?

(c) What will it cost?

21. As regards the first question, the Centre fulfils the requirements for both staff and equipment. The advantage of the comparative smallness of the Development Centre is that it has at its disposal a team of specialists in various branches (mechanical engineering, measurement engineering, machine-shop technique and electronic engineering) who know each other well and desire to co-operate. With the equipment, which is of a universal nature, almost any kind of prototype can be made and tested, and practically any mechanization scheme carried out and tested.

22. The principal's rights to his own invention are very effectively safeguarded by the conditions governing the acceptance of commissions. The staff of the Centre stands under an oath of secrecy. The Development Centre surrenders to the principal all claims to possible patents, provided the principal fulfils his financial obligations. The regulation is based on the idea that the principal must feel safe and must be able to make all his data available unreservedly, but it has the disadvantage of making it virtually impossible for the Development Centre to pass on later to third parties the knowledge thus acquired. This disadvantage must be accepted, since otherwise principals would not be prepared to place commissions at all.

23. A more difficult problem is that of expenditure on development work. Although development work is generally less costly and more likely to produce favourable results than does research, there is the difficulty of making estimates and the risk of the results not being sufficiently worth while. It is practically impossible to give an estimate of the cost while the plans or drawings are being prepared. Not until the drawings are ready can the cost of production be even roughly estimated. Again at the succeeding trial stage, during which modifications often have to be made so as to correct faults due to lack of experience, it is hardly possible to anticipate the cost involved. However, the Development Centre has no commercial aims. In fact, with a view to promoting the interests of small and medium-sized industries, the charges for wage-hours, drawing-hours, machine-hours and materials even include a concealed subsidy, the cost of providing information and making buildings and equipment available not being charged in full. Moreover, small firms can be allowed reductions to ensure that the Centre does not defeat its own object. For the smaller the firm, the less comprehension and breadth of vision the entrepreneur can be expected to have with respect to the actual cost of development work. If a small entrepreneur is faced with costs exceeding the price which he himself charges his customers, he will very likely decide to do the development work himself, though he has neither the time, the knowledge nor the equipment to do such work.

D. Relations with industry

24. The Centre is a national institution; it constitutes part of the Government Technical Consulting Service, which belongs to the Ministry of Economic Affairs.

25. It has three links with industry:

(a) An Advisory Committee consisting of five members, two being representatives of medium-sized industries, one of whom acts as chairman and the other as vice-chairman. The Committee's task is two-fold. In the first place, it assists the management of the Development Centre in its administration and its co-operation with industry and other institutions; and, in the second place, it advises the Minister on matters of long-term policy in regard to the Centre;

(b) Contact with the category of firms with which the industrial consultants maintain special relations (as a rule, they are industrial firms with staffs of from 10 to 100) is established via those consultants;

(c) Direct contacts also spring from many of the Development Centre's own long-standing business relations (the regional industrial consultant being kept informed of those direct contacts and of the course they take).

26. The management attaches great importance to maintaining good relations with industry, so as to avoid drifting into the habit of tackling problems from a theoretical angle or engaging in activities that are of no value to industry.

E. Personnel

27. The Development Centre personnel currently comprises: 1 manager, 4 mechanical engineers, 1 measurement engineer, 1 electronic engineer, 3 draftsmen, 1 workshop manager, 1 electrical fitter, 2 fitters, 2 welders, 4 machine-tool operators, 1 store-room attendant and 2 clerks. To balance the team, it will be necessary to add: 1 assistant manager for outside relations, 1 electronic engineer and 1 machine-tool operator.

28. Should interest grow and financial resources permit, the staff could be extended in the same proportions, the maximum being set roughly at forty, with a view to maintaining the team spirit.

F. Commissions

29. The average time needed to make prototypes of any magnitude is from one-and-one-half to two years. Normally, three or four orders of this kind are dealt with concurrently.

30. In addition, there are usually ten to fifteen smaller orders for prototypes taking up to a year in hand. There are also the tests requiring test equipment. Two or three are carried out simultaneously; they entail little work, but may occupy a long period. Other tests, taking as a rule only one or two days, are also carried out regularly.

G. Space and equipment required

31. The present staff occupies: 1 board-room, 1 book-keeping office, 1 drawing office, 7 rooms for the staff, 1 room for the workshop manager, 359 square metres of factory space, 200 square metres of assembly and testing space, 50 square metres of assembly and testing space for electronic work, 150 square metres of store-room

space for new materials and implements, 1 dark room, 1 measuring and checking room of 25 square metres (for this purpose, the centre uses a cellar, which is little affected by the climate and can be easily kept at a fairly constant level of humidity and at a temperature varying only from 12 to 21 degrees Centigrade) and 150 square metres of storage space for old testing equipment and for that in current use.

32. Broadly speaking, the equipment consists of the workshop equipment, mechanical engineering apparatus, electrical and electronic measuring apparatuses and the braking equipment for power measurements.

33. It should be noted that there should be a plentiful supply of machine-tool accessories, hand tools and measuring tools for use in the workshop and elsewhere. Their purchase usually calls for considerably greater investment than is at first expected.

34. Account should be taken of the fact that there will be fairly long periods during which the machine tools, implements and measuring apparatuses are out of use, since the work must not be held up while the staff wait for machines and implements to become available. The Centre believes also that in developing countries, where the personnel problem is usually not so acute as it is in industrialized countries, allowance will have to be made for certain periods of "equipment inactivity", because it is important to make full use of the staff's capacities, and frequent waiting causes the general rate of working to drop considerably.

H. Results

35. According to the accountants' forecast, the Centre as it currently is organized will have cost f 386,450.- in the year 1963, that figure being made up of roughly f 275,000.- for wages and salaries, f 71,000.- for depreciation of buildings, machines and implements, and f 40,000.- for general expenditure. The item "depreciation" would be considerably larger for any new buildings erected or new purchases made at the present level of prices.

36. This expenditure is offset by receipts for work carried out, amounting to f 244,000.-. Giving information, which is not debited, and the keeping available of certain personnel, rooms and apparatuses call for approximately f 143,000.-. The government subsidy, in the mode of calculation, is of the order of 35 to 40 per cent.

III. SCIENTIFIC INFORMATION AND TECHNICAL ADVISORY SERVICES TO UNITED KINGDOM INDUSTRY

Prepared by the United Kingdom Department of
Scientific and Industrial Research

Introduction

1. The effective use by countries in the process of development of the vast store of scientific, technical and industrial knowledge which is available from the more highly industrialized countries demands the provision of machinery which can stimulate interest in technical progress, recognize specific problems and identify the best sources of information and advice required. This is a problem which grows in direct proportion to industrial development and it is, in fact, more acute in those countries which are highly industrialized.

2. The establishment of such services in any country requires, firstly, an intimate knowledge of the social, economic, industrial and technological state of the country concerned; secondly, a comprehensive programme of training is needed for the staff who will man the service; and, thirdly, some form of continuous practical support should be arranged during at least the first three years of the establishment of such news services. The Organisation for Economic Co-operation and Development (OECD) has had some experience in this field of work and has assisted several countries in setting up industrial information services through their National Liaison Officers Scientific and Technical Information Group.

3. The United Kingdom does not possess a highly co-ordinated technical information service, but the Department of Scientific and Industrial Research (DSIR), which was formed in 1916, is charged by the Government with the responsibility for undertaking and promoting industrial research, and it attaches great importance to the dissemination of scientific and technical information as one of the principal means of reducing the gap between scientific research and its application to industrial production and development. The dissemination of information is undertaken by the Department's fifteen research establishments (paras. 8, 9), by its headquarters office in London, and by fifty-one industrial research associations supported jointly by DSIR and industry (para. 10). The methods used include publications of all kinds, lectures, conferences and the mass media - film, television and broadcasting. Industrial liaison activities and on-the-spot technical advisory services are important additional methods used by the research associations. An important new experiment is the creation of an industrial liaison service for industry (para. 13) which is being built up on centres established in colleges of advanced technology and in technical colleges.

A. The problem of communication

4. Technical information is the product of scientific research and development. In its original form, it is written by scientists and technologists f r scientists and technologists and normally first appears as a report in a scientific journal - technical information in its original state therefore usually requires further

treatment before it can be assimilated by the majority of industrial firms (para. 11). But technical information on its own, however well presented, is not enough to persuade the smaller firm to embark on a new product or technique. Such decisions often require also financial, commercial and economic advice of various kinds which the larger firm has available but which the smaller one may find more difficult to obtain than the original technical idea which attracted its attention. A technical information or advisory service may therefore have to be prepared to afford general managerial advice, assistance or suggestions outside the purely technical information field.

5. Another problem is the enormous growth of scientific and technical literature. At the beginning of this century there were no more than 200 scientific and technical journals published in the world. Today there are 25,000 and the number is growing rapidly. It has been established that the output of scientific and technical literature is now doubling every fifteen years. Unless machinery exists to gather in this information, store it and make it readily available and, most important of all, stimulate interest and demand, technical progress could even be retarded. 1/

6. The ability of the individual industrial firm to make use of scientific and technical information depends on its internal organization. The acquisition of new technical knowledge should not be left to random appraisal or chance observation and information will not flow efficiently unless some system of information processing exists. The attitude of management is of great importance, and the existence of scientific and technical information services must be paralleled by a disposition on the part of industrial management to take an active interest in all sources of technical information and to keep abreast of events in and outside its own industry and in the world at large.

7. Many surveys carried out to discover how industry obtains and uses technical information have shown that personal contact is an important (and in the case of small firms the most important) method of introducing technical information and a significant change in a firm's outlook. The acceptance of this has led to increasing emphasis on industrial liaison activities by Government-sponsored and -assisted research organizations in the United Kingdom (paras. 10, 13). Selection, presentation and timing are also important. Communicating the results of research to industry is in a sense a selling operation - an objective approach is needed, as is aiming at particular sectors and even at particular firms in industry. Technical information must also be presented in the right form and at the right level (para. 11) and it may be necessary for the source of technical information to create in industry an awareness of the need for technical information, e.g., by publicity in the mass media (para. 11), before attempting to distribute the information.

B. The means of communication

8. DSIR has fifteen research stations undertaking research which is in the national interest and which cannot reasonably be done elsewhere. The stations serve three purposes. Firstly, they assist central and local authorities by

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1/ A most important step taken by DSIR in this field in recent years was the creation in 1962 of the National Lending Library for Science and Technology. Plans are now also being made to establish a National Reference Library for Science and Invention. See para. 14.

conducting research into such fields as road traffic and safety, coastal erosion, fire protection, and the pollution of air and water. Secondly, they contribute to the efficiency of industry as a whole by their work on such matters as methods of measurement and the properties of materials. Thirdly, they work on specific problems, e.g. the propagation of radio waves and the preservation of fish, which could lead to new developments of national importance in these particular fields.

9. The stations encourage their research workers to publish their results as widely as possible through the journals of the professional and learned societies and by articles in the technical press and supplement these individual activities with specialist publications, reports and bulletins, issued through the Stationery Office, the Government's central publishing organization. All the stations publish summaries of their current work in annual reports and undertake advisory work for industry by direct contacts through their research officers.

10. DSIR also supports fifty-one co-operative industrial research associations in a very wide range of industries, including food, fuel, metals, textiles, ceramics, leather, rubber and plastics, and engineering industries. The Department provides funds in proportion to the amount of financial support each association obtains from its industry - the DSIR subvention varying from 12 per cent to 50 per cent. The research associations undertake fundamental and applied research directed towards the technological development of the industries concerned, but the associations also have an important technical information and industrial liaison function. They adopt various methods, including lectures, conferences, bulletins, reviews and abstracts, but one of the most effective means adopted by many associations is industrial liaison activity. Some research associations use mobile laboratories and demonstration units with accommodation for lectures, including projection facilities for films and slides. Others have laboratory and demonstration benches. These units can be taken into the factory where specific production problems can be studied or new methods of processing demonstrated to industry by operating them side by side with existing processes in association members' factories. Special financial assistance is given by DSIR to the research associations for this kind of work, which is a potent method of reducing the gap between laboratory investigation and industrial practice.

11. The industrial information and advisory services offered to industry by the stations and research associations are supplemented by the information activities of DSIR's headquarters office in London and three branch offices of the provinces. For instance, a publicity group in London has sections dealing with the Press, films and broadcasting, and exhibitions. The first seeks wide publicity in the general and technical press for new scientific and technical developments. The film and broadcasting section is concerned with disseminating scientific and technical information through the mass media of sound and television broadcasting, but it is also responsible for a programme of documentary film production based on the work of DSIR stations, to illustrate new technical methods to specialist audiences. The exhibitions section publicizes the work of the stations and research associations to specialist audiences. A most important activity referred to in paragraph 4 is in relation to the treatment of scientific and technical information. A group of the staff in London prepares popular publications, bulletins, leaflets, advisory notes, etc., to support basic research communications and to render them intelligible to and applicable by industry. An example of one of the last-mentioned activities is a series of free booklets dealing with particular aspects of "low-cost automation". These describe simple or cheap measures or devices that are likely greatly to improve productivity.

12. The officers in charge of the DSIR branch offices referred to above also act as field technical liaison officers establishing close contacts with local industry, government departments, universities and technical colleges, etc., and an interesting development in these branch offices is the creation of mutual assistance schemes through which laboratories of all kinds - Government, academic and industrial - can exchange information, experience, equipment and materials.

13. Recently DSIR and the Department of Education and Science and Local Authorities in the United Kingdom began an entirely new development in the field of industrial liaison. It is difficult, if not impossible, to draw a line of distinction between technical education and the dissemination of scientific and technical information. The connexion is particularly strong in the case of the smaller firm and for this reason industrial liaison centres in the United Kingdom have been and are being established in colleges of advanced technology and in technical colleges. These industrial liaison centres are manned by graduate scientists or technologists with industrial experience and their function is to visit small local firms and assist them to identify their technical problems and encourage them to use the advisory information and educational services provided by DSIR, the colleges and other organizations. Each industrial liaison centre is closely associated with the management training department in its own college and the industrial liaison officer has the opportunity of lecturing to trainee managers on the importance of technical innovation and technical information. It seems likely, moreover, as the system develops, that it will provide for assistance to the smaller firm seeking advice on commercial and industrial problems outside the purely technical information field but which are often inseparable from the technical problems (para. 4).

14. A special institution recently (1962) created by DSIR in the field of scientific information for scientists and to deal with problems raised by the growth of scientific literature (para. 4) is the National Lending Library for Science and Technology. This institution, located on a large site at Boston Spa in Yorkshire, covers the whole field of science and technology, including agriculture and medicine. It acquires literature of value to practising scientists and technologists and has, in particular, a collection of technical and scientific literature in all languages, including an extensive collection of Russian literature. It supplements the library resources of existing organizations by providing a rapid lending service to "approved borrowers", which include industrial firms, research associations, universities, colleges and the larger public libraries. Plans are now being made to establish a National Reference Library for Science and Technology - by amalgamating the Scientific and Technical Department of the British Museum Library with the Patent Office Library. This new library will be located in London.

15. Each of DSIR's fifteen stations and the fifty-one research associations have many specialized collections of literature covering their own areas of interest, and there are many local co-operative schemes in which the public, specialized libraries, the libraries of private firms and educational institutions combine to help each other. There is also an Association of Special Libraries and Information Bureaux (ASLIB), actually one of the fifty-one research associations of DSIR, which stimulates and encourages co-operative effort in this field and has a small research department in the field of library and documentation techniques.

C. Conclusion

16. There are over 3,000 sources of scientific, technical and commercial information in the United Kingdom. The majority of these are libraries covering a wide field and stocking the most commonly required books, periodicals and reference material. The remainder - research institutes, professional institutes, special libraries, etc. - cover one subject field or one industry in great depth.

17. The United Kingdom has no highly co-ordinated technical information system but DSIR is the government department primarily concerned with the dissemination of scientific and technical information to industry. It seeks to stimulate and encourage all sources of scientific and technical information throughout the United Kingdom and, particularly, its own stations and research associations to ensure that such information arising from research is made available to industry in an intelligible and applicable form. It seeks to do this objectively and selectively as far as possible, by creating an awareness of the need for technical information and directing it to particular sectors of industry or even particular firms. Large firms normally have the means of assimilation built in but the smaller firms need special attention and, above all, personal contact. The importance of personal contact has led to increasing emphasis on industrial liaison activities and centres. A new development is the establishment of such centres in colleges of advanced technology and in technical colleges. Technical information and industrial liaison are possibly the most important means of stimulating innovation and technical progress, but no information services can be effective unless industrial management also accepts the responsibility for seeking out new knowledge and ideas.

18. In the field of scientist-to-scientist communication the DSIR has created special institutions to help in this field. The object here is not to increase the amount of scientific and technical information but to organize it and provide means of storage, retrieval and dissemination - in short, to make particular scientific information available to the scientist who needs it. The DSIR both undertakes and encourages research into the techniques of scientific information and documentation.

IV. THE SCIENTIFIC AND TECHNICAL DOCUMENTATION CENTRES AND THEIR UTILIZATION FOR INFORMATION NEEDS OF INDUSTRY IN DEVELOPING AREAS

Prepared by the United Nations Educational, Scientific and Cultural Organization

1. More than 50,000 scientific and technical periodicals are currently published in the world. Inasmuch as periodicals provide the basic elements of the documentation needed by research workers, professors, technicians and industrialists, the above figure explains why the number of scientific and technical documentation centres is increasing continuously. Their function is to collect and classify the documents in their field and to distribute them to the interested individuals and institutions.

2. In various countries, especially after the Second World War, an urgent need was felt for such centres to help accelerate industrial, scientific and economic progress. The help of the United Nations Educational, Scientific and Cultural Organization (UNESCO) was requested, within the framework of the Technical Assistance Programme for the establishment and operation of such centres in developing areas. With the assistance of UNESCO, scientific and technical documentation centres have been created and developed in Mexico, New Delhi, Cairo, Belgrade, Rio de Janeiro, Karachi, Manila, Bangkok, Djakarta, Montevideo, Havana and Seoul. 1/

3. The general scheme of such assistance has been very similar in all the countries concerned. UNESCO has provided a team of two to four experts: the chief of the centre; a documentalist in charge of the publications of the centre; a specialist in bibliography or translations; and an expert in document photo-reproduction. The team stays in the country from three to five years, organizing and running the centre and training the local staff that will replace the international experts. The training of the local staff is supplemented by study tours abroad through fellowships provided by UNESCO. Funds are also allocated for purchasing part of the equipment, materials, books and subscriptions to periodicals.

4. The collection of periodicals is the basis of the documentation centre. Together with books (as in Cairo and New Delhi) or without books (as in Mexico), a collection of 1,000 or 1,500 well-selected periodicals is a good nucleus containing the main publications from different countries in pure and applied sciences (mathematics, astronomy and geophysics, geological sciences, biology, physics, chemistry, medical sciences, agriculture and engineering). The number of periodicals depends, obviously, on the funds available and on the periodicals obtained through exchange with local publications. In some of the centres, 3,000 to 3,500 current periodicals are received regularly. Of these, 8 to 18 per cent are devoted to engineering sciences. To this figure should be added the periodicals on applied sciences in such fields as chmistry, physics, etc.

1/ A detailed description of these centres will be published in the booklet: "UNESCO and the Development of Scientific and Technical Documentation Centres", which is under press.

5. The photo-reproduction service helps to increase this basic and permanent documentation by providing, through agreements with similar centres throughout the world, reproductions either on microfilm (they are very cheap, but they require special reading apparatus) or on paper (directly readable, but more expensive) of articles published in any country, in any periodical, at any time.

6. The reception of periodicals, books, etc. corresponds to the step: collection of documents. Afterwards the material (titles of articles and abstracts) is classified more or less thoroughly, depending on the means and staff available. The third step, distribution, has been developed by sending mimeographed or microfilmed lists of titles of articles (very inexpensive system), or by publishing a printed bulletin by offset, xerography or conventional printing (very effective, but very expensive). These publications are done in the language of the country or in a language generally known by local scientists, technicians and industrialists.

7. The reader who finds mention of an article in which he is interested might consult it directly in the library of the documentation centre or obtain a reproduction. In this way, documentation produced outside the region is made available in it. But the centre is also useful in taking care of the flow of documentation in the opposite direction: to make known outside the area the scientific and technical research papers published in the country or in the region. This has been done by producing mimeographed or printed lists of titles or abstracts of those papers.

8. The panel of technical translators working for the publications edited by the centre also provides on request translations of articles written in foreign languages. The centres generally have a bibliographical service, which helps interested individuals and institutions in preparing documentation needed to carry out scientific or industrial research. It also prepares bibliographies, lists of titles or abstracts on given subjects, when applicants are unable to prepare them by themselves.

9. The users of the centres are more often scientists than industrialists. But it has been possible to show that the scheme described above may be well adapted to fulfil the needs of industry. In Yugoslavia, it was stressed from the beginning that the need for information was mainly in the industrial field. This need was reflected in the importance attached to the centre's holdings of collections of technical and engineering periodicals. The indexing and abstracting of articles is limited to applied sciences. This is carried out by a central staff with the help of engineers working mainly in factories. The result has been the regular publication of sixteen abstracting bulletins in the Serbo-Croat language in strictly industrial fields, namely: plant production, zootechnics, forestry and wood industry, motor engines and machine parts, mechanical engineering, transport engineering, electrical engineering, mining and geology, metallurgy, chemistry and chemical industry, food industry, silicate industry, textile and paper industries, fuel and lubricants, civil engineering and architecture, and transport.

10. The level of industries in the different countries in which the centres were established varied greatly. Practically non-existent for some branches, industries were well-developed in specific cases. But whatever the situation in this respect, the general and common characteristic was the slight use made of the different services offered by the centre. This meant that, besides the

general publicity employed to make known the different services of the centre, a special effort was required for the industrial field.

11. This was carried out in different ways. For instance, a bilingual Arabic-English booklet was published under the title The first scientific and technical documentation service in the Middle East in Cairo and a similar one, in Spanish, in Mexico. The 2,000 copies produced were distributed to all the industrialists of the respective countries, with the collaboration of the corresponding Chambers of Industry. The pocket size of the booklet facilitated rapid consultation: either in one minute - summary, given in the last two pages, or in five minutes - full text. After a very short historical introduction, a clear description was given of the available means and services at the centre and the best way of using them for the industrialists. Special details were provided concerning the different sections of the bulletin and their relation to specific industries.

12. Again, in both countries, the official journals of the Chambers of Industry published regularly, based on material provided by the centres, a technical bibliographical section to help industrialists in the search for appropriate information.

13. The efficacy of this publication was reflected in the increase in the number of subscriptions to the bulletins and in the requests for general information, translations, bibliographies, etc. from industrial firms.

14. Under the title Technical Information for the Textile Industry, a monthly journal was published by the Cairo Centre. It was prepared jointly by a technical specialist of the largest textile factory in Egypt and the UNESCO mission. Every issue contained, in English or French, abstracts of all the articles concerning the textile industry received either in the factory's library or in the Centre. At the beginning of 1959, when the UNESCO mission left the country, 250 abstracts were being published monthly against 108 in the first issue in May 1958.

15. The abstracts were classified under the following headings:

I. Natural fibres;
II. Man-made fibres;
III. Yarn manufacturing;
  1. Opening, picking;
  2. Carding, counting;
  3. Spinning, twisting;
  4. Yarns;
IV. Fabric manufacturing;
  1. Winding, warping;
  2. Sizing;
  3. Weaving;
  4. Knitting, lacemaking;
  5. Fabrics;
V. Finishing and chemical processing;
VI. Analysis, testing and quality control;
VII. Engineering;
VIII. Industrial organizations;
IX. Miscellaneous.

Thus, all aspects and branches of the textile industry were covered. The journal was distributed free of charge to all textile industrialists in the United Arab Republic and to many others in Syria.

16. The Manila Centre publishes, under the title "Technical information sheets", a series of bibiliographical notes on specific subjects of interest to industrialists in the country. Ceramics, coconut technology, plastics, pulp and paper are some of the fields covered. These sheets "are forwarded to a limited and well-selected group of individuals, organizations, schools and factories which are deemed to be in actual need of the information they contain". Their purpose is "to furnish a quick preliminary survey for a specialist on what he has to read to keep abreast of the latest developments in his field".

17. Several centres have taken some action concerning patents, whose importance in the field of technical documentation is increasingly recognized. Probably the most comprehensive action is that taken by the Cairo Centre. In agreement with the Ministry of Commerce and Industry, this centre undertook to hold and disseminate information on some 200,000 foreign patents received yearly from the main industrial countries. The patents were classified by subjects according to the classifications adopted in the country originating the patent. The document reproduction service provides, on request, microfilm or paper reproductions of the available patents, which were listed regularly, by country and by numbers, in the bulletin. One might also consider for this specific type of reproduction, modern copying devices providing facsimile copies in one or two minutes.

18. A service of "technical cards" was offered to laboratories and industrial firms in Mexico. Its aim was to provide information on papers published throughout the world, even if not received in the centre, on any technical subject specified by the subscribers. Such a regular service allowed laboratories and industries to obtain complete and up-to-date documentation on the subjects of direct interest to them. At a reasonable price, information was provided, gathered by a specialized staff from thousands of publications. The users saved the cost of subscriptions to large numbers of periodicals and the salaries of highly qualified staff. In spite of all these advantages, this service did not, in practice, meet with great success.

19. The existing scientific and technical documentation centres operate all the basic services: publications, bibliographical services, documentary reproduction, translations, information, etc., common to both scientific and technical information. The examples described in the preceding pages show that practically all the centres are able to provide a good response to the challenge of furnishing totally (Yugoslavia) or partially (other centres) the type of special information required by industry. In the areas where there are centres created either with the assistance of UNESCO or, in very few cases, through other means - the calls for technical information are already increasing very substantially. It may be expected that they will increase more and more in the future. It is obvious that this demands a corresponding increase in the number of technical periodicals and technical documentation in general, such as: know-how and technical digests at all industrial levels, patents, special reports, industrial catalogues, etc. This increased demand should be reflected also in the background and special fields of knowledge of the technical staff of the centres.

20. Activities and initiatives similar to those described above, as well as new ones, should be multiplied, and co-operation with productivity centres, economic commissions, industrial councils and similar bodies enlarged so as to attract the industrial world in the developing areas into the field of action of the scientific and technical documentation centres. Imagination and perseverance are essential in the long-term action that is required if lasting results of real importance are to be obtained in this sphere.

21. At this point, taking into account the increase in the needs for technical information, the question may be raised as to the advisability of creating in developing areas technical documentation centres, limited to technological information for industrial purposes. Some reasons have already been given in the foregoing pages, which permit a negative reply to this question. Others, no less convincing, may be added in favour of the creation of scientific and technical documentation centres, serving simultaneously scientists, technicians and industrialists. This end must be reached, either by further developing technical information in the already existing centres, or by combining scientific and technical documentation in the centres to be created in the future.

22. Some of the main reasons in favour of the latter action are:

(a) Information centres are an expensive enterprise. In 1954 - and costs have increased considerably since - for its first year of existence as an exclusively national institution, the Scientific and Technical Documentation Centre in Mexico was budgeted at $60,000. During the previous thirty-three-month period, when this Centre was established and operated jointly by the Mexican Government and UNESCO, more than $220,000 was spent. This sum does not include the value or rental of the building in which the centre was located. Such figures show that the establishment of these services may raise a number of financial difficulties in small countries, even if they receive assistance from UNESCO or some other international organization. A regional project, involving several neighbouring countries, might, then, provide a convenient solution. If the creation of a centre already engenders financial difficulties, it is easy to see how unrealistic it would be to establish two separate information centres, one devoted to scientific data and the other to technical information;

(b) Even a small scientific and technical documentation centre requires a specialized staff, which is not always easy to recruit. This especially concerns the director and senior staff of the centres, who should be scientists or engineers, or at least people with good scientific or technical backgrounds. In areas where centres are created for the first time, collecting and distributing scientific and technical information does not exist as a career; and scientists and engineers, especially men, hesitate to choose a new specialization without any clear indication of the future openings in what appears to them an unknown profession. Furthermore, the salaries offered in these posts, particularly to young scientists, are often inadequate; in some cases, administrative regulations, and in others, the low estimation in which the new activity is held are responsible for this. Senior scientists are still more reluctant to give up well-established positions. The difficulties in recruiting staff for the information centres are great enough among scientists, but they are greater still in the different engineering branches, where the shortage is almost general in all countries.

23. Another problem concerns staff training. The UNESCO missions have carried out the training of the staff of the centres at all levels and in all the specialities. In general, this has been done by in-service training, plus, in some cases, specially organized courses for the staff. As already said, this training is completed for senior staff members by studies abroad, through fellowships allocated by UNESCO.

24. Individual or collective training has also been organized for scientific documentalists and science librarians, other than the staff of the centres. This

activity has been of special interest in countries where, owing to material and financial difficulties, documentation or even library training schools do not exist. Regional introductory courses on scientific documentation have been useful in awakening the interest of potential documentalists and showing the way for their development and training through practical work.

25. These courses continue to be organized in different areas, under the direction of local and foreign experts, with the technical and financial assistance of UNESCO. In 1963 courses were held at the Cairo and New Delhi Centres; in November 1964 a course will be held in Buenos Aires. The centre in Brazil regularly organizes general and specialized courses in scientific documentation, open to trainees from Latin American countries.

26. Similar courses might be organized in the existing centres for training technical information staff. The necessary equipment, publications, and materials exist already in the centres. Supplementary specialized instructors might be appointed according to needs.

27. Owing to the scarcity of engineers available for documentation tasks, technical-industrial training for the documentalists and other specialized staff of new centres might be envisaged in some cases. This could be done in close collaboration with appropriate national or international industrial bodies.

<u>Conclusion</u>

28. If, at the end of this brief survey, some conclusions need to be drawn, they might be put as follows:

(a) Governments and appropriate institutions in the developing areas should be encouraged to establish and develop scientific and technical documentation centres, either national or regional; 2/

(b) The already existing scientific and technical documentation centres should serve as a basic nucleus for the subject of scientific and technological information to industry;

(c) Centres to be created should be devoted to both scientific and technical documentation;

(d) Close liaison should be maintained among national and international bodies interested in these matters, especially in the creation of new institutions and in the best possible utilization of the existing ones.

29. This seems the best way to ensure the judicious employment of talents, efforts and funds, which are especially precious because they are rare, and still insufficient, in face of ever-increasing needs.

2/ The International Conference on the Organization of Research and Training in Africa in relation to the Study, Conservation and Utilization of Natural Resources (CORPSA), organized by UNESCO in Lagos from 28 July to 6 August 1964, recommended the creation of at least three regional scientific and technical documentation centres in Africa.

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