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ABSTRACT

This collection of papers is the third of three volumes presenting the proceedings of the United Nations Interregional Seminar on the Employment, Development and Role of Scientists and Technical Personnel in the Public Service of Developing Countries (Volume I, Report of the Seminar; Volume II, Country Papers; and Volume III, Technical Papers). Contained in this volume are these eight papers: (1) Career Planning and Career Development of Scientific and Technical Personnel, Including Improvement of Their Managerial Skills; (2) Role of Scientific and Technical Personnel in National Development, Within the Framework of the Public Sector; (3) National Science Policies Affecting Career Status and Working Conditions of Scientific and Technical Personnel in the Public Sector; (4) Policies and Programmes to Increase and Improve Motivation, Creativeness, Leadership and Other Factors Basic to Effective Performance of Scientific and Technical Personnel in the Public Sector; (5) Development and Administration of Public Personnel Systems to Ensure Maximum Effectiveness in the Recruitment, Orientation, Placement, Promotion, Retention and Remuneration of Scientific and Technical Personnel; (6) Improvement of Management in National Civil Service Systems Having Significant Numbers of Scientific and Technical Personnel; (7) Some Major Issues in Role, Employment and Development of Scientific and Technical Personnel in Public Service; and (8) Health Manpower Planning. (PR)

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REPORT OF THE UNITED NATIONS INTERREGIONAL SEMINAR ON THE EMPLOYMENT, DEVELOPMENT AND ROLE OF SCIENTISTS AND TECHNICAL PERSONNEL IN THE PUBLIC SERVICE OF DEVELOPING COUNTRIES

TASHKENT, UNION OF SOVIET SOCIALIST REPUBLICS
1-14 OCTOBER 1969

Volume III: Technical papers

UNITED NATIONS

Department of Economic and Social Affairs

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NOTE

The proceedings of the United Nations Interregional Seminar on the Employment, Development and Role of Scientists and Technical Personnel in the Public Service of Developing Countries, held at Tashkent, Union of Soviet Socialist Republics, from 1 to 14 October 1969, are published in three volumes, as follows:

Volume I: Report of the Seminar

Volume II: Country papers

Volume III: Technical papers

The papers contained in this volume are presented in the language in which they were submitted and have been shortened to provide basic data only. Editorial changes have been made to ensure the continuity of the texts. Opinions expressed in signed papers are not necessarily those of organs or Members of the United Nations.

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

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CAREER PLANNING AND CAREER DEVELOPMENT OF SCIENTIFIC AND TECHNICAL PERSONNEL, INCLUDING IMPROVEMENT OF THEIR MANAGERIAL SKILLS

Geormbeeyi Adali-Mortty*

The career environment

It may be argued with some justification whether, in the context of the enormous development problems of Africa, priorities are not being mixed up when so much attention is devoted to such a relatively peripheral factor of economic and social growth as the employment and development of scientists and technical personnel, that is to say, to the apparent relegation of middle-level and lower-level manpower to a subordinate degree of emphasis.

There is a question whether there is a danger of placing unwarranted emphasis on advanced training in sophisticated skills at the level of higher institutions of learning and technology to the detriment of education and training at lower levels. This question, which is soon to be dismissed in this paper, does need to be put, if one is to examine the issues raised by this interregional seminar with a sense of proportion and in their proper perspective.

It has been observed by one author that the results of a series of studies conducted in countries of Africa for the purpose of determining the countries' requirements for skilled manpower show that the current capacity of the economies of the countries to absorb new university graduates in any year does not exceed 1 per cent of the number of young people reaching the age of twenty-one in the year in question. 1/ This author explains that a number of reasons account for the low absorptive capacity, the relative cost of educated people in the developing countries of Africa and the high expectations of this class of Africans being two of the reasons. University graduates look down on secondary school teaching; and those who obtain secondary school certificates scorn taking up primary school teaching, or being agricultural assistants or nurses. For one thing, while it costs the United States of America less than 1 per cent of its national income to provide universal primary education, it would cost Nigeria in excess of 3 per cent of its national income to provide this basic education.

With 9 per cent of national income (not including defence) the United Kingdom of Great Britain and Northern Ireland and the United States of America have been able to offer "excellent administrative services - education, health, roads, etc." To provide less than half of these services, most countries of Africa need to spend much more than this percentage of national income.

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1/ W. Arthur Lewis, Some Aspects of Economic Development (Accra-Tema, Ghana Publishing Corporation, 1969).

The comparative rate of absorption of university graduates in the United Kingdom is 8 per cent; in the United States of America, 30 per cent and in Nigeria less than 1 per cent of the age group. The following observation has been made in this connexion:

> "One major difference between the United States of America and the developing countries is the apparently unlimited American capacity to absorb the products of schools. In the southern regions of Nigeria where only three per cent of children finish secondary school, unemployment of secondary school leavers is already causing concern, as it has done for years in India, where only ten per cent of children customarily finished secondary school..." 2/

What has been said of the United States of America in the matter of absorptive capacity is even truer in the centrally planned economy of the Union of Soviet Socialist Republics. Equally true is the situation of Nigeria with respect to capacity to absorb the small number of persons finishing its elementary and secondary schools applies also for Ghana and for other countries of Africa. This being so, the question arises whether the developing nations of Africa should abandon the twentieth century concept of social justice as expressed in terms of the right of each child to equal opportunity whether these societies should revert to the situation that existed in the early days of development of education in Western Europe, when primary education was a privilege reserved for the children of a few families and further education was, as it were, rationed to meet the narrow needs of clerical and administrative skills. One may ask whether any politician, even the conservative or semi-feudal rulers in African today could continue to stem the tide of rising expectations of the people with regard to equal opportunity for universal, formal education.

The dilemmas make a choice difficult - whether, because lack of knowledge is the cause for poor countries remaining poor, to expand education, thus, at the same time, satisfying expectations for social justice; or whether to plan expansion on basis of need, that is to say, on the basis of what a country can afford and can absorb. Thus, one comes face to face with the vexing question of priorities in social and economic development. Ascertainment of priorities is, of course, a function of planning.

Sincethe Second World War, it has become the vogue for Governments in developing countries to draw up development plans and even to set up organizations to take care of manpower planning. Enthusiasm for planning is matched only by the disastrous failure, invariably, of the plans.

Relevant though it is to take note at this stage of the causes of failure of such plans, it is enough to say here that in many countries of Africa, the establishment of manpower planning bureaux is too recent to make any significant impact on educational and training policies and programmes. The considerable achievement of Ghana in the development of education, as in other countries of Africa, has been attained in spite of, rather than because of, any objective projections, forecasts, plans or programmes. Before leaving the matter of

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2/ Ibid.

development plans, inescapable though planning will continue to be, mention must be made of the atmosphere of scepticism that surrounds it. In the absence of the essential variables for planning, such as administrative and organizational expertise, control of capital and of promotion of autonomous domestic saving, centralized control of business and industry, and availability of statistics and personnel, it is to be expected that manpower planning is generally rudimentary.

Notwithstanding the high quality of the report on the first national manpower survey in Ghana (1960), as well as the possibilities that the report discloses, the difficulties under which the survey was conducted were immense. The following paragraph sums up the problem: "When this Survey was undertaken, no statistics on labour had been published for 1959 and the 1960 Census of Population was just starting. Therefore, in the absence of up-to-date figures, the 1958 Labour Statistics were used as the basis for planning the Survey coverage." 3/

It is not surprising that the idea of central planning in a setting of a command economy and organizational expertise, as exemplified by the Union of Soviet Socialist Republics, exists only as a source of disillusionment rather than a source of inspiration for Africa. No country of Africa has anything like the tzarist past experience, nor the discipline to operate total planning with efficiency and honesty, and the patience to postpone consumption to some future time. As conditions are in almost every country of Africa, with the possible exception of Guinea, government planning can be only in the public sector. In a mixed economy, decisions and policies cannot be made for private enterprise. Nor can central planning really plan for them. The most that development plans can do for the private sector is to provide it with the necessary infrastructure, services, utilities and institutional framework to stimulate autonomous development in the sector.

Under the constraints of foreign exchange resources, the Government's exchange control system turns out to be, in effect, the most powerful source of economic control. By these means, the Government makes decisions on the allocation of the limited exchange resources thus, the Government makes the decisions concerning priorities and the canalization of resources to the desired priorities, de facto.

Enough has been said to provide a background for a realistic study of the seminar theme - the employment, development and role of scientists and technical personnel in the public service of developing countries. The moral that would appear to emerge is not necessarily that, at the current level of development, scientists and technical personnel should not be produced, employed and developed as a continuous operation. Rather, there is need for balance in this respect. No elaborate statistical data are needed to establish the truism that the human mind has brought about economic progress. To raise the level of education in any country requires even higher knowledge on the part of the educators. If the African farmer produces only 7 instead of 30 hundredweight of maize, or if half the calves born to his cows die within the first eighteen months, the cause is lack of knowledge.

3/ Survey of High-Level Manpower in Ghana (Accra, Government Printer, 1961).

/...

Basis of career planning

Career planning and development begin with the recognition and ranking of manpower needs. On the basis of past performance and current showings, estimates of tomorrow's skill needs are made. Such estimates are, of necessity, projections made under assumptions of future growth of skill-utilizing operations and of expansion of intake of categories of skills.

Hitherto, manpower needs and priorities have been determined on an ad hoc basis. They were no more than "guesstimates", that is, attempts at rational and objective projections of manpower requirements for future years are quite recent. As a result of the newness of this form of planning on a national scale, methodology, systems and programmes of manpower planning are still experimental. As the free enterprise, developed economies are in far less need of national manpower planning than are the developing countries, there are no patterns - no methods - of proved efficacy by which to test and measure practice. It is arguable whether the planning experience of the centrally planned, developed economics is applicable to developing countries with mixed or centralized economies.

Many countries of Africa, however, like their counterparts in Asia, have established national manpower planning agencies. For example, in the report on the 1960 national manpower survey of Ghana, the need for a manpower bureau is made clear. The report urges that such a bureau should be set up and should proceed to formulate manpower policies, programmes and a comprehensive manpower development plan to serve as the operating agency of the Government for all public organs and training institutions concerned with manpower. In fact, the report asserts that the resulting manpower guidelines should influence the award of scholarships and the ranking of priorities among the various personnel categories, the scarcest of which, at the time, were medical and health personnel, engineering and technical personnel, agriculturalists and secondary school teachers.

In connexion with the occupational projections for the period 1960-1965, the report states:

> "The presence in Ghana of scores of expatriate professional and scientific personnel attests to the shortage of trained Ghanaians in these high-level occupations. The Government is overcoming these shortages by the establishment of the two colleges and by the adoption of an extensive local and overseas scholarship programme. These are now beginning to bear fruit and, in the next five years, Ghana will be producing sizable numbers of engineers, doctors, lawyers, physical and social scientists and other professional personnel." 4/

4/ Ibid., p. 29.

The total labour force of Ghana in 1960 is reported to have been distributed as follows:

Non-farming	293,000	
Estimated employment in agriculture a/	586,000	
Total labour force	879,000	
		Percentage
High-level occupations	58,000	20
Unskilled labour	235,000	80
Total non-farming labour	293,000	100
High-level occupations included in survey	54,000	92
High-level occupations not included in survey	4,000	8
Total high-level occupations	58,000	100

Source: Survey of High-level Manpower in Ghana (Accra, Government Printer, 1961).

a/ Not included in survey.

The manpower profile of Ghana in 1960 that emerged from the survey findings serves more as a model for subsequent surveys and as being representative of those countries of Africa which have been able to afford some efforts in manpower programming.

Concerning the existence of large and increasing unemployment, on the one hand, and shortage of strategic skills, on the other, the Nigerian Federal Minister of Economic Development states that Nigeria "suffers from an acute shortage of most of the scientific and technical skills which are vital to establish and ensure the success of a modern economy". 5/ In the Minister's opinion, therefore, programmes for manpower development and training "must accordingly constitute major considerations in any effective system of economic planning". 5/

The list of national science policy planning institutions in Africa given in annex II to this paper illustrates the popularity of the idea of economic and manpower planning.

5/ Nigeria, National Manpower Board, Manpower Situation in Nigeria, Manpower studies series, No. 1 (Lagos, 1963), preface.

Output of scientists, engineers and other technical personnel from institutions of higher learning

There are two major problems in connexion with the production of high-level skills by national and oversea institutions of higher education and training. First, there exists an imbalance in the matching of supply with demand, largely owing to inadequate determination of skill requirements for future years. This is a result of organizational gap. The result of the imbalance appears in the form of over-supply of certain skills and shortage of other skills for which there is active demand in the labour market. If the problem is not remedied by better forecasting and more rational application of limited resources, it will tend to have a multiplying effect on middle-term and long-term manpower needs. Secondly, there is a lack of a firm policy as to whether (and if so, to what extent), education should be oriented towards development needs.

What job-oriented education means within the context of the developing economies of Africa is clearly described in a publication prepared by the United States Agency for International Development under a contract with the Nigerian Government:

> "By employment-orientation we mean a system which is geared to the realities and needs of the labour market. Due recognition must be made of early school termination by most children and the very limited absorptive capacity of the high productivity sector of the economy. Such an employment-oriented educational and training system assigns to formal educational institutions primary responsibility for the general education needed to produce responsible citizens and trainable workers. The employing sector takes major responsibility for providing specialized occupational training. By providing this training close to, or at the point of employment, (either through in-employment training or through formal occupational training closely linked to employer demands) the supply of and demand for trained manpower can be more easily regulated and adjusted." 6/

From the statistical tables provided in the annexes to the present paper, based on the employment situation in Ghana and some other countries of East and West Africa, it will be seen that the local educational institutions have not caught up with the manpower requirements of those countries. But it should be stressed that it is only a matter of time before output catches up with demand, in absolute terms. The more difficult problem is that of planning and programming in such a way that effective co-ordination will exist between manpower development agencies and economic development planners. If educational planners are to take their guidelines from economic development planners, then both had better be organizationally adequate. Meanwhile, planning or no planning, determination of the needs of the labour market or no, public financial sponsorship of education through scholarship awards and bursaries is a form of control of the type of training that educational institutions provide. Such financial awards do have directive controls of the types of disciplines and courses that student

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6/ United States Agency for International Development, Nigerian Human Resource Development and Utilization (New York, Education and World Affairs, 1967).

beneficiaries pursue. Such controls have an underlying presupposition that the sponsoring authority knows what the labour market requirements are. The question is whether it really does.

International co-operation in the promotion of research and training in Africa

The specialized agencies of the United Nations, notably the International Labour Organisation (ILO) and the United Nations Educational, Scientific and Cultural Organization (UNESCO), have a proud record of achievement in the promotion of manpower training and development, and the stimulation of scientific activity in tropical Africa.

Some of the critical precursors of international co-operation in the matter of research and training are as follows:

(a) General Assembly resolution 1219 (XII), which recognizes the need for international focus on the field of public administration and the importance of training institutes as areas for technical assistance;

(b) The United Nations Conference on Science and Technology for the Benefit of Less Developed Areas, which was held at Geneva in February 1963. That Conference was reportedly the first time that scientists, engineers and technologists from over one hundred nations assembled to discuss the role of science in development;

(c) The Lagos Conference on Organization of Research and Training in Africa in Relation to the Study, Conservation and Utilization of Natural Resources, 7/ which addressed itself to fundamental questions of organization and planning: national scientific policy; organization and implementation of policies for research on natural resources; scientific and technical personnel; finance and research economics; international co-operation. By focusing attention on action areas in which national programming could subsequently be done, the Conference's usefulness, judged by results reported at the Yaounde Symposium, must have exceeded by far expectations of the sponsors and the participating countries;

(d) The Yaounde Symposium on Science Policy and Research Administration in Africa (10-21 July 1967), which was held under the auspices of UNESCO as a part of its series on science policy. It was the first meeting of its kind to be held in tropical Africa. Its purpose was "to hasten the establishment of governmental science policy structures, as well as to increase the efficiency of existing scientific institutions". Because it crystallizes national scientific objectives and programmes, thus tending to give these some order and system, the report of the Symposium 8/ has special relevance for the theme of the present interregional seminar. It was observed at the Symposium that scientific activity, just as the

7/ The report of the Lagos Conference was published by the United Nations Educational, Scientific and Cultural Organization (Liége, 1964).

8/ United Nations Educational, Scientific and Cultural Organization, The Promotion of Scientific Activity in Tropical Africa, UNESCO science policy studies and documents, No. 11 (Paris, 1969).

case with economic activity, provided opportunities for the end-use of scientific and technical personnel. The country papers submitted to the Symposium, which outline the stage of national organizations in science and research, and the programmes contemplated and in existence, make promising reading. Some of the data reported serve as objective indicators of the level of development attained by the participating countries.

Problem of technical and academic obsolescence

In the environments of technologically disadvantaged countries, where exposure to modern advances in knowledge and technology is slight, if existent and where there is an absence of lively academic atmosphere of learned debate, discussion, publications and library facilities, a relapse into virtual semi-literacy is not only possible, but very real indeed. This is even more the case for scientists, engineers and technical personnel. Lack of application in technologically well-equipped settings and lack of demanding practice tend to diminish technical competence. In his contribution to the journal of the Ghana Institution of Engineers, a Ghanaian engineer defined "technical obsolescence" as a condition in which "technology out-distances the capabilities of engineers who have been out of school for some time and have not had the opportunity of keeping themselves technically informed and near abreast with developments in their fields of specialization". 9/ It may be seen that the problem of keeping abreast with change and modernization concerns not only the upgrading of qualifications, but the updating of knowledge and skills. This matter is related to the question of professional standards.

The most desirable form of policing professional standards is that which is self-imposed. Self-respecting professional associations realize this fact, and of their own accord, or under pressure from the larger society of which they are a part, draw up codes of behaviour and standards by which their professional performance shall be measured.

In realization of this fact, the Ghana Institution of Engineers was formally established on 1 June 1968. Among its declared objectives are the maintenance of professional standards, the encouragement of research, the dissemination of publications and new ideas, and the safeguarding of the welfare of members. Other informal ways by which professional interests and standards can be served include the publication of technical journals and the exchange of these with similar professional bodies elsewhere.

In technically deprived communities such as the developing countries of Africa, professional bodies like the Ghana Institution of Engineers can help their Governments to reduce expensive importation of foreign experts by demonstrating local competence and responsibility through voluntary offers of consultancy service on given national technical problems and by overseeing the conduct and performance of indigenous professional firms.

9/ M.N.B. Ayiku, in The Ghana Engineer (Accra), Vol.1, No.1 (1968), pp.31-34

Availability to serve on national bodies or State organs and, the organization of seminars, symposia and conferences are other obvious ways of self-improvement on the part of members of professional organizations, particularly when participants in such meetings are required to submit special papers on given subjects, or when reports on research or occupational experiences are read.

Communication between professional colleagues within Africa, and even within national boundaries, does constitute special problems. If ideas could flow freely among members of the professions and if common efforts were pooled on regional or international levels, efficiency would rise and some economy in the use of resources could be achieved.

Upgrading of qualifications of serving officers

Despite the fact that free, universal (and compulsory) education at the primary and secondary levels remains an ideal to be worked for in most countries of Africa, post-graduate training is usually tax-supported. This is certainly the case in Ghana. People are encouraged to take up pure and applied sciences and agriculture. Scholarships are available for university courses overseas, provided these are not available in Ghana. These courses include dentistry, forestry, veterinary medicine and mining engineering. Selections are made in accordance with regular public service procedures. Successful candidates are then sponsored from the training votes of the departments in which the candidates serve and to which they will return.

As a result of official stringency in the allocation of limited foreign exchange resources, private students whose sponsors can afford the cost of training overseas are not normally permitted to travel abroad for education, with the exception of those in certain fields, such as nursing, where trainees earn allowances for their maintenance in the host country's currency.

Supplementary to the efforts of countries of Africa in meeting the cost of education and training locally and abroad, various foreign Governments provide educational awards in mutually agreed fields. In Ghana, such foreign awards are increasingly being made for certain strategic post-graduate programmes.

In addition to the more orthodox educational facilities, such as colleges, schools and universities, a number of countries of Africa have supplementary institutions for relatively less formal development of skills and knowledge of personnel in the Public Service and the private sector. Two such institutions in Ghana deserve mention. One is the Institute of Public Administration, established by the Government of Ghana in association with the United Nations Special Fund and situated in Accra, the capital of Ghana. The Institute provides pre-entry induction and preparation to newly recruited senior staff for the Public Service. It also recalls serving officers for further training in specific skills and fields. It presents lectures on general subjects and conducts seminars and conferences. The Conference on Research and Consultancy in Public Administration in Africa (January 1966) 10/ was attended by pa ticipants from seven African countries - Ethiopia, Ghana, Liberia, Niger, Nigeria, Somalia and Sudan.

10/ In this connexion, see Institute of Public Administration, Research and Consultancy in Public Administration in Africa (Greenhill, Achimota, 1966)

The Ghana Institute of Public Administration is being expanded to incorporate a staff college which will be known as the College of Advanced Management. It will cater for the development of top executives and policy-makers in the hierarchies of the Civil Service, public corporations, the armed forces and private enterprise.

The other institution operative in manpower development outside of the regular educational stream is the Management Development and Productivity Institute, 11/ a management consulting and training agency. It was established in 1967 and has the support of the United Nations Development Programme and the International Labour Office. Among other functions, the Institute has organized training courses, conferences and seminars for personnel from all sectors of industry in Ghana, covering such fields as general management, industrial engineering, financial and management accounting, marketing and sales. It provides consultancy to business and industry, and conducts special studies into problems of business in the country.

Question of remuneration for professional expertise and services

Questions of equity in relation to other professional classes and of how to reward certain professional groups in short supply in order to attract talent into the said professional training programmes present numerous difficulties in every country of Africa. The situation in Ghana, not being unique, should serve to represent the over-all problem.

One may assume, for purposes of argument, that the ideal determinant of professional remuneration is that which the price mechanism of the open market dictates, given free play of the laws of supply and demand. In such an environment, prices seek and find their own level, including the price of expert service. Even under those conditions, there is bound to be a lag between what an expert earns for service and what the price mechanism would settle for at any given time. In this respect, reward for service as a price differs from the price of material commodities, which fetch what the market will bear at the time of purchase. If this is true in the private sector, it is even more so in the public sector. Even under conditions of imperfect competition, prices in the private sector respond more promptly to the market than those in the rather relatively sluggish public sector. What is more, the built-in mechanism of accommodation to the realities of economic factors - for example, ability to pay - which one finds in profit-oriented operations are generally lacking in public employment. In the Public Service, if the revenue cannot bear the cost of administration, so much the worse for the taxpayer who must pay more in taxes to meet the budget gap. It is not the efficiency of administration, as such, that dictates the increases.

Given a condition of the open market in a private enterprise, the relationship of one scale of salaries and other incentives received by a class of professional personnel to that received by another class of professional

11/ See Management Development and Productivity Institute (Accra-Tema, 1968).

personnel is arrived at through the operation of the market competition for the particular classes of professionals. In the Public Service, on the other hand, the relativities must be determined by the management. Since the variables to be used in the evaluation of positions and in the ranking of various posts is necessarily arbitrary, human error is inevitable. No way has been found to equate classes of professional expertise. The situation with respect to the determination of remuneration for the categories of professional personnel with which this paper is concerned is as set forth in the Report of the Commission on the Structure and Remuneration of the Public Services in Ghana (see annex VI).

As against the official presentation of the situation concerning the remuneration of engineers, scientists and medical practitioners, the remarks of a Ghanaian engineer, concerning conditions of employment of engineers in the Civil Service, are of interest:

"Ghanaians by nature are very sensitive to incentives and tend to aim at attaining levels with the highest incentives. In this connexion it is interesting to note that the newly established Ghana Medical School will turn out about forty graduate doctors next year. This is far more than the total number of engineers produced by the University of Science and Technology within the first nine years of its existence, and it will certainly be more than the number which Kumasi will turn out next year. It is again worth noting that the Faculty of Law of the University of Ghana turned out thirty-one graduate Lawyers. The above situation is obviously due to the fact that the training of an Engineer is both rigorous and exacting and the practice painfully unattractive in pay and terms of service.

"Recommendations

"In order that we might look forward to a more prosperous future for Ghana, it is important to devote more resources to the training and utilization of engineering manpower. The following recommendations, if seriously considered and implemented, will go a long way in improving the situation:

"(a) The planning, design and execution of projects with high engineering content should be managed such that Ghanaian Engineers (including the young) are identified with these projects to ensure that there is a sense of decisive purpose and something worthwhile and challenging to work for. This will also induce Engineers to keep up to date.

"(b) University of Science and Technology must be given every assistance in expanding and updating their facilities for training of Engineers.

"(c) The Government must be more willing to involve Engineers in national issues by ensuring that on all technical matters and at all stages the Ghana Institution of Engineers is not only consulted but invited to participate in the discussions.

"(d) The Government should not discriminate against Doctors and Engineers, as compared, for example, to Lawyers in pay and terms of service. Medicines and Engineering are rigorous disciplines, and young men and women need to be encouraged to undertake them. The Government, as the principal employer, must use its pay scales as market incentives to direct the flow of talented people where they are most needed.

"(e) Probably, the most important suggestion is that the Ghana Institution of Engineers must identify itself more fully with political, sociological and economic matters with high technological content and thereby ensure that its professional advice is recognized at the highest councils of state.

"(f) Engineers must be engaged in managerial positions in factories and other industrial establishments. The need for this has been recognized in industrially advanced countries.

"(g) Professional Engineers must be employed in organizations that need them /sic/, for example, Ministries of Industries, Works, etc." 12/

To illustrate the above-described situation of engineers in Ghana, the salary scales for lawyers, medical doctors and engineers as of June 1968, as well as a graph of the progression of these personnel in the Ghana Civil Service, are given below.

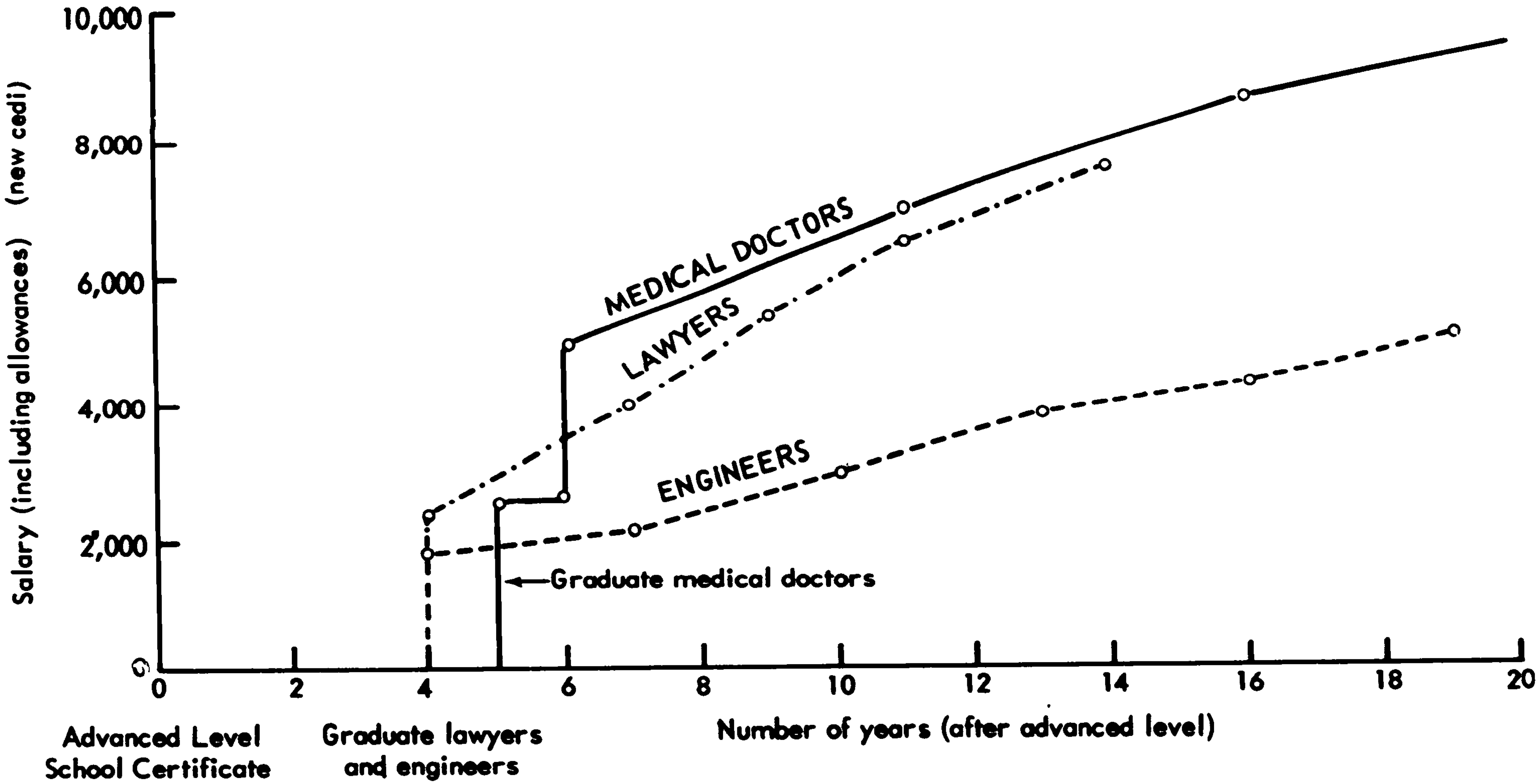
12/ Ayiku, op. cit.

Table 1. Salary scales for lawyers, medical doctors and engineers in the Ghana Civil Service, June 1968

(New cedi)

Legal officers	Salary scales	Medical doctors and dentists	Salary scales	Engineers	Salary scales
Assistant State Attorney	2,400 - 3,000	Houseman	2,580	Assistant Engineer	1,840 - 1,960
State Attorney	4,000 - 5,000	Medical Officer	4,968 - 5,484	Engineer	2,080 - 2,640
Senior State Attorney	5,900	Medical Officer	6,904 - 8,320	Senior Engineer	2,940 - 3,540
Principal State Attorney	6,100	Deputy Director/ Regional Medical Officer	8,652 - 9,372	Assistant Engineer-in-Chief	3,900
Chief State Attorney	6,500	Consultant	9,152 - 9,872	Deputy Engineer-in-Chief	4,300
Director of Prosecutions	7,000	Director	9,564 - 10,404	Engineer-in-Chief	5,000
Chief Parliamentary Draftsman	7,000				
Solicitor-General	7,200				

Progression of engineers, lawyers and medical doctors in the Ghana Civil Service



Note: Based on data available as of June 1968

Loss of trained personnel

Of the several causes of loss of personnel - death, retirement, failure to keep up-to-date, emigration and low productivity (known also as under-employment) - the most serious, in terms of the categories of skills under consideration here, are the last three. Passing reference has been made to the dangers of intellectual "rust", that is, failure to keep up-to-date with scientific and technological developments, and of the problem of doctors trained abroad refusing to return home upon completion of their training.

The size of the problem of outflow of trained personnel from developing countries has been effectively delineated in a report by the Secretary-General of the United Nations. 13/

For developing countries, the problem of "brain drain" is serious not in terms of the absolute number of emigrant high-level personnel, for the numbers are small, but rather in terms of the strategic or critical skills that are skimmed off. Critical skills are thinly spread. To train a medical doctor overseas costs from L4,000 to L6,000. Those specialists who emigrate are usually engineers, medical personnel or scientists - categories of personnel of which scarcely any of the developed countries, with the possible exception of the Union of Soviet Socialist Republics, have sufficient supply. Other categories of scarce personnel lost to developing countries are administrators, economists and agriculturalists. Of this group, some leave to take up employment with international agencies; and while the number of such international employees is even smaller than those otherwise lost, their loss to national development is unfortunate. This is not to say, however, that had they remained in their posts in their home countries. they would have been given an opportunity to utilize their expertise to the fullest degree. As an exponent of the Ghana Scholarships Secretariat stated recently, "For professional men, Ghana [and that goes for other developing countries too] in the foreseeable future, even if she strains her economy to pay world-market salaries, cannot provide the conditions of work, the equipment, the infrastructure that exists in the affluent countries where the students have been trained".

Remedies can be found only through a clear appreciation of the hard facts of the economic and social factors that are underlying causes of intellectual and technical exodus, much as a medical doctor's treatment and prescription are preceded by the diagnosis.

Appeals to conscience and to a sense of patriotism are wholly beside the point. As a former Special Commissioner for Redeployment of Labour in the Government of Ghana, the author became well aware of the problem of misuse and under-use of high-level manpower. Such specialists are either given jobs that are not sufficiently challenging, or are placed in office posts when they should be active in the field, or are assigned to posts having requirements that are not remotely related to their qualifications.

13/ Official Records of the General Assembly, Twenty-third Session, Annexes, agenda item 47, document A/7294. See also documents E/4483/Add.1 and E/4483/Add.2.

Other conditions that are frustrating to talented, high-level personnel in developing countries are those concerning the virtual non-existence of capable support staffs and technicians, without whom high-level personnel become rather impotent. Add to this the shortage of well-trained supervisors; productivity is depressed because the importance of supervision is not sufficiently recognized. These are factors that cannot be overcome by an appeal to national consciousness or to a sense of mission.

Conclusions

Important though the role of the State may be in providing the avenues and conditions favourable for the career prospects of scientists and technical personnel in the Public Service, the onus of bringing about a recognition of the career needs of scientific and technical personnel, and the crucial contribution that these professional categories can make to national development rests on the professional associations themselves. Members of the professions must organize themselves. Having done so, they must then bend their efforts to the raising of their professional status in the community. Respect for individual professions is a function of their collective quality of performance and service in their home societies. High salaries, in themselves, will not engender social respect or acceptance; high standards of technical qualifications and of service are the secrets of success.

ANNEX I

SURVEY OF HIGH-LEVEL MANPOWER IN GHANA

Table 2. Employment, by group and by occupation, 1960

	Number reported employed as of March 1960		Vacant posts 1960	
Professional group				
Architects and town-planners (0-01)		49		13
Engineers (0-02)				
Civil engineers (0-02 02-22)	234		70	
Electrical engineers (0-02 24-36)	84		20	
Mechanical engineers (0-02 38-58)	181		25	
Chemical and metallurgical engineers (0-02 60-72)	5		-	
Mining engineers (0-02 74-82)	42		-	
Total engineers a/		546		115
Law officers (L-81) b/		33		2
Editors (0-92)		62		2
Accountants (0-Y110)		391		33
Social scientists				
Economists (0-Y420)	10		3	
Statisticians (0-Y440)	9		4	
Sociologists (0-Y920)	7		-	
Total social scientists		26		7
Physical scientists				
Chemists (0-11)	12		6	
Geologists (0-19, 30)	13		34	
Other physical scientists	13		-	
Total physical scientists		47		40
Biological scientists				
Botanists (0-22, 20)	19		2	
Zoologists (0-22, 30)	12		3	
Total biological scientists		31		5
Medical doctors		310		161
Dentists		16		5
Pharmacists		300		27
Agriculturalists (professional)		167		22

ANNEX I (continued)

		Number reported employed as of March 1960		Vacant posts 1960
Teachers				
Primary and middle schools	12,900		-	
Secondary schools	700		200	
Technical Institute	181		30	
Teacher Training College	348		25	
University College staff	142		-	
Kumasi College staff	74		-	
Total teachers		14,345		255
Librarians (0-Y3)		20		5
Surveyors (0-03)		183		-
Auditors (0-Y1-20)		37		-
Other professionals		10		-
Total		16,573		690
Administrative-managerial group				
Government and local officials (1-01)		1,680		63
Mining, manufacturing, construction, electricity, water-supply etc. (1-11)		881		-
Wholesale and retail trade (1-11)		523		-
Banks, financial institutions (1-13)		370		-
Transport, storage and communications (1-14)		113		-
Service industries (1-15)		59		-
Other industries		403		-
Total		4,029		63
Subprofessional and technical group				
Agricultural technicians		385		-
Draughtsmen (0-X1)		339		-
Engineering and science technicians (0-X9)		1,262		-
Medical technicians		350		4
Nurses and midwives		2,600		-
Engineering and deck officers (ocean transport) (6-01-02)		47		-
Aircraft pilots (6-21)		20		-
Designers		-		-
Total		5,003		4

Source: Survey of High-level Manpower in Ghana, (Accra, Government Printer, 1961), p. 13, table IIA.

a/ Including n.e.c.

b/ Government only.

Table 3. Distribution of senior salaried personnel,[a] by occupational group

Occupational group	Number as of March 1960	Number projected by July 1965	Additional positions	Replacements Losses	Replacements Expatriate	Additional personnel required b/
Architects and town-planners	49	63	14	14	18	46
Surveyors	183	246	63	29	6	98
	232	309	77	43	24	144
Engineers						
Civil	234	330	96	65	65	226
Electrical	84	178	94	19	29	142
Mechanical	181	263	82	49	20	151
Chemical and metallurgical	5	20	15	2	0	17
Mining	42	56	14	11	6	31
	546	347	301	146	120	567
Scientists						
Chemists	21	34	13	5	4	22
Geologists	13	55	42	4	26	72
Other physical scientists	13	14	1	4	6	11
Botanists	19	23	4	4	-	8
Zoologists	12	10	2	4	-	2
	78	136	58	21	36	115
Social scientists						
Economists	10	12	2	3	2	7
Statisticians	9	29	20	2	9	31
Sociologists	7	8	1	1	-	2
	26	49	23	6	11	40

Table 3 (continued)

Occupational group	Number as of March 1960	Number projected by July 1965	Additional positions	Replacements Losses	Replacements Expatriate	Additional personnel required b/
Lawyers c/	33	54	21	4	8	33
Editors	62	101	39	6	-	45
Agriculture, forestry, fishing	167	317	150	20	57	227
Other professionals (e.g., accountants, auditors, librarians)	458	596	138	90	60	288
	720	1,068	348	120	125	593
Administrative-managerial group						
Manufacturing, construction and mining	881	973	92	137	-	229
Wholesale and retail trade	523	624	101	86	-	187
Banking and finance	370	568	198	56	-	254
Transport and commerce	113	133	20	21	-	41
Service industries	59	98	39	7	-	46
Other industries	403	536	133	43	-	176
Government and other officials	1,680	2,219	539	140	31	710
	4,029	5,151	1,122	490	31	1,643
Medical personnel	310	1,210	900	300	125	1,325
Dentists	16	33	17	0	-	17
Pharmacists	300	360	60	10	-	70
	626	1,603	977	310	125	1,412
Total	6,257	9,163	2,906	1,136	472	4,514

Source: Survey of High-level Manpower in Ghana (Accra, Government Printer, 1961), p. 22, table IVA.

a/ Positions requiring university degree or the equivalent.

b/ Including replacements of personnel lost.

c/ Government service only.

Table 4. Employment in 1960 and future projections, by personnel group

Personnel group	Number reported employed March 1960	Projected number required to be employed: As of July 1961	As of July 1963	As of July 1965	Estimated losses 1960-1965	Estimated gross need, 1960-1965 c/: Number	Percentage of 1960 level
Professional							
Architects and town-planners (0-01)	49	62	62	63	14	28	57
Engineers (0-02)							
Civil engineers (0-0202 - 22)	234	309	347	330	65	161	69
Electrical engineers (0-02 24 - 36)	84	121	166	178	19	113	134
Mechanical engineers (0-02 38 - 58)	181	218	264	263	49	131	73
Chemical and metallurgical engineers (0-02 60 - 72)	5	6	20	10	2	7	340
Mining engineers (0-02 74 - 82)	42	51	53	56	11	25	59
Total engineers a/	546	695	850	837	146	437	82
Physical scientists							
Chemists (0-11)	21	29	33	34	5	18	86
Geologists (0-19, 30)	13	47	55	55	4	46	354
Other physical scientists	13	14	14	14	4	5	38
Total physical scientists	47	90	102	103	13	69	147
Biological scientists							
Botanists (0-22, 20)	19	23	23	23	4	8	42
Zoologists (0-22, 30)	12	13	10	10	4	2	17
Total biological scientists	31	36	33	33	8	10	32
Total scientists	78	126	135	136	21	79	101

Table 4 (continued)

Personnel group	Number reported employed March 1960	Projected number required to be employed			Estimated losses 1960-1965	Estimated gross need, 1960-1965 c/	
		As of July 1961	As of July 1963	As of July 1965		Number	Percentage of 1960 level
Professional (continued)							
Law officers (0-81)	33	46	53	54	4	25	76
Editors (0-92)	62	78	92	101	6	45	73
Accountants (0-Y110)	391	441	489	504	82	195	50
Social scientists							
Economists (0-Y420)	10	12	12	12	3	5	50
Statisticians (0-Y440)	9	19	24	29	2	22	244
Sociologists (0-Y920)	7	8	8	7	1	2	29
Total social scientists	26	39	44	48	6	29	112
Other professionals	10	12	12	12	1	3	30
Agriculturalists b/	167	190	250	317	38	188	112
Medical doctors	310	372	450	600	120	410	132
Dentists	16	34	39	47	6	37	231
Pharmacists	300	326	349	380	60	147	49

Table 4 (continued)

Personnel group	Number reported employed March 1960	Projected number required to be employed: As of July 1961	As of July 1963	As of July 1965	Estimated losses 1960-1965	Estimated gross need, 1960-1965 c/: Number	Percentage of 1960 level
Subprofessional and technical							
Surveyors (0-3)	183	225	242	246	29	92	50
Draughtsmen (0-XI)	339	402	434	443	24	128	38
Engineering and science technicians (0-X9)	1,262	1,502	1,686	1,712	224	674	53
Auditors (0-Y1-20)	37	39	41	43	4	10	27
Librarian (0-Y3)	20	28	34	37	3	20	100
Engineering and deck officers (ocean transport) (6-01-02)	47	94	128	131	18	102	217
Aircraft pilots (6-21)	20	22	22	22	6	8	40
Designers	0	0	22	22	0	22	-
Agricultural technicians	385	540	800	1,000	46	661	172
Nurses and midwives	2,600	2,924	3,361	4,100	500	2,000	77
Medical technicians	350	394	481	530	10	190	54
Total	5,243	6,170	7,251	8,286	864	3,907	75
Administrative and managerial							
Government and local officials (1-01)	1,680	2,012	2,139	2,219	140	679	40
Mining, manufacturing, construction, electricity, water-supply etc. (1-11)	881	930	947	973	137	229	26
Wholesale and retail trades (1-12)	523	543	581	624	86	187	36
Banks, financial institutions (1-13)	370	506	480	568	56	254	69
Transport, storage and communications (1-14)	113	127	131	133	21	41	36
Service industries (1-15)	59	76	93	98	7	46	78
Other industries	403	474	505	536	43	176	44
Total	4,029	4,668	4,876	5,151	490	1,612	40

Table 4 (continued)

Personnel group	Number reported employed March 1960	Projected number required to be employed			Estimated losses 1960-1965	Estimated gross need, 1960-1965 c/	
		As of July 1961	As of July 1963	As of July 1965		Number	Percentage of 1960 level
Education							
Primary and middle school	12,900	14,265	16,935	19,250	1,595	9,050	70
Secondary	700	1,000	1,600	2,200	325	1,825	260
Technical	181	212	238	261	45	176	97
Teacher training	348	360	380	398	60	75	21
University College	142	149	149	148	17	23	16
Kumasi College of Technology	74	115	152	159	19	104	140
Total	14,345	16,101	19,454	22,416	2,014	11,190	78

Source: Survey of High-level Manpower in Ghana (Accra, Government Printer, 1961), p. 23, table IVC; p. 24, tables V-1 and V-2; p. 25, tables V-3 and V-4; p. 26, table V-5.

a/ Including n.e.c.

b/ Including forestry officers.

c/ Excluding replacement of 8,000 unqualified "pupil teachers". If it is assumed that "pupil teachers" will be replaced at the rate of 900 per annum for ten years, the requirements for the period 1960-1965 would about equal the expected supply. The introduction of compulsory primary education would require 12,000 additional teachers.

ANNEX II

PROMOTION OF SCIENTIFIC ACTIVITY IN TROPICAL AFRICA

Table 5. National science policy planning institutions in intertropical countries of Africa

Country	I. National science policy planning institution II. National development planning institution	Legal establishment	Date of establishment	Controlling body	Date of first evaluation of scientific and technical potential
Burundi	I. -	-	-	-	-
	II. Ministère du Plan et du développement	-	1964	-	-
Cameroon	I. Office national de la recherche scientifique et technique	Loi fédérale	May 1966	Ministère du Plan et du développement	May 1966
	II. Ministère du Plan et du développement	Décret	May 1966	Président de la République fédérale	
Congo (Brazzaville)[a]	I. Conseil national de la recherche scientifique	Décret	1966	-	-
Ivory Coast	I. -	-	-	-	-
	II. Ministère du Plan	-	-	-	-
Dahomey	I. -	-	-	-	-
	II. Ministère de l'économie et du Plan	-	-	-	-
Ethiopia	I. -	-	-	-	1965
	II. Ministry of Planning and Development	Imperial Decree	1959	-	-
Gabon	I. -	-	-	-	-
	II. Commissariat du Plan	Décret	1960	Ministère chargé du Plan	-
Ghana	I. Ghana Academy of Sciences	Executive instrument	January 1963	Ministry of Education	-
	II. Ministry of Economic Planning	-	-	-	-
Upper Volta	I. -	-	-	-	-
	II. Ministère du Plan	-	1960	-	-
Kenya	I. -	-	-	-	-
	II. Ministry of Economic Planning and Development	-	-	-	-

Table 5 (continued)

Country	I. National science policy planning institution II. National development planning institution	Legal establishment	Date of establishment	Controlling body	Date of first evaluation of scientific and technical potential
Liberia	I. -	-	-	-	-
	II. Department of National Planning and Economic Affairs	Act of legislature	1960	Secretary of National Planning and Staff of Department	-
Madagascar	I. Comité national de la recherche scientifique et technique	Décret présidentiel	1961; reorganized in 1963	Vice-Présidence du gouvernement	1964
	II. Commissariat général au Plan	Décret présidentiel	July 1960	Présidence de la République	-
Malawi	I. -	-	-	-	-
	II. Ministry of Planning and Development	-	-	-	-
Mali	I. Conseil national de la recherche scientifique et technique	Loi	30 January 1967	Présidence du Chef de l'Etat	-
Nigeria	I. Nigerian Council for Scientific and Industrial Research	Federal Government Decree	December 1966	Federal Government of Nigeria	-
Rwanda	I. -	-	-	-	-
	II. Ministère du Plan et de la coopération internationale	Declaration gouvernementale	November 1966	-	-
Senegal	I. Conseil interministeriel de la recherche scientifique et technique	Décret	October 1966	Présidence de la République	-
	II. Ministère du Plan et du développement	-	December 1962	Présidence de la République	-
Togo	I. -	-	-	-	-
	II. Haut Commissariat au Plan	Décret Presidentiel	1964/1965	Présidence de la République	-
Zambia	I. National Council for Scientific Research	Act of Parliament	July 1967	Autonomous	1967
	II. Office of National Development and Planning	Presidential Decree	1965	Government	-

a/ Now known as the People's Republic of the Congo.

ANNEX III

SCIENTIFIC MANPOWER IN GHANA

Table 6. Ghana: estimated number of graduate scientists, December 1966

Biological sciences		
Agriculture		
Agriculture a/	430	
Forestry	34	
Fisheries	14	
Veterinary	15	
Soil science	10	
		503
Medicine		
Medical practice b/	562	
Dentistry	37	
Pharmacy	82	
Ophthalmic optician	12	
Physiotherapy	9	
Other medical specialties	35	
		737
General		
Nutrition, food science and biochemistry	26	
Botany	32	
Zoology	48	
Biology c/	11	
		117
Total biological sciences		1,357
Physical sciences		
Engineering		
Engineering d/	361	
Architecture	46	
Physical planning and design	70	
		477
Earth sciences		
Geology	22	
Land surveys	8	
		30
General		
Meteorology	9	
Chemistry	45	
Physics	72	
Mathematics	48	
		174
Total physical sciences		681
Total all sciences		2,038

Source: Ghana, Report of the Committee of Experts to Advise on the Future of the Ghana Academy of Sciences (Accra, Ghana Information Services, 1967), p. 29.

Note: These data represent only those scientists included in the calendars of the universities in Ghana, the staff list of the senior Civil Service Commission, estimates for the private sector and registers of occupational groups. Scientists employed by specialized agencies of the United Nations, in technical assistance programmes of foreign Governments and by religious bodies are excluded unless listed in the above-mentioned sources.

a/ Including specialists not clearly shown in the sources.

b/ Including specialists.

c/ Including hydrobiology.

d/ Including all types of engineers.

Table 7. Ghana: distribution of scientists by field of specialization, December 1967
(Figures in parentheses indicate Ghanaian personnel)

Scientific field	Sector: General Government	Sector: Higher education	Sector: Business enterprise	Total
Natural sciences				
Physical sciences				
Mathematicians	40 (-)	34 (16)	-	74 (16)
Physicists	37 (7)	34 (16)	1 (1)	72 (22)
Geologists, earth scientists, geophysicists	44 (16)	5 (2)	7 (1)	56 (19)
Chemists	34 (10)	28 (11)	12 (3)	74 (24)
Sub-total	155 (33)	101 (43)	20 (5)	276 (81)
Biological sciences				
Botanists a/	12 (8)	16 (5)	1 (1)	29 (14)
Biologists b/	19 (6)	9 (6)	-	28 (10)
Zoologists c/	36 (18)	19 (3)	-	55 (21)
Nutritionists, food scientists, biochemists	28 (25)	15 (5)	5 (2)	48 (34)
Sub-total	95 (57)	59 (17)	6 (3)	160 (77)
General science graduates and unspecified specialist degrees	347 (108)	-	8 (4)	355 (112)
Group total	597 (198)	160 (60)	34 (12)	791 (270)
Engineering				
Engineers: all types d/				
Group total	291 (153)	62 (37)	262 (126)	615 (316)
Medical science				
Physicians	302 (157)	49 (39)	197 (49)	548 (245)
Dentists	22 (18)	-	11 (11)	33 (29)
Pharmacists (graduates)	20 (20)	21 (13)	8 (5)	48 (38)
Nurses (graduates)	5 (5)	4 (1)	-	9 (6)
Group total	349 (200)	74 (33)	216 (65)	639 (318)
Agriculture				
Agronomists and rural scientists	116 (116)	48 (36)	25 (25)	189 (177)
Forestry scientists	33 (33)	-	-	33 (33)
Soil scientists	10 (10)	3 (2)	-	13 (12)
Fishery scientists	11 (11)	-	-	11 (11)
Veterinarians	11 (11)	4 (3)	-	15 (14)
Group total	181 (181)	55 (41)	25 (25)	261 (247)
Grand total	1,418 (739)	351 (191)	537 (128)	2,306 (1.151)

Source: Peter Nonkoh, "A survey of scientific high-level manpower in Ghana", unpublished manuscript.

a/ Including mycologists and plant geneticists.

b/ Including hydrobiologists.

c/ Including entomologists and parsitologists.

d/ Mainly electrical, civil, mechanical and chemical engineers.

ANNEX IV

DISTRIBUTION OF STUDENTS AT UNIVERSITIES IN GHANA

Table 8. University of Ghana, Legon: number of students enrolled, by course, 1961/62-1965/66

Course	1961/62	1962/63	1963/64	1964/65	1965/66
Arts	340	540	629	786	818
Law (Bachelor of Arts)	68	94	75	96	-
Law (Bachelor of Laws)	-	-	43	41	146
Economics	70	47	75	98	129
Administration (Bachelor of Science)	-	38	92	133	145
Agriculture (Bachelor of Science)	33	42	27	25	42
Science	93	78	93	136	181
Medicine	-	51	71	82	102
Education	33	36	33	-	-
Social administration	30	31	33	37	37
Diploma in nursing	-	-	20	40	44
Licentiate in theology	-	5	8	8	9
Non-degree courses of the Institute of African Studies	-	4	25	70	130
Non-degree courses of the School of Administration	-	183	73	120	145
Special admission	9	8	5	8	5
Special course in law	-	-	24	24	-
Master of Arts	-	14	39	48	36
Education (Master of Science)	-	-	-	1	-
Master of Science	-	3	19	16	9
Research students	6	3	11	5	8
Post-graduate diploma	-	-	2	7	5
Other higher degrees	-	-	-	12	10
Total	682	1,174	1,397	1,793	2,001

Source: Ghana, Report of the Committee to Advise on the Future of the Ghana Academy of Sciences (Accra, Ghana Information Services, 1967), p. 58.

Table 9. University of Ghana: provisional enrolment by faculty 1966/67

	First year	Second year	Third year	Total
Undergraduates				
Arts and social studies				
Special admission	6	1	-	
Bachelor of Arts	368	289	249	
Economics	-	52	75	
Administration	60	46	48	
	434	388	372	1,194
Agriculture (Bachelor of Science)	21	14	5	40
Science				
Bachelor of Science	122	56	46	
Pre-medical	62	-	-	
	184	56	46	286
Law	36	36	35 39 a/	
	36	36	74	146
Medical school		101		101
Post-Graduates				
Arts and social studies				
Master of Arts	10	15	-	
Research	7	-	-	
Diploma	6	-	-	
	23	15	-	38
Science				
Master of Science	4	8	-	
Research	1	-	-	
	5	8	-	13
Agriculture	2	-	-	
Research	1	-	-	
	3	-	-	3
Diplomas and certificates				
Arts and social studies	171	115	49	335
Agriculture	9	-	-	9
Total number of students				2,170

Source: Ghana, Report of the Committee of Experts to Advise on the Future of the Ghana Academy of Sciences (Accra, Ghana Information Services, 1967), p. 59.

a/ Practical.

Table 10. University of Science and Technology, Kumasi: student enrolment, by faculty, 1960/61-1966/67

Faculty/department	1960/61	1961/62	1962/63	1963/64	1964/65	1965/66	1966/67
Agriculture	74	71	59	47	44	51	141
Architecture	79	95	114	125	189	153	200
Fine arts and crafts	22	34	30	51	80	124	136
Engineering	135	204	276	276	321	357	302
Pharmacy	29	22	49	59	86	94	71
Science[a/]	194	228	208	250	379	543	362
Liberal and social studies	-	55	-	-	-	118	88
Total	533	709	736	808	1,099	1,440	1,300

Source: Ghana, Report of the Committee of Experts to Advise on the Future of the Ghana Academy of Sciences, (Accra, Ghana Information Services, 1967), p. 61.

a/ Preliminary science course: Two-year courses in biology, chemistry, physics, mathematics, leading to G.C.E. "A" level; first year = 55; second year = 206.

Degree courses: Four-year courses in applied biochemistry, applied physics, chemical technology, leading to degree of Bachelor of Science:

Course	First year	Second year	Third year	Fourth year
Applied biochemistry	15	9	6	10
Chemical technology	7	3	-	2
Applied physics	29	14	5	-
Total	51	26	11	12

ANNEX V

UNIVERSITY ENROLMENT IN NIGERIA

Table 11. Nigeria: total enrolment in universities, by faculty, 1965/66

University	Arts	Education	Law	Social science	Pure science	Medicine and pharmacy	Technology	Agriculture, forestry and veterinary medicine	Post-graduate	Total
Ahmadu Bello	293	-	52	116	131	-	303	51 a/	10	956
Ibadan	653	272	-	314	563	467	-	224	195	2,688
Ife	239	-	104	72	159	72	-	47	20	713
Lagos	81 b/	-	100	260	152 b/	118	61	-	1	773
Nigeria	395	393	110	718	334	-	295	334	-	2,579
Total	1,661	665	366	1,480	1,339	657	659	656	226	7,709

Source: Nigerian Human Resource Development and Utilization (New York, Education and World Affairs, 1967), p. 65. Data were obtained from the National Universities Commission.

a/ Including one student of veterinary medicine at Ibadan.

b/ Including fifty-two students reading education: arts, thirty-four; pure science, eighteen.

ANNEX VI

ENTRY POINTS FOR PROFESSIONALS IN THE PUBLIC SERVICES IN GHANA*

"341. The very clear and logical rules laid down by a working party on salaries of graduate and professional grades in the Civil Service in 1960 seem to have become obscured over the years. These rules are as follows:

'18. For posts which require a graduate qualification, which may normally be obtained in three years, candidates should enter at the minimum point of the appropriate scale.

'19. We consider that where a post requires post-graduate training as a condition precedent to appointment, a candidate should be granted two incremental credits for every year of such training. Thus where a candidate for appointment is required to have one year's post-graduate training before appointment he should be eligible to receive two incremental credits and enter at the third entry point.

'20. Serving officers who undertake post-graduate or post-qualification training should not, in our view be eligible for the credits recommended in paragraph 19. Such officers will be receiving a salary and earning pension and will be acquiring seniority while undergoing such training. Those who are required to spend additional years to acquire post-graduate qualification lose these benefits by comparison with their contemporaries who enter the Service immediately after graduation. The two incremental credits recommended for each year of necessary post-graduate training are intended to compensate them for this loss.

'21. Where a course lasts more than three years, two increments should be awarded for each additional year. Thus a candidate who enters the Civil Service with a degree which normally requires four years' training, i.e., one year in excess of the normal three-year degree course, would receive two incremental credits and enter at the third entry point.

'22. For those persons who may have obtained a degree or qualification in a University or Institution "outside Ghana the entry point in the relevant scale should be calculated on the length of time the corresponding qualification could have been attained at an institution in Ghana".

"342. We recommend that these rules be applied to determine the entry range for the following types of post: Engineers, Surveyors, Architects, Geologists, Veterinary Officers, Agricultural Officers, Scientific Officers, Forestry Officers, Fisheries

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* Material in this annex is excerpted from Ghana Ministry of Information, Report of the Commission on the Structure and Remuneration of the Public Services in Ghana (Accra, 1967), pp. 52-54.

Officers, Statisticians (First or Upper Second Class Honours degree or a post-graduate diploma), Economists (First or Upper Second Class Honours degree), Professional Accountants, Game Wardens, Inspectors of Mines, Factories and Machinery, Town Planning Officers, Meteorologists.

"343. Subject to their satisfying a strict test of professional and managerial competence and performance on somewhat the same lines as for Administrative Officers, Professional Officers would qualify for advancement to the main operative grade - N⊄2,580-3,984 - after three years' satisfactory service or practical experience. In those professions (e.g., Architecture) in which there is a recognized full professional qualification (as opposed to academic degree) which may be awarded after a specified period of practical experience (which should not be less than two years), then the acquisition of that qualification should be accepted as qualifying for advancement to the main professional grade.

"344. Advancement beyond the grade above the main professional grade should be by competitive selection (subject to the existence of vacancies) after five years' satisfactory service (or practical experience outside the service) as a fully-qualified Professional Officer.

"345. The Salary ranges for the professional classes listed in paragraph 342 would be:

Entry grade	Ranges from N⊄1,812 upwards according to the rules quoted in paragraph 341.
Main Professional Grade	Range N⊄2,580-N⊄3,984
Senior Professional Grade . . . . (Regional Professional Officers, Assistant Directors, etc.)	Range N⊄4,260-N⊄4,848

"346. At all levels, Professional Officers would be eligible to apply for Chief Executive appointments with District or Regional Authorities and they would also be eligible to be considered for vacancies in the Principal Secretary posts. To make a reality of this proposal, it will be necessary to provide managerial training for those Professional Officers who seek this avenue of advancement.

Legal Officers

"347. We have commented elsewhere on the salary award made in July 1967 to Legal Officers. We recommend the following salary structure:

"Assistant State Attorney	N⊄2,040 - N⊄2,388
State Attorney) Senior State Attorney)	N⊄2,580 - N⊄3,984

Principal State Attorney Chief State Attorney	....	N¢4,260 - N¢4,848
Director of Prosecutions Chief Parliamentary Draftsman	....	N¢6,180 - N¢6,972
Solicitor-General	....	N¢6,564 - N¢7,404

"348. It will be observed that we have recommended the deletion of two of the grades in the existing hierarchy. We can see no functional reason for such a large number of distinct grades and titles.

Medical and Dental Officers

"349. We have been made aware of the great dissatisfaction among Medical Officers about their conditions of service. This has been exacerbated by the decision on legal salaries to which we have referred earlier.

"350. At the date of our establishment survey, there were reported to be 167 vacancies for Medical Officers/Senior Medical Officers out of a total establishment of 472. Of the 305 officers at post, about half were expatriate. The wastage of Ghanaian doctors by resignation is at the rate of about 12 a year - almost 10 per cent. "There are reported to be about 200 Ghanaian doctors practising overseas who cannot be attracted back home under prevailing conditions. It will be some years before the output of the new medical school makes any appreciable impact on the position. Meanwhile as the population grows, the need for medical services increases. The overall shortage of doctors imposes long and irregular hours of work in conditions which must in many cases be incompatible with any normal professional standards. In these conditions, there is a real threat of imminent break-down in this important social service.

"351. Whatever improvements we may make in conditions of service for doctors are unlikely in the short term to bring the supply/demand ratio into balance. The output does not match the growing need and will not do so until the medical school is fully developed. We do not think it will be possible to attract more than a few of the Ghanaian doctors working overseas. We hope for no more than a gradual improvement of the present situation, and in our recommendations to make a realistic and sympathetic acknowledgement of the very heavy load of work and responsibility and the difficult, if not intolerable, working conditions in the medical service. These conditions are likely to prevail for a number of years and in our view are unique in the Public Service.

"352. We have considered the possibility of re-introducing in some form or another the right of Government Medical Officers to practise privately and to charge fees for their skills. In the present situation, an attractive case can be made for this measure since it would improve the remuneration of doctors proportionate to the amount of their own efforts and skills without imposing a burden on the public budget. The weight of opinion of all bodies enquiring into this issue in recent years is against it. The practical difficulties of administering such a scheme equitably and of controlling abuses are great. Moreover, such a system would appear to pre-empt a decision on the comparative importance of curative and preventive medicine. We have therefore decided not to recommend the re-introduction of private practice for Government Medical Officers.

"353. We do, however, feel that the situation demands that members of the public should pay more for the scarce medical skills which they demand. We hope therefore that the Government will see fit to recoup at least some part of the cost of our proposals by higher hospital fees.

"354. We recommend that Government Medical Officers should be entitled to charge fees for such services as the provision of insurance certificates and other non-Governmental Medical Reports. This recommendation we would hope could be given immediate effect.

"355. We recommend the following salary scales:

Houseman	N¢2,580 for one year
Medical Officer	N¢3,468-N¢3,984
Senior Medical Officer (after five years)	N¢4,404-N¢5,820
Regional Medical Officer Consultant, Deputy Director	N¢5,652-N¢6,372
Director	N¢6,564-N¢7,404

"356. The Regional Medical Officers are new posts which we recommend should be created now to provide for the Medical Officers in charge of Korle Bu, Kumasi and Affia Nkwanta hospitals and subsequently for the creation of the new Regional Authorities.

"357. We consider it is highly desirable to create a post of consultant so as to provide equitable career prospects for specialist doctors who wish to continue in practice rather than go into administration.

"358. In addition to salary, we recommend the following professional allowances:

Medical Officer	N¢1,500 p.a.
Senior Medical Officer	N¢2,500 p.a.
Regional Medical Officer/Deputy Director/Director	N¢3,000 p.a.
Consultant	N¢3,500 p.a.

"359. We strongly recommend that the new rates of professional allowances should be introduced with effect from the 1st January 1968, as a practical recognition of the difficult position of Medical Officers at the present time."

THE ROLE OF SCIENTIFIC AND TECHNICAL PERSONNEL IN NATIONAL DEVELOPMENT, WITHIN THE FRAMEWORK OF THE PUBLIC SECTOR

Jorge A. Sabato*

While this paper is intended to analyse generally the role of scientific and technical personnel in national development, within the framework of the public sector, as the question relates to developing countries at large, the author's expertise in the subject derives from his experience and knowledge of Latin American countries. The scientific and technical personnel considered here are those with a university degree or equivalent qualifications. Technicians, librarians and other auxiliary personnel are not included in the present analysis.

To understand the frame of reference within which the role of scientific and technical personnel in national development is examined in this paper, it is necessary to review briefly several important concepts.

Scientific and technical infrastructure

In any given country, the very complex world of research and development activities in science and technology defines the scientific and technical infrastructure of the country, which comprises the following components:

(a) The educational system that produces, with the necessary quality and quantity, the persons who assist, direct and/or perform research and development: scientists; technologists; assistants; technicians; administrators; librarians;

(b) The institutes, centres, laboratories, pilot plants and other facilities where research and development are conducted;

(c) The institutional system of planning, promotion, co-ordination and stimulation of research and development (national research council, national academy of science and engineering, science foundations etc.);

(d) The legal-administrative mechanisms that regulate the operation of the institutions and activities described above in (a), (b) and (c).

(e) The economic and financial resources utilized in the above-mentioned systems and facilities.

The analysis of the scientific-technological infrastructure as a whole and of each of its components provides a useful method of describing and evaluating the state of science and technology in a country, and of comparing it with others.

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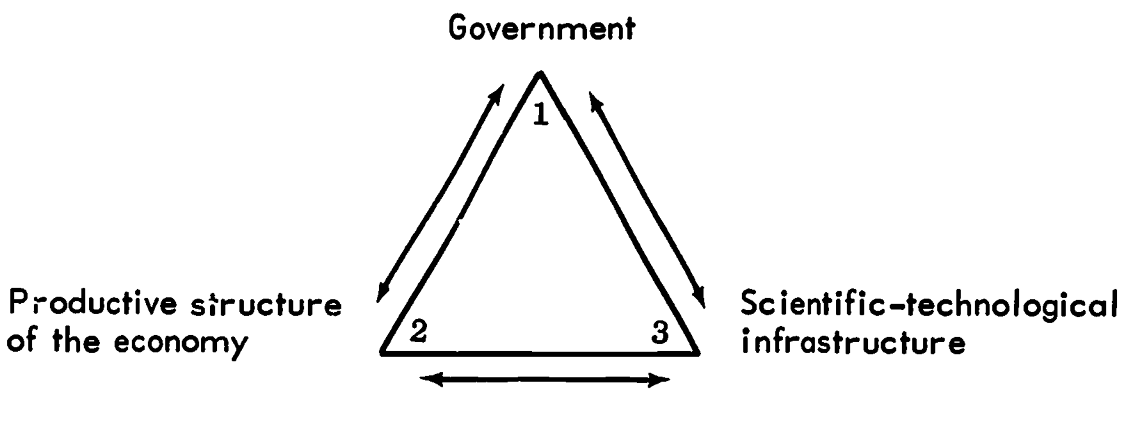
In some developing countries, the scientific-technological infrastructure is very weak because each of its components is very weak. In others, however, some components are rather strong; but the resulting infrastructure is weaker than expected because other components are not in good shape. This is the case for Argentina, where component (c) is quite developed, but as component (d) is always in difficulty, the scientific-technological infrastructure of Argentina is not as good as it could be. It is common that more attention is given to components (a) and (b) (and in many respects they deserve it); but experience shows that if at the same time the other components are neglected, the results can be quite disappointing.

A simple model

Science and technology will play an important role in national development only if there is a concerted effort, an explicit target, a co-ordinated action of three fundamental elements of society, namely: (a) the Government; (b) the productive structure of the economy, and (c) the scientific-technological infrastructure.

To describe the complex set of relationships among these three elements, a very simple model may be used: a triangle in which each vertex or angular point corresponds to one of the three elements and each side to the corresponding interactions.



Source: J.A. Sabato, "The influence of indigenous research and development efforts on the industrialization of developing countries", paper submitted to the International Conference on Interdisplinary Aspects of the Application of Engineering Technology to the Industrialization of Developing Countries, Pittsburgh, United States of .merica, October 1968.

The Government vertex consists of all the institutional components responsible for the formulation of policies and the corresponding mobilization of resources with respect to both the productive structure and the scientific-technological infrastructure.

The productive-structure vertex is the set of all the productive sectors that provide the goods and services demanded by the society. It is obvious that each vertex represents a point of convergence of multiple institutions, decision-making agencies, production units and various other activities. In the triangle there are relations established within each vertex, which shall be called intrarelations; and relations between vertices, called interrelations. There are also relationships established between a triangle or between each of its vertices with the external environment (that is, external to the triangle), which shall be called extra-relations.

Using this model, the successful incorporation of science and technology into development would be expressed in terms of the success or failure to establish "triangles" corresponding to different sectors of the economy, to different branches of one sector, to two or more sectors having a common target, and so forth. The maximum degree of success would be obtained when it became possible to establish a "large triangle" corresponding to the society as a whole. Consequently, in this context, the degree of development of a society (or of part of it) would be measured by the "relative perfection" of its corresponding triangle; and comparisons could be made among different countries and also among different sectors of the same country. Thus, a "well-developed country" would be one where the existence of many well-established triangles could be recognized, including one corresponding to the whole country. Inside this country however, "less developed sectors" might exist side by side with "very well-developed" ones.

Through the analysis of the vertices and sides, a ranking can be established among countries, differences can be evaluated and technological gaps can be measured. From among Latin American countries, some examples may be cited which would illustrate how the model helps to describe complex situations:

(a) Vertices acceptable, but sides very poor. This is the case where the productive-structure vertex is reasonably good, and the scientific-technological vertex is acceptable; but the Government vertex is weaker than the other two (it has not yet been able to define scientific, technological and industrial policies), although likely to work. The sides (the interrelations) however, are practically non-existent (at the vertices also, the intrarelations are rather weak). Consequently, the incorporation of science and technology into industry is far below socio-economic possibilities, and modern technology is therefore incorporated mainly through the extra-relations of the productive-structure vertex with foreign industry. The situation may be different for the agricultural sector, where interrelations and intrarelations are developed enough to counteract the weakness of the Government vertex;

(b) Vertices and sides very poor or non-existent;

(c) Vertices taking shape, but sides still practically non-existent;

(d) Vertices and sides in development: this may be the case where budgets for research and development have been increased, scientific policy is being established, and intrarelations and interrelations are being improved.

As is shown below, the triangle is a very useful model for study of the role of scientific and technical personnel, because it provides terms of reference which are always related to the interactions of science-technology-development.

The public sector and the model

During the past fifteen years, the importance of the public sector in developing countries has grown considerably, not only quantitatively (as expressed, for example, as a percentage of the gross national product), but qualitatively through the incorporation of new activities with a high content of science and technology. In the majority of the developing countries, the Government, in addition to its traditional duties, now performs a very complex set of functions that years ago were non-existent or in the hands of private concerns, mainly foreign. And this happens not only in the centrally planned economies - where it is, of course, a natural consequence of a political system - but in many free enterprise economies, where it can be seen that the Government, going far beyond the classic administrative boundaries, is now a very large (if not the largest) producer, distributor, buyer and seller of goods and services as varied as oil and sugar, electricity, vitamins and houses, iron and telephone calls, water and railway tickets, cement and books; where it can also have the control or property of the banking system and the monopoly of the export-import trade, of the communications system and of many industries (such as fuel, iron and steel, cement, petrochemistry, even tobacco and salt). At the same time, typical Government responsibilities, such as education, welfare and defence, have achieved a rather high degree of sophistication; and science and technology are becoming an important part of national development plans.

It follows that if one uses the triangle, it will be seen that the public sector is not localized exclusively at the Government policy-making vertex; but that some fractions of it (for example, a State oil company, a State railway system, a State book-printing house) belong to the productive vertex, while others belong to the scientific-technological vertex (national research council, national institute of agricultural research, national astronomical observatory etc.). Moreover, fractions of the public sector could belong to two or three vertices at the same time, e.g., an atomic energy commission may be responsible both for research in nuclear physics and for the production of nuclear raw materials (uranium, heavy water, graphite etc.), or a ministry of industry that dictates the country's policy concerning the motor-car industry may own the State motor-car company and do research on motor-car manufacture problems in its own research laboratories.

Consequently, while the research and development that the public sector performs to satisfy society's needs would be neatly localized at the "scientific-technological vertex" (such as universities and national research institutes), the research and development for the public sector's own needs could be institutionally distributed in two or three vertices. And so the scientific and technical personnel in charge of research and development in the public sector would not all belong to the same "class": a scientist doing pure research at a central electricity board does not have the same status as a scientist doing exactly the same kind of research for a national research council, in spite of the fact that both are employees of the public sector. This is an unfortunate situation, one that affects the definition of the role of scientific and technical personnel and the coupling of science and technology to the socio-economic reality of the country. The scientist institutionally located at the scientific-technological vertex considers himself a true scientist, one concerned with the progress of science. His colleague, who is institutionally located at the productive vertex, is regarded as a kind of second-class scientist, just dedicated to simple, practical things.

This important problem could be solved using the triangle model, where all personnel engaged in research and development belong, by definition, to the same vertex; both therefore have the same status regardless of the fact that the institutions where they are employed are located at different vertices. In developing countries, the major portion of the total research and development investment comes from the public sector. In Latin America, for example, the public sector accounts for near 96 per cent of the total money spent for science and technology; 1/ for some Latin American countries, the number are as follows: Argentina, 98 per cent; Brazil, 98 per cent; Colombia, 94 per cent; Peru, 93 per cent; Venezuela, 99 per cent. It follows that the majority of the research and development scientific and technical personnel are employed in the public sector, or its salaries come from it, as in the universities. In a developing country, the scientific-technological infrastructure of the country is practically equal to the scientific-technological infrastructure of the public sector; therefore, the main problems related to scientific and technical personnel must be solved in the public sector.

Yet, to deal with the new and complex kinds of demands described above, the public sector requires the following categories of highly trained scientific and technical personnel in addition to those engaged in research and development.

(a) Professionals: personnel at the operating or productive level, such as a metallurgical engineer in charge of a rolling-mill, a medical doctor at a hospital, a chemist in charge of production control at a brewery, or a civil engineer at the Ministry of Public Works. The scientific and technical capability of this category of personnel makes it possible for the public sector to perform efficiently a vast number of social and economic functions;

(b) Managers: top personnel at the decision-making level of organs and institutions, such as ministers, members of planning councils and committees, boards of directors, general manager's office, industrial boards, public service boards. The scientific and technical capability of this category of personnel is very important when decisions are taken in a wide spectrum of problems.

In the model given here, these two categories of personnel are not located at the scientific-technological infrastructure vertex; they are therefore outside the scope of this report. Nevertheless, as they interact strongly with the research and development category, due consideration should be given to their mutual relationships.

1/ Organization of American States, Department of Scientific Affairs, Características de los Institutos Latinoamericanos de Investigación Tecnológica (Washington, D.C., 1965).

The main problems

With respect to scientific and technical personnel in developing countries, two main problems must be considered: (a) procurement of human resources, both in quantity and quality; (b) efficiency in the use of the available personnel.

To date, much more attention has been paid to the first problem than to the second one, and for a simple reason no one worries much about how to use something until he has it. Thus, while the first problem has not yet been solved everywhere, its existence has at least been recognized. The second problem - which in a number of developing countries is already more serious than the first one - has not yet passed the "understanding stage"; and it currently needs much more analysis and study. The following data on Latin America show the relative importance of both problems.

Like other developing countries, the Latin American countries invest too little in science and technology: for 1965, such investment amounted to about 0.2 per cent of the gross national product. For Argentina, perhaps the country with the most developed research and development infrastructure in the region, it was a mere 0.3 per cent of gross national product.

Scientific and technical personnel are scarce in Latin American countries, as is shown by the following table:

Scientific and technical personnel, selected countries

Country	Graduates per 10,000 population	Proportion of the economically active population	Proportion of total population
	(percentages)		
United States of America	4.7	2.7	1.1
France	2.0	1.9	0.8
Germany (Federal Republic)	1.0	1.9	0.9
Spain	0.6	-	-
Argentina	0.8	0.9	0.3
Costa Rica	0.3	0.7	0.2
Venezuela	0.5	0.6	0.2
Peru	-	0.5	0.2
Ecuador	0.2	0.3	0.1

Source: Organization of American States, Inter-American Cultural Council, *Situación actual del desarrollo científico y technológico: implicaciones al nivel de política y de estrategia* (Washington, D.C., 1969).

2/ Organization of American States, Department of Scientific Affairs, *Meeting of the Inter-American Ad Hoc Science Advisory Committee* (Washington, D.C., 1966)/

In absolute numbers, Argentina - with a population of 23 million - has 4,500 scientists and technologists working full time in research and development, 3/ as compared with 242,800 in the United States of America, 4/ and 45,000 in France. 5/

While in 1967, in the United States of America, 173,200 persons graduated in sciences and engineering, 6/ in all Latin America, in 1965, only 12,000 persons graduated in the same branches; 7/ but in 1966, the total number of students in sciences and engineering was 165,000, out of a total of 831,000 university students. 8/

The "brain drain" is high in Latin America: 9,159 university graduates emigrated from Latin America to the United States of America during 1962-1966, of which 37 per cent were engineers and scientists (2,423 engineers and 967 scientists). 9/

With respect to the procurement of human resources for science and technology, these few data show that Latin America as a whole produces scientific and technical personnel (graduates per 10,000 population) at the same level as that for Spain, and that the level for Argentina - the most developed country in this respect - is near that for the Federal Republic of Germany; In stock (as a proportion of the economically active population), Argentina, Uruguay and Costa Rica have about half of what the Federal Republic of Germany has. At the same time, and with respect to how efficiently these personnel is utilized, the brain drain indicates that there are not good opportunities for the available personnel. This conclusion is confirmed by the following available information:

3/ Informe presentado a la 2a Reunión de la Conferencia Permanente de Dirigentes de los Consejos Nacionales de Política Científica y de Investigación de los Estados Miembros de América Latina, Caracas, Venezuela, December 1968.

4/ National Science Foundation, American Science Manpower, NSF 68-7 (Washington, D.C., 1966).

5/ Rapport du Comité consultatif de la recherche scientifique et technique: prospective de la recherche scientifique et technique en France (1968).

6/ United States of America, House of Representatives, Committee on Government Operations, "Scientific brain drain from the developing countries", 23rd report, 28 March 1968.

7/ United Nations Economic Commission for Latin America, Education, Human Resources and Development in Latin America (United Nations publication, Sales No.: E.68.II.G.7).

8/ Inter-American Development Bank, Socio-Economic Progress in Latin America (Washington, D.C., 1968).

9/ United States of America, The Brain Drain of Scientists, Engineers, and Physicians from the Developing Countries into the United States, hearing before a sub-committee of the Committee on Government Operations, House of Representatives, Ninetieth Congress, Second Session, 23 January 1968 (Washington, D.C., Government Printing Office, 1968).

(a) In Colombia, a recent study made by the Colombian Institute for Advanced training shows that enough engineers are being produced by Colombian universities to meet future development needs, but their proper utilization will be a serious problem; 10/

(b) A study of high-level manpower in the economic development of Argentina 11/ shows that although engineering is the third largest profession and is growing at the most rapid rate, many engineers are not employed in the engineering field, but are in political, executive and administrative positions.

(c) In Mexico, over 20 per cent of the engineers trained by Mexican universities work in sales and management positions rather than in engineering positions. 12/

The situation is clearly stated in a recent report by the Executive Committee of the Inter-American Cultural Council (Organization of American States): "The scientific and technical personnel existing in Latin America are not properly utilized in the scientific and technological system". 13/ There is, then, in Latin America, a definite lack of efficiency in the use of the scientific and technical personnel. This lack originates from a lack of understanding on the part of both the public sector and the scientific and technical personnel of their mutual role in the development process.

Some "illnesses"

For the majority of developing countries, the support given to science and technology is more rhetorical than real. At every possible opportunity, Heads of States, ministers, senators, generals, businessmen and even scholars emphasize that science and technology are absolutely vital for the health, wealth and security of the country. But the hard facts that usually follow these bright words

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10/ Colombian Institute of Technical Training Abroad, Colombian Institute for Advanced Training, Human Resources Department, Resources and Requirements for Highly Trained Personnel, 1964-1975 (1966).

11/ M.A. Horowitz, "High level manpower in the economic development of Argentina", in Frederick Harbison and Charles A. Myers, eds., Education, Manpower and Economic Growth: Strategies of Human Resources Development (New York, McGraw-Hill, 1964).

12/ "The influence of the availability of desirable human resources", paper submitted to the International Conference on Interdisciplinary Aspects of the Application of Engineering Technology to the Industrialization of Developing Countries, Pittsburgh, United States of America, October 1968.

13/ Organization of American States, Inter-American Cultural Council, Situación actual del desarrollo científico y tecnológica: implicaciones al nivel de política y estrategia (Washington, D.C., 1969).

show that science and technology are not given more than a minimum of support - far less than the economy would actually permit. The general economic situation of the country can be used as a pretext for the low investment in science and technology, and is used to explain what is the rather common behaviour of the public sector with respect to scientists and technologists: rigid Civil Service rules and antiquated administration procedures; total indifference when a research institution is destroyed by political action or by simple oblivion; lack of capability to guarantee continuity of the research activity; poor salaries; political "patronage"; restrictions to academic freedom; lack of flexibility and imagination to utilize resources already available.

A good example of this rhetorical support is the attitude towards the problem of brain drain: "More attention is paid to the brain drain in the United States of America than in Latin American countries, as measured by such indices as the number of studies on the subject, by press and magazine stories, and by official inquiries. The reasons for this are not clear, but the general tendency in Latin America to undervalue the contribution of scientists, engineers and physicians national development may provide part of the answer not only for their relative complacency but also for migration itself". 14/

The situation is even worse for the personnel not institutionally located at the scientific-technological vertex. To the public sector administrators, they are just "Civil Servants", and thus do not deserve the benefits that are occasionally given to "official" scientists, those who belong to the vertex. The fact that they undertake research and development is more of a nuisance than anything else, and they are usually victims of the change of organizations (the so-called "restructuring") so frequent in the public sector of developing countries. They end by being used in low-productivity, bureaucratic, administrative work which has very little relationship to their training and aspirations. In the majority of developing countries, the public sector has poor understanding of the role of science and technology in development. This is a direct consequence of a poor understanding of the development process itself. It is usually not understood that development is an integrated process involving both the accumulation of material, human, and intellectual resources, and the promotion of their efficient use.

It is not surprising then that the current situation of the scientific-technological infrastructure is far from satisfactory. A recent report states:

> "The Latin American technico-scientific infrastructure is weak, particularly in quantity and quality of human resources. Even worse, it is greatly disconnected (very thin intra-relations) totally isolated (almost non-existent inter-relations) and increasingly alienated (its extra-relations with the foreign technico-scientific infrastructure are more important than its intra-relations). Lacking concrete demands from the other two vertices and incapable of defining its socio-economic role, its components self-define their role in the abstract and devote their efforts to the general progress of

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14/ Statement by Charles Kidd, Executive Secretary of the Federal Council for Science and Technology, before the United States Senate, Immigration and Naturalization Sub-committee, 6 March 1967.

Science and Technology, that are considered from an intellectual point of view and not as development tools of their own society. It results then that the Research Councils - whenever they exist - accomplish successfully their mission of reinforcing the infrastructure but are of little efficiency in using that infrastructure to solve concrete problems of the society". 15/

The foregoing description is a good summary of the following typical situations that greatly affect the performance of scientists and technologists:

(a) There exists strong isolation from the other two vertices;

(b) Isolation leads to alienation from the concrete socio-economic needs of the country;

(c) From such alientation, anxiety and frustration follow as well as resentment, bitterness, weariness, mediocrity, obstructionism and/or emigration.

Consequently, the efficient use of scientists and technologists is rather poor, and the net results of their action is less than expected. It has been already pointed out that administrations in the public sector have a responsibility in this process. But they are not the only ones to be blamed; scientists and technologists themselves must recognize that they are also responsible and must try to define this responsibility. It is usually said that scientists and technologists are responsible only for carrying out good science and technology. This may be true in a developed country; but in a developing country, it is not enough: it is the main function of scientists and technologists, but, unfortunately, not the only one. Again, one confronts the problem of understanding the real nature of the development process itself. Development means more than stepping up growth of national income. It means eventually transforming a traditional society into a modern one. Development is costly and painful; it is not a gift of God or nature.

A developing country is, then, a country in crisis, and it will remain in crisis as long as it remains "developing". Scientists and technologists usually tend to forget this simple fact and to believe that a developing country is a country already built, a country where science and technology can flourish as well as in a developed country. They request an order, a security and a continuity that a country in crisis, by definition, cannot give to them or for that matter to anyone else. They dream of a "strategy for order" when the only realistic one is a "strategy for chaos". In a country in crisis, their own responsibility cannot end with good research and development: they must also help to build up the frame of reference where good research and development can be accomplished.

15/ Organization of American States, Economic Commission for Latin America, Informe para el Comité Asesor para la Aplicación de la Ciencia y la Tecnología al Desarrollo, de las Naciones Unidas, en relación al Plan Mundial de Acción en Ciencia y Tecnología, March 1969.

Roles of scientific and technical personnel

A review of the various effects that research and development would produce in a developing country would help to define what that country could expect from its scientists and technologists. Provided that proper "triangles" have been established where, through the right kind of interactions, science and technology are linked to the socio-economic reality, research and development gives capabilities to the country that it could not otherwise have and, at the same time, it helps to produce socio-economic changes and to open new roads for development in the following ways:

(a) Mainly through interrelations with the other two vertices, research and development give the capability to evaluate natural resources, including human resources, and to design strategies and policies for its development and exploitation;

(b) Through interrelations with the other two vertices, research and development also give capability to make decisions in such problems as:

(i) Introduction of new technologies (nuclear energy, petrochemistry, micro-electronics);

(ii) Investment priorities - foreign and/or domestic among several sectors of the economy;

(iii) Armaments to be produced or imported;

(iv) Technologies to be imported and how this can be done;

(v) Technologies to be locally developed and how and where this can be done.

Mainly through its relations with foreign scientific and technological infrastructures, research and development give capability to forecast technological changes and thus make it possible to design better development strategies, taking into account those forecasted changes.

At different stages of the development process, research and development perform the following functions:

(a) Improve the capability to adapt, of a particular importance at the stage of substitution of imported goods;

(b) Produce capability for sustained creation, of a particular importance at the stage when substitution of imported goods has been ended;

(c) Strengthen the capability to find specific answers to specific problems, particularly important in relation to national programmes for housing, food, health, etc.;

(d) Improve the capability to obtain and to absorb external aid;

(e) Strengthen the countervailing power of the country in its negotiations with other countries;

(f) Improve the technological balance of payments;

(g) Help to design better development strategies.

As concerns social changes research and development can accomplish the following tasks:

(a) Generate confidence in a country's own forces and a clim te more favourable to absorb and to produce change;

(b) Create a social awareness of the importance of science and technology;

(c) Improve the quality and quantity of human resources;

(d) Increase the probability - mainly through a "demonstration effect" - that executives, administrators and managers would employ analytical techniques and objectives criteria for decisions;

(e) Act as a powerful deterrent to brain drain, not only because research and development provide more opportunities to work, but because - through the triangle - scientific and technical personnel are given a sense of belonging to a socio-economic structure.

In the present context, and closely related to the role of scientific and technical personnel, a research and development system interacting with other elements of society is what really matters. A strong, but isolated, research and development system would certainly produce good science, but its impact on development would be rather weak.

It is now simple to realize that the "professional" role of scientists and technologists - to produce good research and development - can be transformed into the "social" role of active participants in the development process only if proper triangles are established. As an example, one may examine the contributions of scientists and technologists to a country's decision-making capability.

In matters related to industrialization, a developing country must take scores of decisions involving scientific and technological variables; some of these decisions may even shape the future of the country for many years ahead. It is therefore important for a country in such a position to be able to analyse, to judge and to decide according to the best interests of the country. There is, of course, plenty of available foreign advice (such as consultants, international and regional agencies), which can be hired, bought or even obtained without charge. But in any case, the final decision is up to the local personnel, and they must take into account parameters that are better evaluated by indigenous advice. This is, at any rate, what the developed countries always do, and what the developing countries prefer to do, if only for self-respect. The local scientists and technologists must then fully participate in the decision-making, and this would be possible only if they have a fluent interrelation with the decision vertex.

Such problems as the installation of the first nuclear power-station, the establishment of a fully integrated steel industry, the uses of new energy sources as the most efficient exploitation of mineral ores require the existence of as perfect a triangle as possible. Only in this way could the research and development system be mobilized and employed at its full capacity,and the decision would then really be controlled by the country.

Efficient use of scientific and technical personnel

In this analysis, the key element in achieving the role just outlined for scientific and technical personnel in a developing country is to establish a complete system of interactions between them and the socio-economic reality of the country. This must be explicitly understood by both administrators (in the broad sense of the word) and scientists and technologists, and must be defined as the precise target to be obtaining a very complex process that every particular society must work out according to its own particular characteristics. As concerns improving the efficiency in the utilization of scientists and technologists it is not possible to give "recipes" which will be valid for every country. In all cases, however, there are various aspects that must be carefully considered:

(a) The problem itself must be studied with the full participation of scientists and technologists. They must be aware of the difficult nature of the problems and must have a permanent dialogue with administrators;

(b) The status of scientists and technologists must be defined by the kind of work they perform and not by the kind of institution to which they belong. In the triangle, all must be considered to be at the scientific-technological vertex. There would be no problems with the personnel working at an institution belonging to that vertex; but certainly some administrative problems (salaries, promotion, working hours) would originate at the institutions belonging to one of the other vertices. These problems, however, must be welcome because they would be concrete cases through which administrators would learn what a scientist really is. When all scientists achieve the same status, a very important obstacle to fluent intrarelationship at the scientific technological vertex will be eliminated;

(c) Channels of communication established between the three vertices must include mobility of personnel, so that scientists and technologists would be included in the boards of directors of national or State companies (such as railways, oil and electricity); and administrators would be included in the councils of scientific organizations;

(d) It is particularly important to establish ways and means to interact with managerial personnel and with professionals at the operating or productive level. These two categories must be the best links between scientists and technologists, and the concrete problems of the public sector;

(e) National Civil Service policies and procedures for recruitment, promotion, training, professional development and retention must be designed with the aim of maximizing the interactions among the vertices. This approach would also permit designing the right kind of incentives for scientists and technologists. It is usually believed that good salaries are the best incentive. The problem is not so simple, however, and there is evidence that for scientists and technologists a variety of incentives is necessary (intellectual challenge, social rewards and so forth).

In brief, in the majority of developing countries, scientists and technologists are currently just "spectators" of the national development drama. The central issue is not how to increase their numbers, but how to transform them into "actors".

NATIONAL SCIENCE POLICIES AFFECTING CAREER STATUS AND WORKING CONDITIONS OF SCIENTIFIC AND TECHNICAL PERSONNEL IN THE PUBLIC SECTOR

Norman Kaplan*

Scientists and engineers and becoming increasingly important members of the public service in more and more countries. There are more scientific and technical personnel than ever before and much more is expected of them. In connexion with the increasing employment of such personnel, numerous questions are raised. Some of the questions with which this paper deals are as follows:

(a) Whether scientific and technical personnel are contributing as much as they could (or should) towards the realization of national objectives related to science and technology;

(b) Whether these personnel are organized in such ways that they are encouraged to produce their best and most creative work;

(c) Whether there is a basic conflict between the necessity to organize scientific activities and the apparently equal necessity of scientists to be unfettered by organization, that is, to be autonomous in their work;

(d) Whether organizations can be fashioned so as to provide a climate - psychological, physical, administrative etc. - that will enhance the creativeness and productivity of each of its members; and if so, determination of the policies and practices that are most likely to achieve such results;

(e) In determining the above-mentioned policies and practices, whether to look towards national science policies and objectives, and the ways in which different States have organized their scientific establishments and activities; or to concentrate on general factors affecting recruitment, career opportunities, performance and productivity in any sector of the public service;

(f) Whether scientists (and possibly engineers) should be considered a group significantly different from others in the public sector so that separate policies and practices should apply to them;

(g) If differences exist between scientists and engineers in the Public Service and those in other sectors, what those differences are; or, to put it another way, whether one should expect (and encourage) differences among scientists engaged in research in a laboratory located in a Government agency building, in an industrial or factory compound, in a university building, in a hospital, or in a building of a scientific academy.

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The answers to the foregoing questions, as will be seen, are rarely readily at hand. No one has discovered a "magic formula" for putting together a research organization, and there is still much to be learned which will require much more study than has previously been the case. Before seeking some answers, however, it is necessary to make sure that the right questions are being asked.

The concern here is with scientists and engineers engaged primarily in research and development activities within the public sector of a society. Each of these categories must be examined. It cannot be assumed that all scientists are alike, and that, as a consequence, there is one type of organization that is most appropriate for all scientists or, for that matter all scientific activities. It cannot be assumed that all engineers are like all scientists or that engineering activities require the same kind of organization. The utility of research and development as an undifferentiated category must also be scrutinized. Finally, one must ask whether the public sector is unique in so far as the conduct of scientific and engineering activities is concerned.

One begins with the questions whether scientific work in the public sector is inherently different from such work elsewhere, and whether scientists are different from other Public Servants, and if it is believed that they are, whether current notions of Public Servants should be re-examined. National science policies must then be considered - especially those which seem to be most relevant for the working conditions and the output of national laboratories and other public sector research establishments. From this level, one can move to that of the research organization, considering a range of factors that may affect the research climate and the output which may be expected. In doing so, particular attention is paid to a variety of types of organization, depending not only upon the nature of research conducted, but (perhaps more significantly) upon the nature of the organizational objectives and leadership. Next to be considered are scientific and engineering careers, as well as a number of attributes of a more individual nature, which may be one set of pre-conditions for achieving an effective research effort. One ends with the essential beginning - namely, with good people; but this is no longer sufficient. Good people can lose their drive and motivation in a poor organization or with poor leadership, or with ambiguous organizational goals functioning in the context of inadequate national science policies.

While some observers feel that there are serious difficulties and conflicts between the needs of individual scientists and organizations generally, most people feel that this is particularly true for Government bureaucracies. The reasons for this view are not difficult to fathom, particularly when one is thinking of a stereotyped Government organization. The system is seen as full of rigidities, almost all of which stifle individual creativeness and encourage mediocrity. In this view, the typical bureaucrat "plays it safe" and avoids any unusually risky undertakings. In going by the book, the bureaucrat protects himself and his job security. He is less likely to incur the wrath of his superiors and is more likely to receive increases in salary and promotions in an orderly and regular fashion. Not only is the individual bureaucrat discouraged from engaging in risky or creative behaviour, but the organization itself is cast in a similar mould. The organization may have to turn away a very bright and potentially creative recruit because there does not happen to be a post for him. On the other hand, the organization may hire a rather mediocre recruit to fill an opening which may be lost if it remains unfilled for too long a period. Because of job security the organization may find it difficult to transfer, or even to dismiss, a man who is no longer producing adequately. The role of seniority in the promotion system may make it difficult for an organization to reward a particularly promising young man for his performance ahead of that of colleagues with longer tenure. At other times, people may be promoted simply because new posts exist and may be lost to the organization if not used promptly. It may be difficult to undertake new projects, however promising they may appear, until these have been approved and appear as line items in the next budget cycle. By the time that happens, the initial enthusiasm for the idea may have waned considerably. By the same taken, it may be difficult to halt further work on a project which has a secure line in the budget, even though it is felt that the project is not progressing satisfactorily or has reached a dead end. One could undoubtedly extend the list of stultifying characteristics of many bureaucracies, whether in the public or the private sector. To the extent that such practices characterize an organization, they would be clearly inimical to the conduct of an effective, much less a creative, research enterprise.

While the degree of uncertainty and the amount of risk involved varies from project to project, much of scientific research inevitably involves some risks and uncertainties. This situation alone would make it difficult to reconcile the rigidities and red tape of bureaucracy with the requirements of research. This is not to say that research cannot, or should not, be organized. Indeed, it is difficult to conceive of many research undertakings that could be carried out without some form of organization. This is particularly the case, of course, for any area requiring complex instruments and equipment or the active co-operation of scientists from a number of different disciplines. So the question again is what kinds of organizations seem most appropriate for what kinds of scientific and engineering activities.

Thus far, it has only been asserted that most scientific research is probably incompatible with a rigid bureaucratic form of organization. The question now arises whether this means that such scientific work is inherently different from all the other activities undertaken by most national Governments. At one level, the answer would have to be affirmative, but it may be suggested that perhaps much more attention should be given to the nature of Government organizations in general. It may well be that the old-style Government bureaucracies are an inappropriate form of organization for many of the activities carried out by modern Governments, with science as a prime, but not an exclusive, example. It is beyond the scope of this paper to develop this point in any detail, but it is the basic contention here that the prevalent ideas about national Government organizations are still largely of the nineteenth century. There has been a failure to adjust the ideas about such organizations to the realities and requirements of the second half of the twentieth century. To the extent that this is true, it must be concluded that research activities do, indeed, require a more modern and appropriate form of organization. It is hoped that the recognition of the need for new organizational forms and new practices and policies for the conduct of creative research activities may lead to a re-examination of and, ultimately, changes in other spheres of Government organization. It is in this sense that the so-called "unique requirements of scientific research" may one day be seen as essential and desirable requirements for many other types of activity which require as much creativeness, risk-taking and flexibility.

One may ask whether scientific work and research in the public sector are significantly or necessarily different from the same type of work carried out in the private sectors. This is an important question, and, yet, the answer is a deceptively simple "no". There may well be differences between the public and private sectors in many countries, but in the context of this paper, such differences are both artificial and irrelevant. For example, there may well be differences in salary scales, either at the beginning or at other points in a scientific career. There may well be differences in status, so that working in a Government laboratory gives one higher or lower status, compared with the other possibilities. There may well be differences in working conditions: the hours, for example, may be more inflexible in a public laboratory. Nevertheless, the fact that such differences may exist in some countries does not necessarily mean that these differences are either essential or desirable. Moreover, such differences are not inherent to the research process itself, although it is readily admitted that such differences and distinctions may affect the final outcome. This could, for example, occur through the inability to attract the best people or even to hold them; the "climate" in the laboratory could be so affected that the morale of its scientists would be something less than it should be, with the result that they would not work at optimal effectiveness. It may be much more important to learn how a research activity is organized, how problems are chosen, how priorities are reviewed and what criteria are used in taking decisions on whether to continue a project, to bring it into the pilot stage and the like, than to stop at the laboratory door of a private industrial firm because they are ostensibly a profit-making enterprise while the Government laboratory may not be. Such ideological differences between public and private enterprises may turn out to be largely irrelevant for most research activities much of the time.

The most relevant and most significant fact about any research organization (whether in the public or the private sector) is the objective of that organization. One of the great difficulties with most of the traditional analyses of research organizations is that they have tended to treat the category of Government or public laboratory as a single homogeneous entity, but the fact that the employer is the same does not mean that all the laboratories are necessarily the same. In the United States of America, for example, there are Government laboratories that differ very little in any significant way from a number of university laboratories engaged in the same kind of research. There are also some whose objectives are not unlike many industrial laboratories in so far as both are interested in developing improved or new products. The objectives are quite different in these two Government laboratories, despite the fact that the scientists in both have the same employer, receive their salaries from the same source and may be even operating under the same Civil Service regulations with respect to tenure, salary levels and a host of other related personnel practices. What is crucial, as is shown below, is, first, the clear recognition of the differences in objectives; and, secondly, the formulation of internal policies and practices consonant with the objectives. Thus, there may be much of value to be learned (and perhaps even to be tried) from a private industrial laboratory, even though one is considering a laboratory in the public sector. In the remainder of this paper, the concern is not so much with whether a particular laboratory is located in the public or the private sector, but with its stated objectives and goals. An attempt is made to apply what is known about laboratories of different types, irrespective of where they are located, with the major criteria being the similarity of objectives, in the first instance, and how effectively these objectives are being met, in the second.

Relevance of national science policy

It goes without saying that the first requisite of a national science policy is clarity of objectives. It is not enough to state the general hope and conviction that the pursuit of science and its progress are essential goals of the country. There have been a number of eloquent and ringing affirmations of the importance of science to a country when, at the same time, that country might be losing some of its best young scientists to other countries and might be unhappy with the achievements of its scientists because there had not yet been any cash return from its investment in research. If the primary objective of the country in question is to harness science to the task of economic development, then the policies should be more explicit and the organization of the effort should reflect such objectives.

Clarity and, indeed, candor are especially important in formulating policies with respect to the role of scientific research in economic development. In fact, it might be more realistic and is bound to have a salutary effect if scientists and engineers, on the one side, and economists and other Government officials responsible for major national policies, on the other, all worked together to formulate and to review periodically national science policies. All too often, scientists may be given responsibility for formulating national science policies without a very clear understanding or without clear and co-operative relationships with other parts of the Government or the economy which those policies are supposed to affect. This situation results in policies that exist in a vacuum, operating at cross purposes with the very ends they are trying to achieve. If the scientists have had an opportunity to participate at that stage of the process, it is much more likely that the country's scientists as a whole will have a much better understanding of the objectives and what they mean for them in their own work. It would be less likely that scientists could complain, for example, that a general science policy statement implies much more support for basic research and less "pressure" to work on applied problems.

Such general statements are of crucial importance because their character should have a direct and determining effect on the structure of the scientific enterprise which is created. They are also important because of their potential effect on the motivations and aspirations of a country's scientists.

In a similar vein, the hierarchy that attributes the highest prestige (if not, other rewards) to pure or basic research, less to applied and least to developmental research, is also a product of a past age, although, of course, this was not the case when modern science first began to flourish in the seventeenth century. As long as this hierarchy, which is often an implicit part of the baggage of scientists, is left unchallenged, there will be difficulties in attracting first-rate people to work on applied problems. No single country can, by itself, secure a complete change in scientists' attitudes towards this hierarchy. But scientists' attitudes on this question are beginning to change and are ripe for still further change, as there is increasing awareness of the inappropriateness of this hierarchy for scientific efforts in the world of today.

A clear statement and conception of national objectives would also affect the actual structure and location of scientific enterprises. Thus, a laboratory operated by (or under the jurisdiction of) a research council, a science ministry or a university cannot be expected to do effective applied work that will have a direct impact on, for example, the country's steel industy. There may well be a need for laboratories at the university, at particular Government ministries, and at hospitals and industrial establishments, as well as for some that are, perhaps, independent of any of these institutions. But its institutional location should tell much about the objectives of a particular laboratory. There are still differences of opinion as to whether it is better to have a particular industrial laboratory located physically within the factory gates or whether some slight degree of physical detachment is not more desirable. There seems to be little doubt that complete physical separation and isolation are less likely to result in work of relevance to that particular industry. Again, there is no universally accepted dictum concerning the optimal location of laboratories, but current thinking leans more towards some kind of proximity, physical and otherwise, with respect to the major objectives of the laboratory. The main point here is that proximity reinforces for the scientist the importance of the objectives, while distance and isolation may make it easier for him to forget the original intent of the laboratory's research efforts.

What is being stressed is the vital importance of clarity and the continuing involvement of scientists and engineers in formulating national science policies. But the really crucial problem of the substantive nature of such policies, especially for developing nations, is beyond the scope of this paper. The relationship between science and economic development is complex and still little understood. There is beginning to be appreciation and understanding of some aspects of some policies and practices which seem (do not seem) to work in specific situations. At the extremes, however, it seems clear that where there is a heavy emphasis on basic research and an isolation of scientists from agriculture and industry, tangible returns on research will not be the likely result in the short run. At the same time, merely emphasizing applied research, without a direct and continuing relationship to economic policies, is likely to be equally unproductive. It is futile to encourage scientists to try one course and then to abandon them because of impatience or poor economic planning. 1/

For some of the reasons already mentioned, as well as for some which are developed below, very few, if any, special policies dealing specifically with the conditions of work would appear to be necessary. Because of the differing and evolving objectives of different laboratories and research organizations, a maximum of flexibility and local autonomy is likely to produce the best results. It seems ludicrous to specify particular hours of work when one type of research may require constant attention for twenty-four or forty-eight hours at a time, or another can only be done during hours of darkness. Within broad guidelines,

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1/ The United Nations and the United Nations Educational, Scientific and Cultural Organization have sponsored a number of international and regional conferences on this subject, the proceedings of which may be consulted with profit. See also C.H.G. Oldham, "Science, technology and economic development: science policy and science aid", in Ward Morehouse, ed., Science and the Human Condition in India and Pakistan (New York, The Rockefeller University Press, 1968), pp. 133-137. In this volume, there are also a number of other highly relevant papers, especially those by Hoelscher M.G.K. Menon and Y. Nayudamma.

each laboratory, and perhaps even sections of a laboratory where this is appropriate, should be free to set whatever policies are deemed appropriate for the effective conduct of research in that particular setting. This may well result in the practices being much more "liberal" in one laboratory than in another. Such differences should be examined, along with other factors, to see whether - and, if so, in what ways - they affect the productivity and even the creativeness of the laboratory. This examination must, of course, be done with great care and, ideally, should be part of the continuing programme of research on research. In all probability, some degree of diversity would be essential simply because of the diverse nature of the research, on the one hand, and of the scientists involved, on the other.

As has already been argued, special or different policies for science and scientific research are or should be largely unnecessary. Again, a maximum of flexibility and even deliberate experimentation with organizational forms and practices is much to be desired over the rigidities of a neat and centrally managed enterprise. There may be, however, special problems in specific situations, especially in connexion with policies on remuneration and promotion. Such a problem may arise in two respects: first, in relation to other high-level professional, non-scientific categories within the public sector; and, secondly, in relation to other scientific occupational categories in the private sector in those countries where it exists.

There is a continuing problem concerning the criteria for promotion. It is fairly well-accepted practice that promotion should not be a matter of organizational responsibility. That is, promotion should not be based upon, nor should it necessarily entail, responsibility over a number of subordinates. Scientists should be promoted with appropriate titles without having to assume administrative responsibilities for which they may not be at all suited. This dual ladder of upward mobility within an organization is now fairly common practice in many of the more progressive research organizations and takes into account the fact that not all scientists are good administrators; and, yet, they may need increased recognition and prestige through promotion.

A second, perhaps slightly more complicated problem lies in the relationship of seniority to promotion, as well as to increments in salary. The old notion that seniority alone automatically entitles one to regular increments and promotion no longer seems an adequate rationale, whether for scientists or for any other highly skilled occupational categories. The criteria should be more nearly related to the objectives of the organization and the extent to which the particular person is instrumental in helping to meet those objectives. Thus, increased seniority by itself, must lead to a diminution in the effectiveness in meeting the organization's objectives and goals. The answer does not rest in rewarding an employee simply because he has been in the organization for a long time; but, rather, in finding a situation in another organization in which that person can make an even greater contribution precisely because of his seniority. In such a situation, seniority is not only valued, but is of value. The solution will differ for different persons in different situations and in different organizations. A man who has been engaged in research for a considerable period of time may find it more exciting and be more usefully engaged in teaching for another period.

Organizing research organizations

Numerous "recipe" books have been written to tell how to run a research organization. There have been the "nine dilemmas" and the "ten myths", plus a spate of books and articles, some based on research, but more based on personal experience and anecdotes, all of which purport to be knowledge about research organizations. 2/ The plain truth is that very little is known in any hard and fast sense.

Part of the accepted dogma holds that scientists and organizations are antithetical to each other. The scientists need freedom and autonomy to do their best work. The organization, by definition, deprives the scientist of at least some measure of his autonomy; and, therefore, it is argued that there is an inherent and irreconcilable conflict. This is nonsense.

At one end of the spectrum are those activities usually labelled "applied" or "developmental", engaged in by scientists and engineers. Such activities are subject to reasonably good estimates as to probable costs, number of personnel required and the time needed for completion of the target. Such activities can be programmed, to use the computer jargon, and the job of the organization is not only to facilitate performance, but to ensure that there shall be some reasonable adherence to the estimates of time and money.

At the other end of the spectrum are those research activities whose outcome can scarcely be predicted. Costs cannot be estimated with any great precision; instead, it is necessary to work within an agreed budget. Fairly specific schedules and budgetary allocations make much less sense at this end of the spectrum, while they may be essential at the other end. Neither type of activity is in and of itself more important, or less, to the organization; and the fact that greater control is and can be exercised in one case is a function of the nature of the activity and not of its prestige value. Regardless of whether the end-results of certain activities can be predicted in advance, the organization's main task is to facilitate the conduct of research activities. Its job is to provide the scientists and engineers with the equipment and supplies necessary to the conduct of their work, within budgetary limits and, in some cases, subject to the availability of the instruments or supplies. This activity should be viewed as a co-operative undertaking by the scientists, the supply officers and the organizational leadership. It is understood that supplies, for example, should not be wasted; but it is not the main purpose of a research organization to maintain rigid control and constant vigilance so that it takes, for example, three vouchers and six forms in triplicate to obtain a pencil or a chemical vital to the conduct of an experiment.

2/ See Herbert A. Shepard, "Nine dilemmas in industrial research", Administrative Science Quarterly, Vol. 1, No. 2; (Fall 1956), pp. 1-20; K. Guy, Laboratory Organization and Administration (London, MacMillan and Company, Ltd., 1962); Charles D. Orth, III, Joseph C. Bailey and Francis W. Wolek, Administering Research and Development: The Behaviour of Scientists and Engineers in Organizations (Homewood, Illinois, Richard D. Irwin, Inc. and Dorsey Press, 1964). See also a short annotated bibliography by George P. Bush and Lowell H. Hattery, "The 1967 research administration bookshelf", Research/Development, Vol. 18, No.11 (November 1967), pp. 34-37.

bureaucratic requirements, as well as the failure to review the efficacy of past policies and procedures, often result in a situation in which more and more of the organization's time and energy are devoted to the maintenance of procedures and controls and less and less to the performance of the activities which were thought to be the very raison d'être of the organization.

In the last analysis, the quality of leadership up and down the line in any organization is probably the single most important variable in the situation. Here again, one must rely on personal reminiscing and other anecdotal material rather than on hard data. It seems fairly safe to assert that the outstanding scientist does not necessarily make an outstanding organizational leader. Very often, the organization has succeeded in losing a good scientist - and his output - while acquiring a poor leader who has a negative effect on the output of many other scientists as well. The current folklore continues to maintain that the leader of a research and development organization should be, at least, a respectable scientist, rather than a layman or even a mediocre scientist. This folklore has rarely been challenged, so it would be difficult to consider alternatives, although it should be noted in passing that even the lay administrators of today are likely to have at least some science background and, in general, to have a greater appreciation of the problems of science and research than would have been the case several generations ago. Again, the contrast appears to be between the administrator turned out in the British "two culture" tradition (which was certainly a factor in the past), compared with the greater emphasis currently placed on science in the educational systems of most countries - even that of the United Kingdom of Great Britain and Northern Ireland.

The term "leader" is used here deliberately in contradistinction to the usual notions about a director. It is a commonplace to observe that the old-style director who actually "directed" in a completely authoritarian fashion is probably on the way out everywhere. It is not simply the change in terminology, however, that is important, but the change in style and its implications. The effective leader today certainly puts the stamp of his ideas on the organization, but he does that by giving the people nominally under him more autonomy rather than less. Within established goals, the man at the bench is usually given considerable autonomy with respect to how he is to move towards achievement of a mutually accepted goal. While his work may be reviewed from time to time, the scientist is not "told" what to do and how to do it, nor is he supervised on a daily and continuing basis. In these circumstances, the scientist well understands that he must produce; if he does not, he must certainly take part of the responsibility. Since the scientist chose to come to the particular organization and has had a hand in settling the kinds of problems on which he is engaged, he can in effect, enjoy all of the autonomy said to be essential to bring out the best in him.

The scientific leader of a research organization must also be an effective advocate for his organization with the organizations and people to whom he is ultimately responsible, whether this be the finance ministry or some other cabinet minister, a legislative body, or another institution. From them, the scientific leader must obtain the resources needed by the laboratory to carry out its mission (within the context of what is reasonably and realistically available). He must also act as a buffer between the layman and "his" scientists, explaining to each group what the other needs and wants.

Whether the scientific leader assumes directly all or most of the responsibilities for purely administrative matters is difficult to assess in the abstract. It depends, in part, upon the extensiveness of administrative duties characteristic of public sector laboratories in a particular country; and, in part, upon the personality and predilections of the particular scientific leader. Some thrive on a bit of administrative responsibility, while others detest it. Some have found it helpful to work in tandem with a chief administrator who is responsible for all non-scientific matters in the organization, while others find it impossible to make this accommodation.

All research organizations are, by their very nature, plagued by the problem often referred to euphemistically as "hardening of the arteries" or, more simply, aging. The general reason is that research is innovative and often revolutionary in its implications, while organizations tend to be more conservative, once they come into being. The problems are exacerbated when an old organization is dominated by or predominantly made up of the "old-timers" who were involved with its inception. The problem is further exacerbated when such an organization is in the public sector, at least so it is generally believed.

There are still other manifestations of this problem. It may be that the director is too old or has been in the job too long and has thus lost some of his vitality or flexibility. It is also possible that the director finds it impossible to change with changing needs or changing goals. Very often, it is not a matter of aging as such, but of the appropriateness of a particular style of leadership at a particular stage of development in an organization. Thus, the kind of charismatic leader who may be the best possible choice for an organization that is just being formed may turn out to be the proverbial "square peg in a round hole" at a later stage when the organization may need stability and consolidation. The problem may be concerned less with the nature of the leadership and more with the inability to do anything about some of the personnel who may no longer be productive or who have become obsolete. This is a particularly trying situation when seniority and tenure regulations make it virtually impossible to effect any change. Still another kind of related situation arises when there is a distinct change in the objectives of the organization or in their emphasis; people originally hired to fulfil given kinds of objectives may not be appropriate in a newly defined situation.

While the foregoing examples by no means exhaust the types of situation that have been encountered in various organizations, they are at least illustrative of a wide range of problems encountered. Again, solutions are not simple, but at least there is indication of where one should be heading. Organizations, no less than the individuals within them, should review themselves periodically to see whether goals are still meaningful and whether the organization is effectively working towards their accomplishment. This could be a matter for continuing self-appraisal, or a variety of other techniques could be employed, including the use of visiting committees of outsiders.

Organizations faced with a declining interest in their original goals need not necessarily cease functioning. They can shift their goals to those considered more significant to the society, and, in the process, bring about a change in the type of work done and, over time, perhaps even in the character of the personnel employed. Such efforts should be studied very carefully to see whether they yield any generalizations, since it is not clear whether it it better for an organization whose original purposes are no longer relevant to quietly cease to exist or whether an effective organization should turn its energies in other directions.

Several points are, however, clear: first, the importance of early recognition of the declining significance of original objectives so that appropriate action can be planned; secondly, appropriate action may be to shift the emphasis of the organization or it may be to let the organization cease to function, but, in either case, early recognition permits an orderly transition and avoids the kinds of crises that are destructive to the morale and productivity of all concerned; thirdly, such periodical appraisal by insiders, as well as outsiders, of both the nature of the organizational objectives and the effectiveness with which these are being carried out can also provide an early warning for those organizations whose major problem is simply old age. In all cases, a good degree of flexibility is obviously essential and must therefore be a constituent element in the system. Lastly, it scarcely needs be re-emphasized that rigid and static organizations are a crucial element in determining the careers and opportunities of a country's scientists and engineers, and the results which may be expected from them.

While the aging of an organization is a persistent problem, once it has been in existence for a long time, the size of a laboratory is a question that must be faced from the very outset. Size is, in part, a function of the work to be undertaken and the equipment necessary to perform such work. It is inconceivable to try to operate an accelerator in a physics laboratory with only a handful of men. It is possible to maintain a laboratory in some branches of chemistry or biology with perhaps as few as a dozen workers. Research that requires very expensive equipment, such as an electron microscope, must seek to achieve some optimal utilization of the equipment, which has implications for the size of the unit. It is not very likely that any country can afford to provide every one of its biologists with his own electron microscope.

But beyond these more or less technical limitations on the size of the laboratory, there are a number of other equally significant considerations. One of the most important of these factors is the often unexamined tendency to permit laboratories to become larger and larger in the mythical expectation of achieving economies of scale. While it may be true that, up to a point, centralized and large-scale purchasing or maintenance of experimental animals or some other service component may be more economical, this point is often exceeded as sections of an organization gain a vested interest in extending and maintaining their own existence. The economy realized may turn out to be largely mythical; and, in fact, other costs often not taken into account may actually vitiate the financial savings. The inconvenience, the loss of time, and bureaucratic red tape and other cumbersome procedures may actually result in a diminution of the over-all effectiveness of the laboratory's main tasks. Any organizational practices of this nature, which obstruct rather than facilitate the conduct of research, affect the morale and productivity of the scientific workers and may be self-defeating in the end.

There is, however, the continuing problem of the critical mass needed for a research undertaking in order to ensure at least a minimal amount of healthy interaction and an avoidance of isolation and stagnation. Related to this problem is the question of how many disparate types of activities are best carried on within a single organization. One solution that has been tried by a number of industrial firms in the United States of America is to try to keep the staff of any single laboratory at somewhere around 100-125 people. When a laboratory begins to exceed this limit, consideration is given to forming a new unit. Each unit enjoys considerable autonomy, but all participate in setting the over-all objectives of the firm. A number of these units may be located on the same "campus" so as to enjoy some of the advantages of centralized library facilities and other services, but each is quite autonomous with respect to its own special requirements and objectives.

It must be emphasized again that such solutions are more a matter of conventional wisdom and pragmatism. Much better studies and data are needed before any particular pattern of organization is accepted as optimal. At this point, much more conscious and deliberate experimentation might well be undertaken.

Although budgeting practices may seem at first glance to be the prime concern of a laboratory director and a finance ministry, such practices inevitably exert a considerable effect on the style and "climate" in a laboratory. And, to the extent that this is so, these practices have an effect on the careers, the productivity and even the mobility of the scientists and engineers in the laboratory. Some form of budgeting is obviously essential in any organization and, properly utilized, can be a valuable tool in planning and maintaining some degree of organizational flexibility. Difficulties usually arise, however, because of the tendency of many Government officials to view the budget primarily as a mechansim of control. When viewed in this fashion, the budget tends to be akin to a strait jacket. 3/

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3 In its most rigid forms, the typical national budget tends to be on an annual cycle with each individual item broken down into minute details and regarded as "line items". Line items tend to be considered inviolate, and the possibility of shifting some funds from one line to another is usually surrounded by a maze of restrictive and discouraging regulations. The expenditure of time and effort, even money, in any attempt to obtain a change makes one wonder about the function of the budget as a mechanism for getting the job done. It is not at all clear that such rigid conceptions of the budget actually do result in greater control or even in greater savings. As was just mentioned, an enormous amount of time and energy may be expended in an effort to circumvent these rigidities, the cost of which is unfortunately hidden and does not appear openly in the budget itself. Secondly, such budgets are often accompanied by a stringent rule, variously stated, which, in effect, prohibits the carry-over of unexpended funds from one budget period to the next. The usual consequence of this rule is a tremendous flurry of activity just before the end of the particular budget period in an effort to expend all the remaining funds. Such a last-minute spending spree may not be very economical or even productive; yet, it is often regarded by the organization in question as an essential activity lest the budget for the following year be cut because some official may interpret unexpended funds as a sign that too much funding had been requested previously.

This type of control is most certainly counter-productive in any kind of research and development organization. The uncertainties that are an inherent part of the research process make such a budget particularly inappropriate. The lack of flexibility and the discouragement of any kind of creativeness would make such budgeting procedures almost disastrous for any research organization.

The budget of a research organization should facilitate and not hamper the attempt to achieve accepted objectives. Considerable flexibility can be achieved with virtually no loss in accountability by relying on fewer fixed lines; by providing only very broad categories instead of minute and detailed breakdowns; and by easing the process so that funds may be shifted from category to category, as deemed necessary during the actual operation of the organization. Once the over-all level of the budget has been agreed upon, most, if not all, of the responsibility for actual expenditures and for allocations to particular subcategories should be in the hands of the director of the research organization. The director may well wish to delegate this responsibility further down the line in his own organization, again within guidelines agreed for each unit within the organization. Thus, the project leader would have the main responsibility for the allocation of the over-all sum allotted to him and would have to learn to abide by the decisions he makes. Such a system provides no less accountability or responsibility, but it does introduce considerable flexibility and even the ability to exploit new developments within the available resources with a minimum of delay and red tape. This is essential for the maintenance of a reasonably dynamic atmosphere within the laboratory and for the encouragement of whatever creativeness there may be within the laboratory.

One further point might be mentioned in connexion with budget problems. Until recently, the annual cycle seemed to be an almost inviolable practice in most of the world. Even this bastion is beginning to fall, however, as the disadvantages of this process become more and more manifest. As a recent British experience indicates, it is not merely the fact of an annual cycle that is disadvantageous. A recent paper comments on the difficulties experienced by the National Physical Laboratory (United Kingdom) when it shifted from the annual to the quinquennial plan in 1954. While the quinquennial plan avoided many of the difficulties of the annual cycle and provided considerable flexibility by permitting the carry-over of unexpended balances from one year to the next within the five-year period, it suffered from other rigidities. The most important one seems to have been the difficulty of drawing up a meaningful and sufficiently specific plan for what turns out to be a period of almost seven years (this because of the lead time necessary to draw up the plan and to move it through the proper channels).

In this connexion, the author of the report states:

"Shortly after the second quinquennium began, it became clear that a fixed quinquennial plan was unworkable and in 1961 the concept of a 'rolling' five-year plan or 'five-year forward look' was introduced... under this scheme the National Physical Laboratory reviews its five-year plan annually. It is understood that the plan agreed for the first year of the quinquennium is quite realistic in terms of staff complement and expenditure on equipment and services. For the succeeding two years, the plan is regarded as less firm and the provisional allocations for its fulfilment are understood to be subject to some revision in the light of unforeseen changes in the financial or scientific situation. The plans for the next two years are accepted by both sides (the Treasury and the Laboratory) [illegible] to the tentative estimates which will become progressively firmer year by year. Each rolling five-year plan assumes a constant value for money, and any adjustments for increased costs are made when the following year's plan is agreed." 4/

Whether the particular scheme that has evolved at the National Physical Laboratory is, in fact, the ideal solution for all types of laboratories in different countries is an empirical question to be examined very closely. All that can be said at this point is that it seems to be a very definite improvement over the rigidities of a fixed budgetary cycle. But the fact that the nature of the budgetary cycle and the practices surrounding the actual operation of the budget affect the productivity of the laboratory and the effectiveness of its scientists and engineers can no longer be denied. It is to these twin problems of creativeness and productivity in the laboratory that attention is now turned.

Creativeness and productivity in research organizations

While creativeness and productivity are obviously highly interrelated, they are not identical, and such studies as have been made have attempted to treat these two concepts in a distinct fashion. Underlying this tendency is an assumption, which is often implicit, that productivity is easier to deal with than creativeness. Among those who have studied the problem, there is a general feeling, but by no means universal agreement, that productivity in a research laboratory does not differ too significantly from productivity in any other kind of organization. Creativeness, on the other hand, is often felt to be a special attribute with special problems unique to science and other activities. Be that as it may, the study of creativeness in research laboratories, in particular, is still in its infancy.

Before it is possible to say with any degree of confidence what factors in the laboratory, its organization or even in the larger environment may affect the creativeness of scientists and engineers, it is obviously necessary to be able to identify what is meant by creativeness. Even if creativeness could be identified satisfactorily, it would still be difficult, given the stage of current knowledge, to be able to isolate with sufficient rigour the precise factors and their specific contribution. If such factors could be isolated, it is conceivable that experiments could be conducted in which such factors would be introduced in a controlled fashion. This step is still quite distant; and yet most of the people who have ever been involved in research feel they have quite a good idea about what creativeness is and sometimes even who the creative people are, although this is, admittedly, mostly a matter of intuition.

There is a further difficulty with faith and intuition in so far as no one knows, and there is a tendency to pay little attention to all the potential creativeness which is lost or not fully awakened. In the last analysis, creativeness, at the extreme ends of the scale (the very creative and those who seem completely uncreative), is reasonably easy to detect - though not necessarily

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4/ Sir Gordon Sutherland, "The National Physical Laboratory", in Sir John Cockcroft, ed., The Organization of Research Establishments (Cambridge, Cambridge University Press, 1965).

and not very often before the fact - but it is with the great mass which lies between these two extremes that there is the most difficulty and the most opportunity. As a reasonable working hypothesis, it may be suggested that the truly creative scientist at the very top of the scale will probably express his creativeness almost irrespective of anything in the environment, human or otherwise. The environment may, however, prove to be decisive for all who are below the very top. The degree of encouragement or inhibition may influence a person's realizing his maximum creativeness.

One of the main results that emerges from studies to date 5/ is the complexity of the process of creating. There is also a strong suggestion that creativeness is a product of tensions rather than of their absence. Investigators do not agree on which particular factors should be in a state of tension, but they all seem to agree that some state of pushing and pulling on these factors is most conducive to creativeness: order, but a good deal of disorder at the same time; detachment, but a good deal of attachment at the same time; and so on. Apparently, the really creative person thrives in a dynamic state of tension, and one would suspect that he does much to create this state, at least on a psychological level, for himself. 6/

5/ See, for example, S.A. Mednick, "The associative basis of the creative process", Psychological Review, Vol. 69 (1962), pp. 220-232; S.A. Mednick and M.T. Mednick, Manual: Remote Associates Test. Form I, (Boston, Houghton Mifflin Co., (1966); Donald C. Pelz and Frank Andrews, Scientists in Organizations: Productive Climates for Research and Development (New York, John Wiley and Sons, Inc., 1966); and Gerald Gordon, "The identification and use of creative abilities in scientific organizations", Proceedings of the Seventh National Research Conference on Creativity (March 1966).

In recent years, there has been some hope among some investigators in this field that Mednick's newly created test for creativeness (the so-called "RAT" test) might actually discriminate between degrees of creativeness and non-creativeness. The test requires one to think of an unusually associated word related to three given words. Thus, when presented with the words "rat", "blue" and "cottage", the correct answer would be "cheese". Whether this sort of word association test is, indeed, akin to the creative process or even to one facet of it, as is claimed by Mednick, is still open to question. Obviously, those with high verbal ability are likely to score higher on the test. And, in its current form, the test is necessarily restricted to those who have a superior command of the English language. The Mednick RAT test has been used by at least two other researchers in the field, with several samples of scientists and engineers. Results have been mixed, to say the least; and, of the two, Gordon seems the more optimistic about the potential usefulness of the instrument. Even Gordon, however, does not suggest that this is a sufficient test of creativeness.

6/ See Thomas S. Kuhn, "The essential tension: tradition and innovation in scientific research", in Calvin Taylor, ed., The Third (1959) University of Utah Research Conference on the Identification of Creative Scientific Talent (Salt Lake City, 1959), pp. 162-77.

For the reasons mentioned above, much of the research on creativeness has focused on the psychological dimensions, and considerably less attention has been paid to the environmental factors which may encourage or inhibit creativeness. 7/ From the point of view of any organization or its research director, there are two important questions. The first is how one recognizes the man with the most potential creative ability from among a number of possible recruits; and even if a man has already shown some creativeness in his work, how one can be reasonably sure that he will continue to exhibit this in his subsequent endeavours. The second major concern is what should the organization be doing, or not doing, to encourage the maximum amount of creativeness possible in each person.

The best answer to the first question is probably still the intuition and judgement of the man who has a good record for having spotted such people in the past. There is no test or combination of instruments known today that will necessarily do as well as informed intuition. The answer to the second question is far more complex. Many of the points have already been covered in other contexts. Essentially, it comes down to putting up as few barriers as possible, so that whatever creativeness exists can find an outlet. Such barriers can be psychological, organizational, interpersonal or of other derivation. On the more positive side, creativeness should be nurtured especially by the director, in so far as the director makes it clear that he recognizes what is going on and helps to convince others (usually top management or the financial officers) that what is being done is creative and worth waiting for.

Beyond these two vital questions, there is an even more basic question which is rarely approached with complete candour. The fact is that not all organizations want a great deal of creativeness from all of their scientists and engineers all of the time. 8/ Creativeness has become one of those terribly important words surrounded by an aura of magic. It is the cloak in which everyone would like to be wrapped. Who would not like to be thought of as being original and novel, brimming with brilliant imagination. But, at the same time, it is obvious that creativeness means different things in different situations. This applies not only to the distinction between ability and performance, 9/ but, more concretely, to the fact that many phases of most research require great care, precision and attention to routine details. Undoubtedly, most routine tasks can be approached creatively, even though they require little, if any creativeness. This statement is not so much a play on words as an attempt to underscore the fact that however fashionable creativeness appears to be, most organizations actually discourage it and do little to foster its development.

7/ For an extremely useful annotated bibliography, see Morris I. Stein and Shirley J. Heinze, Creativity and the Individual: Summaries of Selected Literature in Psychology and Psychiatry (Glencoe, Illinois, The Free Press, 1960). See also Calvin W. Taylor and Frank Barron, ed., Scientific Creativity: Its Recognition and Development (New York, John Wiley and Sons, Inc., 1963); Gary A. Steiner, ed., The Creative Organization (Chicago, University of Chicago Press, 1965).

8/ See, for example, Donald A. Schon, "Six ways to strangle innovation", Think (July-August 1963), pp. 29-32; and N. Kaplan, "Some organizational factors affecting creativity", IRE Transactions on Engineering Management, Vol. EM-7 (1960), pp. 24-30.

9/ Pelz and Andrews, op. cit., p. 156.

Really novel ideas may not be supported or may have to go through so many check-points that, even if successful, they are quite worn by the time all of the obstacles have been overcome. A novel idea or a novel approach is greeted by a reminder that a more traditional result and effort are expected first. The unwillingness of a research director to "go out on a limb" and support high-risk undertakings may discourage such proposals from ever seeing the light of day. If a laboratory really needs and wants creativeness, there is much that can be done (or not done) which will help to realize this objective. If, on the other hand, true creativeness would be counter-productive, there should be less of a fetish about it.

In some of his recent work, Gordon has made a distinction between creativeness and innovation which looks quite promising. 10/ By creativeness, he means primarily the ability to recognize a problem, to perceive anomalies and to consider possible resolutions. In contrast to what might be called the problem recognizer, Gordon postulates a problem solver. The innovative problem solver provides a more imaginative, sometimes an even more novel, solution.

Such a distinction is not entirely new, but it does emphasize the importance of clearly defined objectives and goals in any given research organization. An organization concerned primarily with new technology and its improvement will undoubtedly want more of the quality Gordon has labelled "innovation". If high-priority problems have already been defined, whether by the general economic plans for the country or by the specific needs of a particular industry, and there is agreement in the laboratory or research organization that these are meaningful or achievable goals, then the most important type of person is the innovator who will look for the most imaginative solution. Such an organization would be less likely to want to encourage the presence of too many problem recognizers, since this might divert attention from the main goals of the laboratory and result in a high level of frustration. Some problem recognizers would undoubtedly be a valuable element, especially as they serve to "jostle" their colleagues into thinking of new and alternative ways of doing things. 11/ For the most part, however, persons with this type of creativeness should undoubtedly be encouraged to seek out organizations whose main function coincides with their own capabilities - namely, the anticipation and recognition of new types of problems on the horizon.

Summing up, it is clear that there is much that can be done here and now to take advantage of the creative potential of most scientific workers. First, it is essential to distinguish different types of creativeness, not only in the abstract, but in the specific context of the job to be done. It is quite conceivable that people have different amounts of these different types of creative ability; it is even possible to find these different types within the same man during the course of his career. The important thing is to match his type of creativeness with the needs of an organization.

The organization can do much to foster the best in a man by putting up the least possible number of barriers to getting a job done and by providing a sufficiently variegated environment so that there is stimulation from both similar and different kinds of colleagues. It goes without saying that reasonably satisfactory facilities, such as libraries, are a pre-condition.

10/ Gordon, op. cit.

11/ Donald Pelz' contribution is particularly noteworthy. See his discussion of "Dither" and the influence of colleague stimulation in Pelz and Andrews, op. cit.

Lastly, clear-cut organizational objectives that are mutually understood and agreed upon (even jointly created by all concerned) are probably the most important factor in an effective organization. It should be emphasized again that many organizations or sections of organizations (because of the way in which they are organized, because of the lack of clarity of goals, because of the nature of their leadership, or for other reasons) have been primarily responsible for discouraging creative impulses or "strangling innovation". 12/ Creativeness and innovation have been stifled by the very organizations that claim these to be their main objectives. In other words, the organizational environment and the environment in which it exists may play a decisive role in realizing (or failing to realize) the fullest creative potential of scientists and engineers who are a part of that organization.

Next to be considered are some of the problems associated with productivity in the research organization. In one sense, there has been considerably less difficulty in trying to identify productivity. The number of publications or patents, in the case of engineers, has been used as an index of productivity, but with only a degree of success. While papers and patents are indeed one aspect of productivity, these are not sufficient. The difficulty comes, of course, in trying to assess the importance (whatever the criteria for importance might be) of such a unit of output. Countless examples can be cited of a single paper or patent that is worth perhaps a hundred or even a thousand others. There are, moreover, such problems as the opportunity to publish and the encouragement to do so, as well as a host of related factors, bearing upon the significance of any such unit of output.

Significance may be viewed from a variety of perspectives, beginning with the relationship of a particular paper to the field of science of which it is a part. Efforts to get at this more deeply have revolved in recent years around an attempt to use citation indices as a measure of how often other people in the field have cited a particular paper. Even this method is considered less than satisfactory because of the vagaries of citation patterns among scientists and the different norms within subgroups of scientists, not to mention the differing rules in the various journals. Nevertheless, the analysis of citations does provide some clue about the "usefulness" of the paper, however rough a measure it may be.

One further point should be emphasized. Many organizations, especially those in industry and Government (as opposed to universities) may not encourage publication of papers, for a variety of reasons. If failure to publish were used as an index of productivity in such organizations, it would clearly be a poor indicator and would be of little usefulness to the management of such laboratories in trying to evaluate performance within their organizations. Again, one returns to the crucial nature of the importance of clearly defined organizational goals and objectives. To hold out the possibility or even the desirability of publishing his work to a new recruit when this is, in fact, a very low priority objective is obviously self-defeating for both the organization and the person in question. All too often, a scientist wants to publish primarily because he thinks it is expected of him and because it is a basis for evaluating his performance.

12/ Schon, op. cit.

By and large, most of the studies and much of the conventional wisdom handed down by laboratory directors on the basis of their own experiences seem to agree on a few fundamentals which, in their essence, are not significantly different from the factors believed to influence creativeness. If one begins with good people who have a good idea of the specific objective and then stays out of their way, so to speak, then one has every reason to expect satisfactory results. The kinds of tensions mentioned above seem to work for productivity as well. Supervision should not be so close and ever-present as to be suffocating, but it should be present when the scientist or engineer "needs" it. There should be ample opportunity for interaction and discussion with people in the same or neighbouring disciplines, as well as with people in quite different disciplines.

There should also be ample encouragement, as well as opportunity, to keep abreast of what is going on in the field, not only through the literature and professional meetings, but by being able to visit other laboratories and by being attractive enough to be visited by foreign scientists and engineers. There seems to be considerable agreement over the mutual advantages to be gained by this type of interchange, and one finds some arrangements for such "exchanges" or just plain visits not only in university laboratories which have traditionally been open in this way, but in Government and industrial laboratories. 13/

Adequate facilities and their maintenance are, of course, essential for continued productive work in the laboratory. There is some indication that "adequate" means something less than what scientists and engineers with greater financial means may feel they would like to have. All too often, scientific productivity has been virtually choked by too much equipment and too much emphasis on it. Something less than "too much" creates a tension that forces the good scientist or engineer to improvise from time to time and actually to think about his problem, rather than pursuing it mechanically from instrument to instrument. On the other hand, there are increasingly numerous examples where the lack of a particular instrument or the necessity to rely on an old model may severely hamper the kinds of research results to be expected. In some cases, it may simply not make sense to attempt certain problems without minimally adequate equipment. It would be a bit like being forced to work out

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13/ The comments of J.B. Fisk in Cockcroft, op. cit., pp. 209-210, on the policies at a major industrial laboratory might well apply to most laboratories anywhere:

"It is essential, in order to keep up with the advancing forefront of scientific knowledge, to encourage these opportunities to exchange views with others. The research organization of an industrial laboratory cannot hope to provide by itself all or even a majority of the new ideas needed by its sponsors. A more realistic goal is the more modest one wherein the organization keeps in such intimate contact with the whole scientific world that it will know of new results promptly and, sensing their importance, can mobilize to take advantage of them. But only if our own people are themselves doing scientific work of the highest order and are known and respected for their own contributions by professional, society and university people of distinction, can they participate in and profit from these exchanges."

the calculations for a particular experiment on a hand calculator for a year or so when one knows that such calculations could be made in a matter of minutes were a computer available.

Essential also for productive work are adequate salaries and other financial incentives.14/ It is manifestly impossible for salaries to be competitive on a world-wide scale; but, within any particular country, it is essential that salaries for scientists and engineers should bear some relationship to the importance assigned to such activities. This means, in effect, that salaries for scientists and engineers should be on a par with (in specific cases, a bit lower or a bit higher) the most highly skilled and prestigious jobs within the country, not only at the senior level, but at the very outset, so that this kind of career will be attractive to the most highly qualified young people.

There should also be some relationship between the salaries paid at various levels, the prestige generally accorded to various types of activities and the importance of those activities to the country. That is to say, in specific circumstances, it may be ncessary to have a somewhat higher salary scale in order to attract and hold very highly qualified people in industrial and developmental laboratories. Such laboratories, if they are good in every sense of the word, are no longer looked down upon and treated as "second class" in all instances in all countries. In some countries, however, a little of the outmoded "second-class label" undoubtedly still attaches to even the best of the industrial laboratories. This situation might be especially true in a developing country, where the attitudes and the prestige assigned to these different kinds of activity in laboratories are still those of the past. To reinforce such old prejudices by providing greater rewards to university scientists, as opposed to those in applied and developmental activities, may be quite detrimental to the over-all scientific effort of a developing country.

Salaries are very important and status is of some importance, though it is less likely to be admitted openly. Technical facilities also are important. But beyond these factors, there are special problems which are usually a bit more subtle, but which help to create an environment that attracts the best minds and keeps them working in a productive and useful way for the good of the individual, the country and the world. Here one must refer again to the importance of communication, the opportunities to visit and attend meetings abroad (special attention needs to be given to the provision of such opportunities to young people and not just to senior personnel). A scientist does not live by bread alone. He needs the opportunity to see and be seen, to know what is going on in his particular field and to know how well he is doing in a larger, comparative context. The provision of such opportunities is essential for continued growth and development of not only the individual scientist, but indeed, the laboratory as a whole. The cost of providing this king of communication and interchange is relatively modest in relation to the total cost and is virtually a bargain if one considers the much higher costs of following the opposite policy. The over-all costs of research and development tend to be high, but the benefits expected generally make these activities seem worth the price.

14/ United States of America, Federal Council for Science and Technology, The Competition for Quality: The Effect of Current Salary Levels on the Federal Government's Ability to Recruit and Retain Superior Scientific and and Engineering Personnel (January 1962).

General comments and conclusions

In considering the career, status and working conditions of scientists and engineers in the Public Service, there are essentially two approaches. 15/ One is addressed to specific career and status problems with the implicit, even explicit, objective of bringing about some improvements in the existing system through such devices as better pay scales and more fringe benefits. The other approach is to examine some of the underlying conditions and the larger environment in which such factors as salaries and status play some part. The latter course has been chosen in this paper. It has been attempted to single out those crucial elements of the environment which make a real difference to the outcome irrespective of the specific salaries or personnel practices in any particular country. The specific practices are certainly important, but the context in which they exist is far more so. For this reason, emphasis has been placed on the significance of policies and organizational practices, and a clear understanding of the relationship of all these factors to creativeness and productivity. Once this relationship is understood adequately, any necessary modifications of specific personnel practices will seem simple and self-evident. The United Nations Educational, Social and Cultural Organization recognizes this fundamental fact by stressing the importance of "national science policies" 16/ as they affect career and status, which may actually differ in detail from situation to situation. In the present author's view, it is these science policies and their implications for the larger context and environment which determine whether specific career and status decisions have any significant impact.

If one begins with a competent and properly motivated scientist or engineer, it is quite clear that his contributions can be enormous. It is also fairly certain that the kind of organization in which he must work and the science policies that affect his organization and him will be important determinants of whether his contribution, for himself and the society, will ever be realized. Although some progress has been made towards acquiring more precise and more reliable knowledge concerning such factors and the ways in which they may work, the fact is there is still a long way to go. Research organizations, the universities and, indeed, the national organs responsible for science policy should all be playing their parts in trying to achieve a better understanding of the research process itself and of the relationship between the research process and various national goals, such as economic development and technological innovation. Much more research by social scientists, with the advice and collaboration of other scientists, should be encouraged and supported. 17/ The possibility of much more deliberate experiementation with organizational forms and practices for research activities should be entertained and studied carefully.

15/ For a pioneering work in this area, see Edward McCrensky, Scientific Manpower in Europe, (New York and London, Pergamon Press, 1958). For another discussion, see Y. de Hamptinne, "The career of the research worker", Impact of Science on Society, Vol. VI, No. 3 (Sept. 1955), pp. 169-180.

16/ For a very perceptive and broad discussion of the significance of national science policy, see Pierre Pifaniol and Louis Villecourt, Pour une politique scientifique (Paris, Flammarion, 1963).

17/ See Research Management, Vol. XI, No. 5 (September 1968), which is devoted entirely to research on research.

In brief, no country had the one and only solution to the problem of running a research enterprise effectively. Even if it did, it is highly unlikely that its policies and practices could be transferred intact to other countries, to other cultural milieux and to differing traditions. There is undoubtedly much to be learned from countries with long experience and many successes - France, Japan, the Union of Socialist Republics, the United Kingdom, the United States of America and many other countries - but there is also much to unlearn; and there is probably much that can be done better and more effectively if one is not hampered by outmoded thinking.

For example, part of the inheritance with respect to both science and the Public Service has tended to rule out women for such careers. 18/ While this way of thinking may have been in accord with the cultural realities of another time, it is patently absurd today. The employment of women is only one of many changes that can be expected today. As has been repeatedly stressed, different objectives and tasks require different types of organization. That scientists and engineers may have quite different proclivities at different stages of their lives suggests a strong need for free movement among organizations. The opportunity to move easily from organization to organization at different stages of one's career can help attain the best possible match between organizational objectivities and individual capabilities. This possibility suggests the need for rather similar systems of fringe benefits, retirement and other such emoluments to enable - indeed, to encourage people to move. There should be no loss or stigma; rather, there should be considerable encouragement for those scientists who can be productive to move from fundamental to applied to developmental and perhaps back to fundamental research activities, not to mention teaching and other possibilities. The objective would be to maximize the match between organizational goals and individual capabilities.

Throughout this paper, a single major theme, with two parts, has been stressed repeatedly. Many of the fundamental ideas about the nature of science and the Public Service derive directly from nineteenth century European models. Many of the ideas about the nature of science as a career and the Public Service as a career are still back there. They have been dressed in a more modern garb, perhaps, but they are still fundamentally the same old ideas which have little validity or utility in the latter half of the twentieth century. Such notions, for example, as rigid hierarchical organizational maintenance without concern for changing conditions and objectives no longer seem appropriate to the conditions of today. Science is no longer possible in a scientist's garret; it must be organized in order to flourish. Science can be organized to enhance the creativeness of scientists for the benefit of mankind, and there are already some good ideas as to how this might best be done. Some of these ideas have been suggested in this paper, but much more work and experimentation on a continuing basis are essential. In one sense, the brightest and the greatest opportunity lies with the newer countries, which are not forced to repeat the history of other countries; or, to put it more positively, which have the foresight to learn from the past without repeating it because they are turned towards the future. 19/

18/ See, in particular, Jacquelyn A. Mattfield and Carol G. Van Aken, eds., Women and Scientific Professions: Massachusetts Institute of Technology Symposium on American Women in Science and Engineering. (Cambridge, Massachusetts, and London. The Massachusetts Institute of Technology Press, 1965).

19/ For a general treatment of this subject, as well as an extensive bibliography, see N. Kaplan, ed., Science and Society (Chicago, Rand McNally, 1965).

POLICIES AND PROGRAMMES TO INCREASE AND IMPROVE MOTIVATION, CREATIVENESS, LEADERSHIP AND OTHER FACTORS BASIC TO EFFECTIVE PERFORMANCE OF SCIENTIFIC AND TECHNICAL PERSONNEL IN THE PUBLIC SECTOR

Caroll L. Wilson*

The purpose of this paper is to examine the elements conducive to motivation, creativeness, leadership and other factors related to the effective performance of scientific and technical personnel in the public sector in developing countries. In considering affirmative factors, it is necessary also to consider the barriers and handicaps that confront developing countries in providing and maintaining an environment that can attract and hold high-quality scientific and technical personnel in the public service.

The range of "developing countries"

As there are vast differences among developing countries, no universal prescription is valid. Moreover, the term "developing countries" covers a range from the most newly independent States with a few hundred thousand people to vast countries that have been independent for twenty years, such as India, to countries with centuries of independent rule. There is also a great range of cultural differences, including attitudes towards science and technology, and characteristics of social mobility and of tribe or caste.

The type of developing country for which these comments may be useful as a basis for discussion are those moving or desiring to move from predominantly agricultural, often single-crop agriculture, to diversified agriculture, increased industrialization and diversification of export earnings. They are countries in which there are one or more universities, some technical institutes, agricultural and medical services and primary and secondary educational systems.

The basic cultural value system of the society may be of overriding importance in the creation of an environment of challenge, recognition and reward for scientific and technical personnel. The basic value structure of the society and the kinds of skills and activities that the society rewards with recognition and perquisites profoundly affect the career choices of talented young people. If the society confers its prestigious rewards upon those whose education is classical scholarship, it is to such studies that talented young people will turn.

Types of personnel and employment opportunities

The observations in this paper are focused mainly on scientific and technical personnel, but they also apply to other high-level professional personnel, such as medical doctors and economists. Although reference is made to the great need for technician-level personnel, principal attention is directed to those with at least a first degree in their fields. This category includes many who are teachers, but whose basic preparation was in science or engineering.

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Bearing in mind the definition of types of personnel and their educational qualifications, it is useful to consider the types of employment opportunities for such personnel in developing countries. These opportunities occur under the following categories:

(a) Teaching. Teaching may be in the secondary school system, at vocational training institutes or at universities. The presumption is that for teaching at such institutions, at least those at university level, one a priori requirement is a first degree in science or engineering. The largest number of employment opportunities for scientific and technical personnel in developing countries are in teaching at university level;

(b) Research and development. It is to be hoped that there would be some opportunities for research at universities. In many countries, however, research is not done at universities, but at special institutes which are sometimes allied with universities and sometimes independent. The main opportunity for innovative research and development is likely to be at such institutes. The support, leadership and general environment at such institutes are of critical importance in terms of their quality and ability to attract and hold highly qualified people. There may be some employment opportunities for research work in industrial laboratories if such exist, and in technical control functions in industry, but such non-public institutions are unlikely to provide such employment;

(c) Administration. Engineers are required in the administration and for the performance of technical functions in such organizations as the public works department, for the design and construction of roads, bridges, water-supply, buildings etc. The electrical power organization, which may be either a Government department or a Government corporation, requires engineers for the operation and maintenance of hydroelectric and thermal power-stations, and to build and operate the transmission and distribution systems. Other employment opportunities for engineering administrators exist in such activities as the operation of ports, the railway system, the telecommunications system and the airline;

(d) Industrial administration. At oil refineries, motor vehicle repair and maintenance establishments, machinery sales and servicing organizations, and in manufacturing and processing industries, there are also employment opportunities and requirements for scientific and technical personnel.

It is clear that the above-mentioned types of employment opportunities are to be found almost exclusively in the public sector, either directly in a depart department or ministry, or indirectly through State corporations which may exist for operating the railways, the telecommunications systems, the electrical power system and the airline. But the distinction between public and private employment of scientific and technical personnel is not very meaningful in most developing countries because practically all employment opportunities are to be found in the public sector. Thus, the problem of competition or conflict between employment in the public and private sectors, which exists in some developed countries, seems to have little relevance for most developing countries.

In considering the performance requirements in the employment opportunities listed above, it is useful to identify what is expected in the key positions. There is, on the one hand, a requirement for research and innovative scientific and developmental contribution in agriculture, health, industrial development, geology and other services, where the need is for people with original minds working in a situation that favours their being productive. The other general personnel requirement is for institutional leadership in the Government and at universities, research institutes and other technological enterprises. Such institutional leadership is a vital ingredient in the creation and maintenance of conditions that will attract and hold well-qualified scientific and technical personnel. At the same time, persons capable of undertaking such institutional leadership usually have the highest qualifications for service elsewhere in the world and are therefore subject to the strongest pulls to emigrate.

Special character of scientific and technical personnel

It is important to consider what is special and different about scientific and technical personnel, as compared with many other kinds of high-level personnel. The most important and critical difference, in terms of the demands that it imposes upon national leadership in the developing countries, is the international mobility of high-quality scientific and technical personnel. People with good training and demonstrated performance, within the definition of scientific and technical personnel used in this paper, are members of an international scientific and technical community. The very skills and preparation that such personnel have are in short supply throughout the world, including many developed countries, which offer highly attractive conditions of employment and recognition for such personnel. Thus, scientific and technical personnel have an education that has a "cash value" in various countries. By contrast, those with other preparations, such as in law, do not have an expertise that has a cash value abroad.

The real competition for high-quality scientific and technical personnel is not between public and private employers within the developing country, but with developed countries overseas to which national scientific and technical personnel can migrate. In this connexion, reference is made below to factors selected at the Conference on the Migration of Talent from Less Developed Countries, held at Ditchley Park, England (United Kingdom) in February 1968. It is worth while considering more closely the reasons that people migrate for they have a great bearing on the situation confronting the leadership in developing countries in establishing policies and practices which will tend to counteract the "push" and "pull" factors so well described in the following excerpt from the report of that Conference:

"a) The Push Factors - Those which encourage scientific and technical personnel to leave their country of origin.

"1. The educational policies and structures of developing countries often seem inappropriate, both in quantity and quality. As a result, too many of the wrong kinds of graduates are thrown on to the labour market.

"2. The slow rate of economic growth in some countries has meant that their capacity to absorb educated man-power into the economy is less than their capacity to produce such people in their education system. This generates an 'overflow' which contributes to migration.

"3. One of the reasons for the misallocation of educational and training resources is inappropriate man-power planning. This itself is partly due to limitations in present techniques of manpower planning, and partly to a lack of knowledge or concern about such planning on the part of the governments.

"4. The salary structure found in many countries is prejudicial to the retention of highly educated manpower. The issue of wages is extremely complex. On the one hand a university graduate in a developing country could obtain perhaps five times his salary if he worked in the United States. But at the same time he is probably already earning thirty times the per capita income in his own country.

"5. The social structure and traditions of some societies is such as to hinder the efficient use of high-level manpower. For example, in many societies it is still considered beneath the dignity of an educated man to perform any kind of manual task.

"6. In some countries important minority groups are adversely affected by discriminatory attitudes and legislation. The Chinese in Malaya, the Asians in Kenya, the Tamils in Ceylon, can all be cited as examples.

"7. In some countries... political factors have created a climate which is inimical for economic development and academic freedom.

"b) The Pull Factors - The main attractions of the more developed country for scientific and technical personnel from developing countries.

"1. The demand for highly qualified manpower which is growing faster than the capacity of the educational system in the developed country. This results in good opportunities for qualified immigrants. This is especially true of the United States, where the massive federal investment in aerospace and defence has created a tremendous demand for certain types of scientists and engineers. Also the slow expansion of the American medical schools has failed to satisfy the rapidly rising demands for medical care, and has helped to create many job opportunities for foreign trained doctors and nurses.

"2. Both Britain and the United States have further aggravated the problem for developing countries by introducing immigration laws which give priority of entry to people with high qualifications. This was one of the special features of the (British) Commonwealth Immigration Act of 1963. Also the new American law which came into force on July 1st 1968 will make it even easier for scientists, engineers, and doctors from developing countries to enter the United States.

"3. Other pull factors are the converse of the push factors in developing countries: higher salaries, greater social mobility, absence of persecution of minority groups, greater opportunities and political freedom for some people, and fewer bureaucratic frustrations. All of these are factors which influence people to move to the more developed countries. Sometimes the factors turn out to be more imaginary than real, and the migrant becomes disillusioned and returns home." 1/

Needs of scientific and technical personnel for effective performance

In comparison with the push-pull factors enumerated above, it is useful to identify some of the needs of scientific and technical personnel for effective performance. The needs described below relate to high-quality scientific and technical personnel who may be employed in a considerable range of activities, from the direction of a scientific institute to teaching at a medical school, from heading a division in a geological survey to directing the meteorological service, from the conduct of geophysical surveys to serving as scientific advisor to the Chief of State. For those who are in higher level positions, there may be a strong pull from international organizations, which offer a wide range of employment opportunities for professional performance and exercise many of the pull factors cited above for employment in some of the developed countries.

Some of the factors that developing countries need to consider in attracting and holding good scientific and technical personnel are as follows:

(a) Means must be found to avoid isolation from scientific and technical colleagues in other parts of the world. An important component in effective scientific and technical work is interaction with one's peers. This interaction can come about through publications, through travel to international meetings and through periods spent at laboratories or centres in developed countries. The associateship scheme, which was first established by the Centre for Theoretical Physics at Trieste, enables theoretical physicists to spent up to three months each year on a three-year appointment at the Centre at Trieste, provided they reside and work in their home countries during the remainder of the year. Efforts are being made to establish such associateship schemes on a much broader scale, and if these efforts are successful, an important counter-force to the "brain drain" and an improvement in the potential quality of scientific work in developed countries will have been achieved. Important initiatives in these directions were taken by the United Nations Educational, Scientific and Cultural Organization at its 1968 General Conference;

(b) The Government should keep abreast of new literature. The pace of advance in scientific and technical fields is very rapid, and means are needed to enable scientists to follow the literature on a sufficiently broad basis to be informed, to be stimulated and to avoid lengthy commitments of time and resources

1/ "International migration of talent from and to the less developed countries", paper No. 13, - Report of the Conference on Migration of Talent from Less Developed Countries, Ditchley Park, England (United Kingdom), 16-19 February 1968.

to questions that have already been answered by others. Journals are expensive, but there are now available some services which provide to subscribers the tables of contents of leading journals in the life sciences, the physical sciences and the chemical sciences, and in technological fields, for a small fraction of the cost of such journals and much more promptly.

(c) Visiting the developing country for short and long stays should be made attractive to leading scientists and technologists from overseas. Suitable accomodations, laboratory visitor status and quality of the work under way are factors in interesting prominent scientists and engineers to visit developing countries and to remain for significant periods of time. The "natural laboratory" potential of developing countries can provide opportunities for research which are unavailable in other places;

(d) There must be suitable working conditions for scientific and technical personnel. If teaching loads are too heavy (and they often are), scientific and technical personnel cease to remain informed or productive in their professional fields. Although there is often a lack of laboratory facilities, perhaps the greatest handicap to effective performance of scientists and technologists in teaching positions in developing countries is the overwhelming teaching load they must handle.

A balance must be struck between providing, on the one hand, that minimum level of special conditions which will attract and hold scientific and technical personnel, and, on the other hand, providing such special privileges that they are given a "select élite status" so that the remainder of the Public Service personnel are demoralized and resentful. In such circumstances, the measures taken to attract and hold scientific and technical personnel become self-defeating. It is simply not possible nor, indeed, necessary to match directly the rewards that are given to scientific and technical personnel by the developed countries. If the conditions of status, recognition, potential for professional achievement and avoidance of isolation are met, and the spirit within the scientific establishments is stimulating and recognizes and rewards merit, the best scientific and technical personnel in developing countries will remain at home.

Technological innovation

Except for cultural richness, the conduct of scientific and technical endeavours should not constitute an end in itself, especially in a developing country with backward technology and shortages of funds, personnel and foreign exchange. There are many examples of solicitous and generous treatment of scientists and freedom for them to pursue their particular professional interests without any sense of obligation to give attention to the urgent technological problems of the developing country. A disproportionate amount of the scarce resources of many developing countries has been devoted to the support of basic science research institutes or to nuclear energy activities having no real connexion with the developmental needs of the country. The principal purpose achieved by such activities has been to keep at home some scientists who would otherwise have migrated abroad, but there is a real question as to how much of such a luxury developing countries can afford.

Part of this problem derives from cultural attitudes regarding pure and applied science. In a number of developing countries that were formerly part of the British colonial system, the traditional British attitudes towards pure and applied science have been carried over to the universities and research institutes. These attitudes provide large rewards and status for those engaged in pure science and very little for those working in applied science.

A special challenge to developing countries is to generate conditions for recognition of technological innovation, by which is meant the application of science and technology to problems in the developing country. These problems may involve, for example, soil-conditioning for agriculture, new types of crops and growing conditions, adaptation of processing technology for upgrading local products and adaptation of processes and machinery for multipurpose production in view of small markets.

A number of means could be considered for recognition of those who lead in such applied activities. Such recognition could be in the form of prizes, in pay and perquisites of housing, and in opportunities to travel abroad to confer, with colleagues in the field. Recognition of such contributions by top-level political leadership also could be extremely valuable.

There is a tendency to equate expenditures on research and development as a percentage of the gross national product, as a measure of wise investment for national development. Although such expenditures may indicate a good investment, they certainly do not necessarily indicate it. They may merely indicate that the scientists have achieved this allocation of national resources for their own purposes without any real regard for the developmental needs of the country. Thus, on the one hand, political leadership must encourage and cultivate scientific and technical personnel, as well as provide special recognition and conditions for such personnel, and, on the other, it must avoid the diversion of scarce assets and resources to highly academic research.

Environmental needs

One can list a number of things that are necessary ingredients for the creation of an environment that will attract and hold high-quality scientific and technical personnel in the service of the developing country. Some of these factors are as follows:

(a) Recognition by top-level political leadership of the need to recognize, encourage and defend special arrangements to attract and hold scientific and technical personnel;

(b) Science policy leaders with wisdom and close connexion with top-level political leadership, who will take the initiative to educate political leaders as to the needs and potentials of science and technology for national development. To do this, they must leave their "ivory towers" and must themselves understand such matters;

(c) Meeting enough of the special needs mentioned above so that scientists, engineers and medical personnel of the developing country feel themselves a part of the international scientific community and have a sense of commitment, excitement and enthusiasm for tackling the real problems of their country. This means the cultivation of patriotism, which calls for special qualities of leadership;

(d) Attracting ex-nationals to return. Ex-nationals generally have a desire to return to their native country even if they have migrated abroad presumably permanently. If conditions are made attractive enough for them to return for three months a year or during the academic vacation period, some may, in due course, return permanently and greatly enrich the supply of local talent;

(e) Vigorous recruitment of oversea graduates, which, although rarely practised by developing countries, can yield high dividends in terms of retention of personnel in whom the country has already made a substantial investment and who, at that point in their careers, would readily return home if assured of a job;

(f) Perquisites that may be of crucial importance and may be extended to scientific and technical personnel without unduly distorting the salary and reward scales of the Public Service include assistance in having access to current literature, travel to international meetings, funds for reprints of their own articles to circulate abroad, support of local scientific and technical journals, assistance in securing advanced degrees while employed etc. There would be a limit beyond which pay, housing and similar perquisites could not be extended without upsetting the balance within the Public Service as a whole. Under appropriate leadership, however, assistance of the types mentioned above might go far to encourage the development of indigenous scientific and technical resources.

Recent research in the United States of America on research and development management

A growing volume of research and literature reflects the interest of management scholars in the behaviour of scientists and engineers engaged in research and development. Although such studies have been directed to the large research and development establishments in the United States of America, some of the conclusions are relevant and applicable to the management of scientific and technical personnel in any environment.

At the University of Michigan, a study was made of over 1,300 scientists and engineers in industrial Government and university laboratories, to determine the effects of a variety of circumstances of environment, direction, recognition and reward on the productivity of Doctors of Philosophy, engineers and assistant scientists. 2/ A quantitative analysis was made of the factors of freedom, communication, diversity, dedication, motivation, satisfaction, similarity, creativeness, age, co-ordination and group effects on the productivity of those three types of personnel.

The findings of this study were reviewed by one of its authors, who summarized them in the following paragraph:

"As Andrews and I examined the conditions under which scientists and engineers did effective work, we observed a number of apparent paradoxes. Achievement was high under conditions that seemed inconsistent, including

2/ Donald C. Pelz and Frank Andrews, Scientists in Organizations: Productive Climates for Research and Development (New York, John Wiley and Sons, Inc., 1966).

on the one hand sources of stability or confidence (what I have called 'security') and on the other hand sources of disruption or intellectual conflict (that is, 'challenge'). It appears that, if both are present, the creative tension between them can promote technical achievement." 3/

In another authority's review of the same study, the following observations were made:

"Under these circumstances it should not be surprising that the results are complex and sometimes confusing. Many of the relationships are specific to certain criteria of performance and to certain groups of individuals. There are, however, some general results that are well worth noting:

"Is co-ordination compatible with freedom? Best performance occurred when both were present.

"Effective scientists both sought and received more contact with colleagues.

"In both research and development, the more effective men undertook several specialties or technical functions.

"Several simple questions showed that high-performing scientists and engineers were deeply involved in their work.

"Among various motives characterizing high performers, an outstanding trait was self-reliance.

"Effective scientists reported good opportunities for professional growth and higher status but were not necessarily satisfied.

"Colleagues of high performers disagreed with them on strategy and approach but drew stimulation from similar sources.

"Creative ability enhanced performance on new projects with free communication but seemed to impair performance in less flexible situations.

"Performance peaked at midcareer, then dropped, but less among inner-motivated scientists and those in development laboratories.

"As age increased, performance was sustained with periodic change in project, self-reliance, and interest both in breadth and depth.

"In loosely co-ordinated settings the most autonomous individuals did poorly - perhaps because they were isolated from stimulation.

"Groups declined in performance after several years, but less if the members became cohesive and intellectually competitive." 4/

3/ Donald C. Pelz "Creative tensions in the research and development climate", Science, Vol. 157 (14 July 1967).

4/ Donald G. Marquis, review in Industrial Management Review (Cambridge, Massachusetts Institute of Technology), Fall 1967.

In a ten-year study of several hundred graduate engineers, one major firm in the United States identified critical factors in job satisfactions and performance. The most important conclusions were that men who found their work interesting, used their knowledge and skills and felt the work was important found job satisfaction. If their superiors recognized their performance and suitably rewarded them for such performance, their productivity was high and they advanced steadily in achievement and responsibility. 5/ Some of these factors may seem obvious, but they are frequently ignored or their importance underestimated.

Of special relevance to developing countries is Project Hindsight, a study of the utility of research conducted by the United States Department of Defense. The conclusions of this study are so relevant to the comparative value of "science" and "technology" that the following summary of the study merits quotation here:

> "Recently developed weapon systems were compared with systems of similar function in use 10 to 20 years earlier. The most significant finding was that the improvement in performance or reduction in cost is largely the synergistic effect of a large number of scientific and technological innovations, of which only about 10 per cent had been made at the time the earlier system was designed. The common scientific and technological base of the systems was not analyzed. Of the innovations, or Events, 9 per cent were classified as science and 91 per cent as technology. Ninety-five per cent of all Events were funded by the defense sector. Nearly 95 per cent were motivated by a recognized defense need. Only 0.3 per cent came from undirected science. The results of the study do not call in question the value of undirected science on the 50-year-or-more time scale. In light of our finding that 5 to 10 years are often required before even a piece of highly applied research is 'fitted in' as an effective contributing member of a large assembly of other Events, it is not surprising that 'fragments' of undirected science are infrequently utilized on even a 20-year time scale. The most obvious way in which undirected science appears to enter into technology and utilization on a substantial scale seems to be in the compressed, highly organized form of a well-established, clearly expressed general theory, or in the evaluated, ordered knowledge of handbooks, textbooks, and university courses." 6/

This study confirms that the lag from science to invention is rarely less than from ten to twenty years. If resources are scarce, expenditures on technology yield a very much higher return than expenditures on science. Scientific findings are always available in the published literature.

5/ General Electric Co., Behavioural Research Service, Factors Which Influence Careers in General Electric (1966).

6/ Chalmers W. Sherwin and Raymond S. Isenson, "Project Hindsight: a Defense Department study of the utility of research", Science, Vol. 156 (23 June 1967).

The fact that in an advanced and sophisticated technology most of the important innovations have required not the discovery of new knowledge, but the application of existing knowledge to a newly perceived need, suggests that a large part of the needs of developing countries may be met by focusing at first on the needs. If the needs were defined in such terms that a solution would find ready users, the task of the development organization would be to find and adapt existing technology to meet those needs. Much of the relevant technology is available at no charge if one knows what is needed and where to find other solutions to the same need.

The following diagram illustrates the process of technical innovation, which includes the steps of adoption and use. Inputs are required from the market (economic and social utilization) and from the current state of technical knowledge. Taken together, these combine into the demand/technical feasibility recognition, which leads to the design concept, then to search and inventive activity leading to a solution, which, if it meets the demand criteria, is assured of a market.

It is worthwhile to mention that the most successful and rapidly growing firms in the United States of America are those guided by the philosophy that "If we can sell it, we can make it". The reverse philosophy - "If we can make it, we can sell it" - is rapidly becoming obsolete. Too often, after long and expensive research and development to develop a new product or process, no buyer could be found.

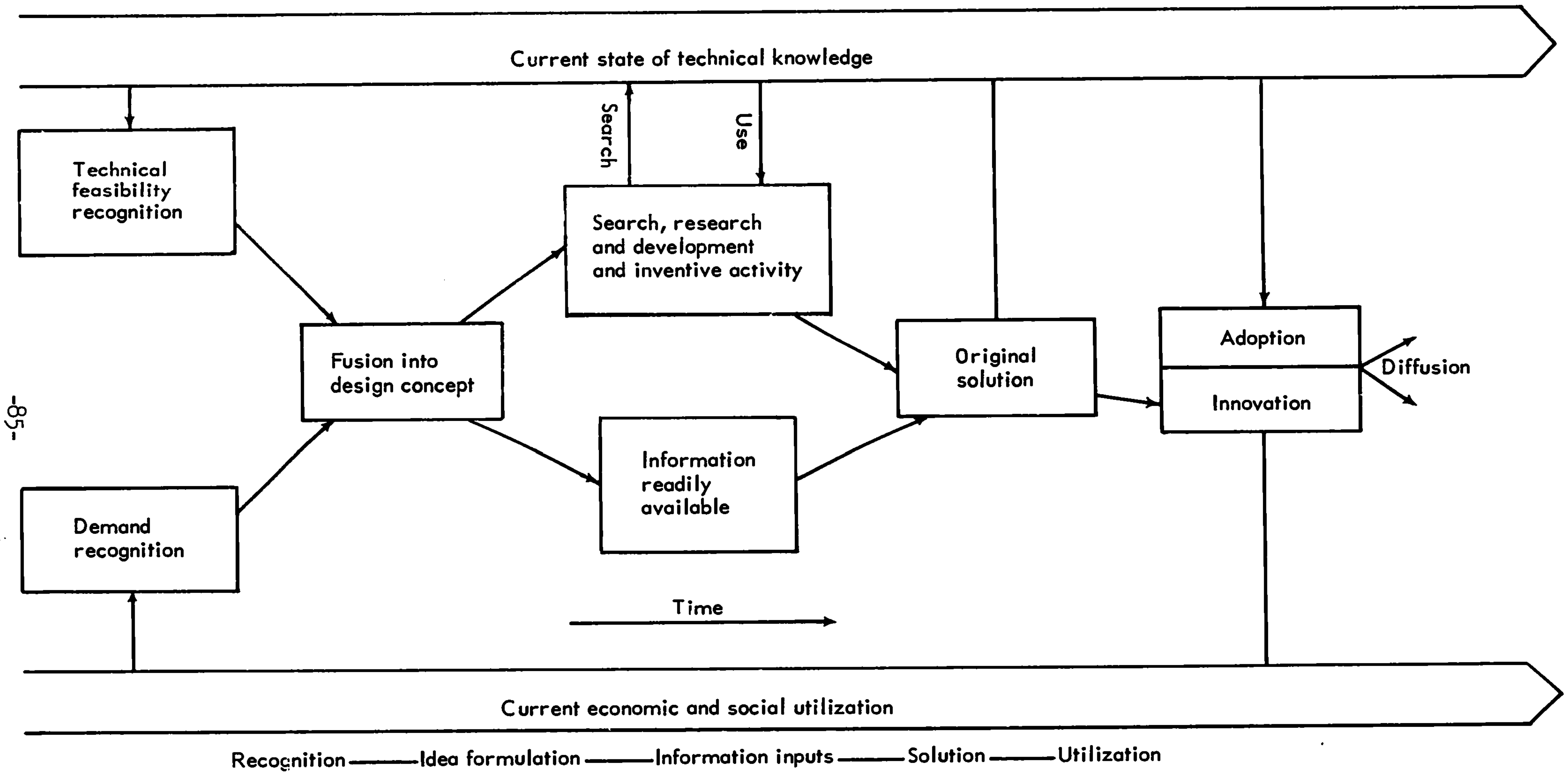
Case of an industrial research institute in a developing country

The case of an industrial research institute in a developing country is discussed in this section. In the decade since it was established this institute has grown to have a staff of about forty professionals and a total staff of over one hundred persons. Work has been principally in product development and utilization of by-products, agricultural chemistry, engineering, economics and small industry assistance. The institute is largely supported by the Government. A study of completed projects showed that very few had been put into use. Most of the projects had been initiated by the institute staff or by Government officials. Almost none had been proposed by "users".

This case is typical of a large number of research and development institutes in developing countries. Little or no use is made of "sales engineers" to study, as a first step, the real problems and needs of the user; and, secondly, to see if there are existing products or processes which could meet the user's needs with or without adaptation. Only as a third step should research be undertaken in the institute. Instead of this sequence, which can lead to a high rate of adoption and use, the usual sequence is that projects reflect the interests or tastes of the staff, or are proposed by outsiders who are not users.

This review suggests that institutes should be rated on the basis of the number and scale of actual use of their projects, and that, wherever possible, the user should participate financially or by continuing consultation as a solution to the need is sought. The end-products of the institute should become things in use instead of reports on shelves.

The process of technical innovation



<u>Source</u>: Personal communication from Donald G. Marquis, Professor or Organizational Psychology and Management, Alfred P. Sloan School of Management, Massachusetts Institute of Technology, Cambridge, Massachusetts, United States of America.

Relevance of experience of developed countries

The relevance of experience in developed countries can be considered in several ways. As stated previously, the distinction between the public and private sectors may not be meaningful in most developing countries because employment opportunities for scientific and technical personnel will be almost entirely in the Public Service. In most hierarchical systems, the largest rewards and highest recognition are accorded to those who supervise the largest number of people. This is almost always the pattern in administrative services. Such an arrangement is not a suitable reward system for excellence in scientific and technical fields. It should not be necessary for scientists and engineers to supervise large numbers of people in order to gain status, salary, recognition and other perquisites. It is important to develop other marks of distinction, e.g. titles, such as "Senior Scientist" or "Research Engineer", as recognition for scientific and technical contribution independent of administrative span.

There are lessons to be learned from both centrally planned economies and free enterprise economies with respect to the recognition-reward system for scientific and technical contributions to national development. Many of the awards and special recognitions developed in centrally planned economies have been meaningful to the recipients and have stimulated achievement by others. The reward system in free enterprise economies is much more diffuse and undirected, and may be much more difficult to apply in developing countries.

There may be limited transferability of experience from a developed country to a developing country in solving these problems. The overriding importance of the value structure of the society usually means that only nationals within a society can devise the means for modifying or making special cases which go contrary to the general value structure. For example, in societies in which applied technology is little recognized or, indeed, represents change which is thought to threaten and therefore be opposed by "the establishment", there are formidable obstacles to rewarding scientists and engineers for innovations whose successful application may modify the power structure of the society. It is a fact that national economic development is achieved only through the application of changes which modify traditional relationships within the society. Thus, the application of science and technology in a society is a revolutionary force. Unless the top-level leadership of the developing country supports such revolutionary purposes and has strong commitments to the introduction of change which will more widely distribute wealth and participation, it is unlikely that any explicit measures for the encouragement and cultivation of scientists and technologists within the country will have much effect or will contribute significantly to national economic development.

DEVELOPMENT AND ADMINISTRATION OF PUBLIC PERSONNEL SYSTEMS TO ENSURE MAXIMUM EFFECTIVENESS IN THE RECRUITMENT, ORIENTATION, PLACEMENT, PROMOTION, RETENTION AND REMUNERATION OF SCIENTIFIC AND TECHNICAL PERSONNEL

Masanori Sato*

National personnel administration

Science and technology have developed remarkably throughout the world and are increasing in national importance each year. Prosperity and national well-being result from such progress, especially among developing countries. National administration is also affected deeply. Large numbers of public employees are now required to possess highly specialized knowledge, not only in administration, but in science and technology, to such an extent that the achievement of many administrative objectives is difficult without the participation of scientists, engineers and other technical personnel.

The responsibility for national personnel administration should be discharged by a central personnel agency and should be conducted under established policy, applicable equally to all the administrative agencies. The central personnel agency should set up personnel standards for national public employees and should conduct national personnel administration uniformly in accordance with such established standards. In national personnel administration, two main principles should be established: the "principle of equal treatment", namely, that all of the staff shall be accorded equal and fair treatment; and the "principle of meeting changing conditions", which means that working conditions of national public employees shall be revised as needed to bring them into accord with dynamic changes in the national society. Both of these principles are closely related to the management of scientists, engineers and other specialists. In this paper, illustrations are given of the validity of these principles.

In Japan, the National Personnel Authority is the central personnel agency; it is composed of three full-time commissioners, one of which must be a scientist. 1/ The background of this requirement is that some seven years ago, a debate was held in the Japanese Diet on the subject of the composition of the National Personnel Authority. It was proposed that one of the three commissioners should be appointed from among persons trained in science and technology, to represent that sector. The Government decided to implement that proposal, which has had a profound effect on the improvement of personnel management policies concerning scientists and other specialists in the Public Service. The presence of a representative of scientists and engineers as a commissioner in the Authority, where he may devote his major attention to the improvement of governmental personnel administration as it involves scientists and other specialists, supports the national policy of promotion of science and technology.

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1/ A brief description of the role of the National Personnel Authority of the Government of Japan is given in annex I to this paper.

Such representation also helps to ensure effective recruitment, development and retention of scientists and other specialists for the Public Service in order to meet changing staffing requirements. It recognizes both the increased participation and the significant role of scientists and engineers in a modern public service. The representation of scientists and engineers at the highest level in a central personnel agency is recommended as a measure that might be considered by developing countries to reinforce their approach to proper recognition of the special requirements of the specialist component of the Public Service.

Principles of recruitment

Personnel administration of scientists, engineers and other specialists should be within the context of the merit principle. The purpose of a merit system should be not only to exclude favouritism in appointments, but to secure persons of superior calibre, thus ensuring impartial and efficient administration of public affairs. The recruitment and selection of scientists and engineers should be made through open competitive examinations.

The methods of selection of scientists and engineers should differ among countries, according to the actual conditions of service. The recruitment and selection methods used in Japan for various personnel categories are described below.

Scientists and engineers in administrative agencies and researchers

The term "researchers" means those who are serving at the laboratories or research institutes designated by the National Personnel Authority, performing laboratory work or doing research and development on a particular project. As a rule, these personnel are appointed, like administrative employees, from among the candidates who successfully pass an entrance examination held annually by the National Personnel Authority. In a specialized field or in fields where there is little demand for new appointees, an entrance examination may be held by each ministry under a method previously approved by the Authority. In appointments tothe research service of those who have obtained a Master's degree or a doctriate, their experiences and/or demonstrated abilities are evaluated by the laboratory, research institute or organization which intends to employ them.

University teachers

University teachers comprise presidents, professors, assistant professors, lecturers, professorial assistants and other employees who are serving at a university or an institution of a similar level designated by the Authority. University teachers may be appointed through evaluation of their experience and/or demonstrated abilities by the faculty council of the university concerned, recognizing the principle of university autonomy.

Levels of entrance examinations

Entrance examinations are conducted according to the educational attainment levels available in Japan. There are entrance levels for three educational categories: college graduates; junior college graduates; senior high school graduates. Entrance examinations are conducted for these levels as follows:

senior entrance examination for college graduates; intermediate entrance examination for junior college graduates; junior entrance examination for high school graduates. No higher level of entrance examination is used in Japan. If a greater number of persons with higher degrees and experience should desire to enter Government service, however, use of a higher level entrance examination will be considered.

It should be noted that appointment on the basis of evaluation of candidates' experience and/or demonstrated abilities is authorized only for laboratories, research institutes etc., in connexion with the employment of scientists and engineers holding higher degrees. Administrative agencies are not authorized to use this exceptional method of appointment for employment of scientists and engineers to serve in administrative offices.

As concerns examination options, two alternatives are possible: (a) examination according to the nature of the position to be occupied; and (b) examination on the basis of the candidate's education. The latter method, which is used in Japan, is usually adopted in countries offering a lifetime career appointment. The Japanese Civil Service has four major components: administrative service; research service; medical service; and educational service. This classification is based primarlily on consideration of the types of duties to be performed by employees. The examination for college graduates to enter the administrative and the research services covers many fields in conformity with the courses or subjects taught at universities. Eleven subject areas are covered in the physical science and engineering fields, ten in the agricultural field and one in the medical and pharmaceutical fields. For the medical and educational services and for fields not included in the examination, each ministry, as a rule, is authorized to make appointments on the basis of evaluation of the experience and/or demonstrated abilities of the candidates.

While it is proper that the scores or other creditable results of an entrance examination with proved objectovity and validity should be respected in determining eligibility, a candidate should not be judged by a single examination for entrance into a lifetime career. An over-all evaluation should be made, including his personality, scholastic records and special skills. The entrance examination for college graduate levels is conducted by the Authority on a Government-wide basis. Candidates for scientific and engeering posts are given a written test for appraisal of educational qualifications, as well as a written test and an oral examination designed to appraise their traits, abilities and character.

The Authority makes a vigorous recruiting effort, utilizing the available information media - announcements in the Official Gazette, newspaper advertisements, and radio, television and other public information programmes. Even with this effort, the shortage of possible entrants into the Civil Service, especially scientists and engineers, has been most acute in recent years. The Authority annually gives explanatory lectures on some sixty campuses to possible candidates for Government employment in fields where a shortage exists. Round-table conferences on recruitment are held with professors and representatives of each ministry or agency.

Remuneration

Compensation of Civil Service personnel, including engineers and scientists, is determined according to the degree of complexity of duties and the level of responsibility of the position held. The pay system for scientists and engineers serving in administrative agencies should not normally be different from that of general administrators, who require a knowledge of law, economics or other disciplines to perform their work. Differences in the nature of the work and in the processes by which the most desirable results are achieved must, however, be fully recognized in salary administration as applied to scientists and other specialists.

Professional achievement as a salary factor

The above-mentioned evaluation method is not applicable to scientists and engineers whose value and ability as managers might be low, but who are highly capable and experienced in their respective fields and whose dominant interest is in pursuit of new knowledge. It is more realistic and, in fact, essential that such employees should not be required to hold managerial positions in order to obtain promotions. On the contrary, they should be given superior credit for their professional abilities as specialists and, accordingly, provided career and promotion opportunities comparable with those of managers, on the basis of their professional output. They should also be given full opportunity to participate in major policy decisions affecting them and their specialized areas of study. In this way, the value to the country of the specialized knowledge and creativeness of scientists and engineers can be given proper recognition. This concept has been accepted in the Japanese Public Service, which employs a "specialist system" that provides remuneration on the basis of training and achievement, rather than on holding a place in the managerial hierarchy.

Laboratory organization

In a laboratory or research institute, employees in the research service should be divided into groups according to research activity. There should at least be a leader for each group; therefore, the number of leaders may be much larger than the ratio of managerial officials in an ordinary administative agency. Flexibility should be allowed in determining the number of group leaders. The group leader, in addition to his own work as a researcher, is responsible for the control and co-ordination of the whole study project being conducted by his group members. His primary role should be to give detailed and thorough guidance to the studies of his subordinate researchers, drawing upon his experience and knowledge.

It is very important to mention that even in his concept of group leadership, individual researchers may be more interested in research than in co-ordinating subordinates' studies. Their advanced specialized knowledge and high creative ability should be considered, as was previously stated, in terms of compensation and other benefits, on the same basis as group leaders. To implement this doctrine, a special "researcher system" should be established, by which any research workers, even an ordinary researcher whose position is subordinate to that of his leader, may be permitted, on the basis of his knowledge and achievements, to reach even the top grade held by the head of an institute.

Use of scientific research corporations

As a means of obtaining greater flexibility in organization and management, including remuneration, a small number of research institutes in Japan, which engage in special and important research activities, are operated as special corporate bodies. That is, such an institute is a type of Government establishment conducted under private management. Most of the expenses necessary for facilities and research activities, including personnel expenditures, are defrayed out of the National Treasury, although private enterprises are requested to bear a part of the burden. In comparison with the national institutes that are restricted by the provisions of the National Public Service Law, these corporate institutes are permitted to operate more flexibly and freely as concerns establishing conditions of employment which will be more acceptable to the staff. For example, scientists and engineers employed at these institutes are better paid and are permitted to hold posts concurrently in private industry or at a university. They are also permitted, to some extent, to act as consultants to private industry.

Personnel policy for professors and research workers in universities

The approach described above also should be considered in determining compensation for university professional staff. Universities are institutions of learning entrusted with the duty of training capable minds. University teachers accomplish this aim through their research and class instruction. University teachers should therefore, in the opinion of the present author, be rated highly as concerns remuneration. In most countries, however, university teachers seem usually to be compensated according to job level, such as professor, assistant professor, lecturer or professional assistant; that is, there is a job-oriented pyramidal type of pay structure.

In Japan, in particular, a fixed personnel complement is assigned for each level at each university, coupled with a compulsory retirement age. The opportunity to be promoted to a higher level depends upon a vacany occurring in that level owing to the retirement or death of a senior employee or an increase of the fixed personnel ceiling. This method must be changed to improve the conditions of employment of competent university teachers. A more flexible system should be adopted, which would authorize, for example, that a competent assistant professor may be paid the salary of a professor on the basis of his ability, even while still designated as an assistant professor. In order to maintain a stimulating environment, a plan should be devised whereby a professor deemed to have lost his research ability or leadership qualities could be required to resign his post in favour of a promising junior, independent of a compulsory retirement age system.

Related to this objective of creating an attractive environment for universities, the principle of university autonomy for the cause of academic freedom and the development of learning should not lead to a formalistic, rigid way of operation by which affairs pertaining to university administration would be determined exclusively by a university faculty council composed only of professors. Consideration should be given to a more co-operative arrangement in which the entire teaching staff of the university, including assistant professors and those at lower job levels, might participate in university administration.

It is also most desirable that the remuneration system for universities and national research institutes should be so established that personnel interchange could be smoothly made between them at any time.

Training

With the advance of science and technology, the responsibility of scientists and engineers for undertaking administrative tasks has gradually increased. Consequently, a need arises for some degree of management training similar to that offered to administrative officials. Scientists and engineers must also strive for self-development with respect to their administrative capability.

To cope with the new age of scientific and technological innovation, specialists in science and technology should always know the actual state of technological advance in their field of specialization, both at home and abroad. It is therefore necessary to establish personnel policies and a training system which would enable specialists in science and technology to receive at regular intervals training suited to their age or type of duties (e.g., for a younger employee, an opportunity to be sent for study at college or university, both at home and abroad; and for a comparatively older employee, an opportunity to be sent abroad on a tour of investigation or of observation and study of the actual situation of industrial technology and industrial production). This system would embrace also the possible granting of what is referred to in some countries as "sabbatical leave", that is, periods of leave with pay for professional development.

Factors affecting retention

It is absolutely essential to give full consideration to the question of providing researchers with ample funds, adequate facilities and better treatment. The general environment of their research should also be the subject of careful examination to ensure retention within the Public Service of a talented work force.

Leadership

A major requirement for ensuring retention of highly qualified staff is the provision of inspirational and intelligent leadership which is responsive to their needs. Research done by incapable men results only in a waste of research funds. A research institute, quite unlike a private enterprise or an administrative agency, is manned exclusively by specialists who can achieve fruitful results only when they are able to work under conditions that enable them to devote all their energy to research and studies.

Therefore the desirable personal traits that the institute head and the group leader in a research institute should have are described below. The head of a research institute, nominally an administrator, must possess such character and ability to lead that researchers will be attracted by his scholarship and personality.

Competent researchers under an able leader who enjoys the implicit confidence of everyone will pursue their work at highest motivation and will contribute to a system of mutual co-operation and support of the entire establishment. Top management of Government agencies should fully appreciate the role of the institute head and should grant to him the right and opportunity to speak authoritatively on the matters under his jurisdiction.

In Japan, institute heads are too burdened with routine fiscal and administrative matters. This situation might be improved by providing the institute head with an associate to deal with fiscal and administrative matters. Speaking concretely, the head of the institute, besides knowing the trends in the development of new technologies outside the institute should have more opportunities to devote his time to research activities, including placement of the right man in the right place.

In summary, one cannot over-estimate the value of having the head of a research institute pursue an administrative policy that generates a congenial environment, encouraging researchers to pursue research without inhibitions or irrelevant demands on their motivation and drive.

Use of deputy

The tremendous advance of science and technology requires top officials of those administrative agencies which are primarily concerned with technology to judge the international trends in those fields. When the top official is a scientist or engineer who can make such judgements, he should be assisted in administrative matters by a deputy official who is especially proficient in administration. And, conversely, if the top official is a proficient administrator, his deputy should be an official able to judge international trends in science and technology, to ensure that national policies on science and technology shall be properly implemented.

Qualities of research workers

Selection of research staff is a crucial decision for management. A research worker should be a person who perseveres in his research work and brings it to successful completion; co-operates with others as necessary; and clearly realizes his lack of ability or his deficiencies, especially in his own field.

Conclusions

As has been pointed out above, there are many important areas for improvement and development in the scientific and industrial fields, especially in the developing countries. Government leaders should, show greater interest in and appreciation of modern science and engineering. It is only with such leaders that the appropriate and effective utilization of scientific and technical personnel in the Public Service can be realized and the industrial and economic growth of a country achieved, as envisaged in this discourse.

It goes without saying that scientists should never forget to make the best use of their scientific abilities for the well-being of mankind. In other words, it is of paramount importance for scientists to build up a character with a rich sense of humanity before they engage in scientific work.

ANNEX I

THE NATIONAL PERSONNEL AUTHORITY OF THE GOVERNMENT OF JAPAN

The National Personnel Authority was established as the central personnel agency of Japan. The Authority is set up under the jurisdiction of the Cabinet, but it holds a position of independence from the Cabinet.

The Authority, which is composed of three commissioners, is responsible for the maintenance of equity in personnel administration and for the protection of employees' interests. The Authority is required to maintain strict neutrality and absolute fairness. In addition to its general administrative powers, the Authority possesses quasi-legislative and quasi-judicial powers over a wide range of important personnel matters, unparalleled in the case of an administrative agency in Japan.

The uniqueness of the areas in which the Authority is empowered to act and its strong powers are linked directly with the powers and the responsibilities of the commissioners of whom the Authority is composed. For this reason, very rigorous qualification requirements are laid down concerning the persons to be appointed as commissioners. The main provisions of the National Public Service Law with respect to the qualification requirements and the terms of office of a commissioner in the National Personnel Authority are cited below:

"Article 5. Commissioners of the Authority.

"Commissioners of the Authority shall be appointed, with the consent of both Houses of the Diet, by the Cabinet from among persons 35 years old or more, who are of highest moral character and integrity, of known sympathy with the democratic form of government and efficient administration therein based on merit principles and possessing a wide range of knowledge and sound judgment concerning personnel administration.

"The appointment and dismissal of a Commissioner shall be attested by the Emperor.

"No person shall be appointed as a Commissioner who is, or within five years previous to the proposed date of appointment has been, an officer, political adviser or other similarly politically influential member of a political party or who, within five years previous to the proposed date of appointment, has been a candidate for national or prefectural elective public office, as provided by rules of the Authority.

"With respect to the appointment of Commissioners, no two persons among them shall be members of the same political party or graduates of the same department of the same university."

"Article 7. Term of Office.

"The term of office of a Commissioner shall be four years. However, a Commissioner who is appointed to fill a vacancy shall remain in office during the unexpired portion of the term of his predecessor.

"A Commissioner may be reappointed. However, he shall not remain in office continually for a period exceeding 12 years.

"No person who has been a Commissioner shall be appointed to any position in any agency of the National Government other than the Authority for one year after the termination of his service as Commissioner."

As stipulated in article 5, there is a restriction on the minimum age of a commissioner, but the Law does not provide for his maximum age. The reason for this restriction is that since a commissioner is entrusted with such an important mission, he is expected to perform his duties to the best of his ability by making the most of his knowledge, insight and experience. As concerned the "attested officials" referred to in article 5, these are limited to a small number of persons and comprise - in addition to the commissioners - State ministers, Justices of the Supreme Court, ambassadors and a few others. In view of the historical tradition of Japan, those receiving the Emperor's attestation for their appointment enjoy very great prestige and high social position.

The Authority Secretariat is composed of the following bureaux: administrative services; recruitment; compensation; equity and employee relations; Institute of Public Administration. Each of these bureaux is assigned an area of responsibility. The post of Director-General is established for the purpose of directing and supervising those activities which are performed by the bureaux and the Institute.

Before the assigned activities are conducted by each bureau and the Institute, they are placed before the meeting of the Authority for consideration and discussion. A meeting is, as a rule, held at least once a week and the Director-General attends as executive secretary. Decisions of special importance are made by a resolution of the Authority.

As compensation, recruitment, service discipline and so forth, which are under the jurisdiction of the Authority, are particularly important in securing and retaining capable scientists and engineers in Government service, the commissioner who represents the scientists and engineers bears particularly heavy responsibilities in this respect.

ANNEX II

SCIENCE AND TECHNOLOGY ADMINISTRATION IN JAPAN

With a view to reconstructing its war-damaged industries, Japan has taken the series of measures described below.

Japan Science Council

To promote science and technology, as well as general knowledge, a nation-wide organization, the Japan Science Council, composed of 280 representatives, was established. Members are elected by vote of all the scientists in Japan and are placed under the jurisdiction of the Prime Minister. The Council makes recommendations to, or issues statements for, the Government on measures for promotion of science and technology.

Science and Technology Agency

The Science and Technology Agency, a ministerial level organization and an important agency of the Government, was established and charged with conducting science and technology administration. The Agency has as its head a minister of State and is responsible for planning and developing the Government's important policies on science and technology.

Policies concerning "large science" are planned, developed and put into execution by the Agency. Space development, the peaceful uses of atomic energy, and the development and exploration of the ocean are the typical examples of the fields covered by its policies.

The Agency has under its jurisdiction five large-scale institutes, the National Aerospace Laboratory, the National Research Institute for Metals, the National Institute of Radiotherapeutic Science, the National Research Centre for Disaster Prevention and the National Institute for Research in Inorganic Materials, which have been established specifically for the purpose of studying major problems in the areas of science and technology.

On the other hand, fifteen research institutes connected with industrial circles are under the Agency of Industrial Science and Technology of the Ministry of International Trade and Industry. In addition to these institutes, each ministry has the research institutes that are necessary for its activities.

The Science and Technology Agency is responsible for over-all co-ordination and integration of all the governmental research institutes.

Council for Science and Technology

The Council for Science and Technology is the highest advisory body to the Prime Minister on major national policies concerning science and technology. Its membership consists of the ministers directly or indirectly concerned with science and technology and some distinguished experts selected for their learning and experience.

As may be seen from the foregoing descriptions, the science and technology policy of Japan is well-ordered and organized to a great extent. There still remain, however, some problems concerning improvement in liaison and operation in those organizations.

IMPROVEMENT OF MANAGEMENT IN NATIONAL CIVIL SERVICE SYSTEMS HAVING SIGNIFICANT NUMBERS OF SCIENTIFIC AND TECHNICAL PERSONNEL

Harry S. Hoff*

The Scientific Civil Service of the United Kingdom

In the Public Service of the United Kingdom of Great Britain and Northern Ireland, scientists and technical personnel are concentrated mainly in a group which has come to be known as the Scientific Civil Service. The technical field covered by the Scientific Civil Service is unusually wide - probably wider than that of any of its counterparts, particularly in other Western countries. One of the reasons for this is the signal success of research and development in the Government Service during the Second World War - radar being a notable case in point. In the first year or so of the war it was found that the quickest and most effective way of getting things done for the national need was to expand the existing governmental research establishments by bringing in scientists and engineers, mainly from the universities. Government research proliferated, to excellent purpose.

At the end of the war, many of the newly imported scientists and engineers from the universities wanted to move out again; many others, however, wanted to stay where they were, as they saw the prospect of other successes, equally signal, in the future, for example, the civil atomic energy programme. It was natural for the results of proliferation to remain.

For the Government service of a developing country, coming newly into scientific and technical activities, with needs and resources that are at once more limited and more specific, one would expect a very limited number of fields to be marked out and closely watched thereafter to prevent undesirable proliferation.

From the current experience of the Governments of the United Kingdom and the United States of America, which, upon finding themselves short of funds, decide immediately to cut back scientific research and development, the developing countries may observe that this decision is more easily made than implemented. Research projects seem to take on an organic life of their own; so do research establishments - the scientists and engineers are "getting on with it". It is well to recognize right at the beginning that it is usually much easier to open up a field of research and development than it is to close it down.

Structure of the Scientific Civil Service

The current structure of the Scientific Civil Service dates from a period of reorganization that followed immediately after the end of the Second World War. 1/

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1/ United Kingdom, Barlow Committee, White Paper, Cmd. 6679 (London 1946).

Any organizational structure produces its own management problems, and it is one of the functions of management to suggest and procure changes of organizational structure. As human beings neither are perfect nor show any signs of being perfectible, no organizational structure for them can be put forward as either perfect or likely to be perfectible; one can only conclude that some organizational structures look as though they will produce fewer problems than others, and then try them.

Over the past twenty-two years, the members of the Scientific Civil Service have, by and large, done what was expected of them with more than adequate success. The organization is generally held in high esteem in the scientific-technological world; some of its members and some of its research establishments, are internationally known. With the Fulton Committee's recommendations 2/ for the Civil Service having been accepted by the Government, however, the time has come to test another structure, to change from a three-class structure (with grades in each class and facilities for class-to-class movement) to that of the United States of America, a unified grading structure with no classes. 3/

A developing country that has a Civil Service proper based on a three-class structure will probably be inclined, as was the case in the United Kingdom in 1946, to organize its scientific and technical personnel in a three-class structure - if it is not already doing so. But if a unified grading structure seems preferable, the longer the change-over is delayed, the longer it will take. Current unofficial estimates of how long the change-over will take in the United Kingdom are from seven to ten years.

From the management point of view, the question that determines the choice of structure bears a resemblance to the fundamental question in the management and direction of scientists and engineers. The fundamental management question is how to achieve a balance between allowing scientific thought and investigation to range freely without interruption and exerting the administrative and financial control necessary to keep it within the bounds of economic advantage; the structural question is how to achieve a balance between permitting and encouraging a man's freedom of movement in jobs and maintaining a framework that meets the needs of effective administration.

When reorganizing the group of scientific and technical personnel in 1946, it came naturally to members of a three-class Civil Service to think of a

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2/ The Fulton Committee was set up in 1966 to examine the structure, recommitment and management of the Civil Service. Its main recommendations affecting the Scientific Civil Service which were accepted by the Government in 1968, are as follows: (a) a unified grading system to replace the current three-class structure; (b) an increase in opportunities for scientists and engineers to reach key administrative posts; (c) the setting-up of an organized scheme for training in management at all levels of the Service. See United Kingdom, Fulton Committee, The Civil Service, vols. 1 and 2, Cmd. 3638 (London, 1968).

3/ In the United States of America, the term "class" is used in the Civil Service to designate a particular professional or occupational group of persons within a grade, a group made by vertical division within the grade. This concept is very different from the British use of the term to designate a major group of persons, the group being made by horizontal division across the whole organization.

three-class structure for such personnel. When that had been done, it came equally naturally to them to identify in research and development three predominant roles that a scientist or engineer might play according to his innate gifts, his education and his experience. The three classes and their respective roles are as follows:

(a) Scientific officers. This class is considered the initiating, directing, inventive brain of the scientific research, design and development work of the Civil Service;

(b) Experimental officers. This class acts in support of the scientific officers in new investigations, taking responsibility for their organization and execution in both the experimental and managerial senses;

(c) Scientific assistants. This class undertakes the detailed work of construction, observation, calculation and reporting.

In being divided horizontally into three classes, the Scientific Civil Service resembles the Civil Service proper; but it may seem less analogous than it looks when the numbers in the classes are taken into consideration. In 1968, the approximate numbers were as follows:

Civil Service		Scientific Civil Service	
Administrative	2,700	Scientific	4,100
Executive	83,000	Experimental	7,600
Clerical	192,000	Assistant	5,700

The Civil Service proper thus appears as a pyramid, with a tiny élite found within the apex-slice; while the Scientific Civil Service is more like an up-ended brick, divided into three nearly equal slices. This difference produces a difference in the difficulty of getting into a particular class and of getting promoted when in it. Light is thrown on the latter difficulty by the fact that in the administrative class, just under 50 per cent are earning over £3,500 per annum; while in the scientific class, the figure for the same salary is just under 25 per cent.

The Scientific Civil Service consists of these three classes, and the staff of most Government research establishments are drawn predominantly from them. But in those establishments where the research and development involves, for example, engineering design and construction, or testing, or production on a limited scale - and there are many such establishments - there are to be found members of several other specialist classes, such as those of the works group, comprising engineers of all kinds, technicians, draughtsmen and so forth. 4/ These personnel

4/ The works group was formed to run those parts of the Government Service which are concerned mainly with production, for example, the Royal Ordinance Factories. Only a relatively small segment of these personnel work at research establishments.

are interspersed among members of the scientific, experimental and assistant classes, often doing jobs indistinguishable from the jobs of their colleagues in the Scientific Civil Service, but having different pay scales, different prospects and possibly different prestige. This situation makes a complication for administrators and managers. Although the latter have not had to cope with serious disaffection among the people doing the jobs, the situation is one to avoid. 5/

Devices for attracting entrants

Any organizational structure produces its own management problems, the first problem being to get the right people into the organization. The scientific class was deliberately set up as an élite class, in order to try to attract into the Civil Service scientists of a higher calibre than had usually been attracted before the war. At that time, there had been a single class, comprising what was subsequently divided into the scientific and experimental classes; it had definitely not attracted - as importation of scientists from the universities during the war showed - a due share of the really top-level scientists. The device was successful. Now that the reputation of the Scientific Civil Service has been established, it is possible that the disappearance of an élite class, as a result of the introduction of a unified grading structure, will not discourage the really top-level scientists from entering the organization. It is to be hoped that this will be the case.

Apart from the standard attraction of a Civil Service job, that is, its permanency and its system of annual increments of pay within a grade, the scientific officer class was made more attractive by a promise that the average good scientist in the class could expect to earn promotion from grade to grade - on the basis of performance on the job, not of age or seniority - so as to arrive at the third grade up, called the "career grade", by the time he was in his mid-thirties. This was made possible administratively by fluid complementing over the first three grades; that is to say, by setting a limit on their over-all complement, but allowing the individual complement in each grade to run freely. This device also was successful in its aim; but it is more difficult to operate practically, when in the course of time an organization ceases to expand and may contract. In the latter case, the result is a growing preponderance of men in the career grade - too many, by the criterion of what is called the normal age distribution.

In any large organization, the higher posts tend to be increasingly managerial. This holds, of course, in the Scientific Civil Service, and the fact was recognized in 1946. But there are a certain number of top-level scientists, very desirable for the organization, whose capacity for doing original research - as

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5/ In the Civil Service as a whole, there is an extraordinary multiplicity of classes - forty-seven generalist classes, each with its own gradings, pay structure and prospects, most of them representing a classification of specialists by vertical division into separate enclaves, rather than by further horizontal stratification; and 1,400 departmental classes.

well as their determination to do it - persists strongly into middle age; they simply do not want to have to give their minds to administrative and managerial problems.

In order to attract such men to the Civil Service, an appropriate type of special merit appointment was created within the normal grading system, as free as possible from managerial and administrative demands, corresponding to a university readership rather than to a professorship. These appointments begin to be available in the grade above the career grade - where the pay scales are, broadly speaking, comparable with university scales. Such an appointment is made as a result of a candidate being nominated by his employing department and being finally selected by personal interview with a Civil Service Commission panel of high-level scientists. The appointees obviously are some of the most talented scientists in the organization, those who have been promoted the most rapidly. The usual age for award of special merit appointment is about forty years, but there have been many awards to men in their early thirties. The appointments encourage the appointees, by enabling them to continue their research undisturbed and at the same time giving them special recognition. The presence of special merit appointees is also encouraging to the other scientists in an organization by showing that their own organization is doing research that can compete in quality with any being done in the universities. In the Civil Service, it has been found that the number of special merit appointments need be limited only by the number of qualified scientists who want them. The number currently stands at about twenty.

In the years immediately after the war, the attractions and prestige of university research were still such as to make many of the brightest young scientists, if not engineers, put university research as their ultimate, though perhaps not immediate, choice. As the universities in those days had enough vacancies to absorb them all, research fellowships were invented for attracting a share of them into the Scientific Civil Service for a short term (two or three years), usually just after they had received their doctoral degrees. The idea was that after two or three years they would like the Service and ask to stay. The lure was not higher pay, which would have made difficulties when they wanted to transfer to a regular grade, but greater freedom of choice in research topics. This device also was very successful: a high proportion of rather young group leaders in the current Service began as research Fellows.

Recruitment and selection

Long before the Second World War, recruitment for the Civil Service had been centralized in the Civil Service Commission (a body of independent status appointed by the Crown to ensure, in effect, fair play and absence of nepotism in the selection of personnel). For recruitment to the three classes of the Scientific Civil Service, it was necessary to modify Commission procedures in the light of two facts:

(a) Unlike generalist administrators, scientists or engineers could not be regarded as interchangeable in posts to which they were assigned. For example, an organic chemistry job could only be filled by an organic chemist;

(b) There was a chronic shortage of scientists and engineers. It was not a buyer's market, but a seller's; and sellers have to be treated very tactfully.

The Civil Service Commission ceased to require prospective recruits to take its own written examinations in science and engineering, on the grounds that the results of examinations set by the country's highly integrated examination system of long standing, run by the universities, were acceptable. (In developing countries, which may not have such a long-standing, stable system, the Civil Service might want to set its own examinations.)

Recruits were selected on the basis of only a personal interview conducted by a carefully chosen panel of scientists and engineers, drawn from research establishments and universities, who had previously studied the recruit's academic record, the record of his research and development experience (if any), and his professional references. The panel's technical probing was designed to bring out the recruit's capacity for having ideas of his own, for being "self-propelled" on whatever level (that is, in whichever class) he was proposing to operate.

Certain interesting facts that emerged have remained relevant ever since. During the war, recruitment had been decentralized, that is, Government departments had recruited to temporary posts in their own establishments for the duration. When those temporary recruits who wanted to stay in the Scientific Civil Service were interviewed by the Civil Service Commission, it was found that in small, stable departments the standard of quality in their recruits had been kept fairly level; in large, new, greatly expanding war-time departments the standard of quality fluctuated wildly.

It therefore appears that, in general, a steady level of recruitment is conducive to steadiness in standards, while serious fluctuations in the level of recruitment are not. Not surprisingly, "stop-go" recruitment produces characteristic troubles of its own, those in the "go" phase being the greater. In the "stop" phase, an employer can succeed in cutting off recruitment over a period of months, to find that when he wants to begin again it may take a period of years to reach the former level of employment. In the "go" phase, where the employer has a large number of vacancies to be filled hurriedly (everyone is tempted to fill a large number of vacancies in a hurry, in order to get the work done) he is likely to lower his standards below the threshold he had defined for himself beforehand.

For a Government Service, with its "permanent" jobs and its elaborate procedures to be gone through before an employee can be dismissed, to allow an influx of substandard recruits lays the basis for management problems which become more apparent - and more embarrassing - with each subsequent year; and the higher up in the echelons they are, the harder it is to deal with them. It is most important that a developing country, having decided to expand (rapidly in some cases) its group of scientific and technical personnel in the Public Service, should be constantly alert to this danger.

Because of the principle that, as a rule, the Civil Service offers "permanent" appointments to recruits who are expected to make a career in the Service, it aims at recruiting for junior grades of a class, expecting the senior grades to be filled by internal promotion. This results in recruitment being mainly of fresh graduates (scientific class); school-leavers aged eighteen years (experimental class); and school-leavers aged sixteen years (assistant class). The bulk of the recruits are not experienced in the work they will do in the Service, so that selection usually resolves itself into looking for a combination of education in the appropriate discipline with signs of innate talent or capacity for fulfilling the demands of the particular class.

At the employer's end, the demand tends to take a similar form, not that of a highly specified vacancy, but of something much nearer to a request for a "bright young mechanical engineer who can get interested in heat-exchangers" or for "a couple of bright young assistant experimental officers for the analytical lab, to train on spectrometers".

This state of affairs might be termed "loose"; it can work only on the basis of a fair amount of personal contact between "employer" and "recruiter", which, fortunately, is the case. It happens that the Scientific Civil Service is small enough in number (and the country small enough in area) for its relations with the Civil Service Commission to be on the terms described above, although formal vacancy lists are, of course, prepared by the Government departments. In addition, there are other reasons for using this system. First, whatever the state of the market, the more closely a vacancy is specified the less likelihood there is of its being filled. Secondly, with increasing creativeness, there is increasing difficulty in vacancy-specifying. To specify closely the vacancy for a routine job is fairly easy, but to specify closely the vacancy for a man with certain new ideas about heat-exchangers is difficult.

The fact that there is a fair amount of informal, as well as formal, contact between the Scientific Civil Service and the Civil Service Commission has made the centralized recruitment of fresh entrants work reasonably well; but this state of affairs cannot be presented as ideal, since any sensible employer would like to see how a man performs on the job before offering him a permanent appointment. In 1946, when the results of anarchic war-time recruitment of temporary appointees by the research establishments was scrutinized and reversion wholly to permanent appointments was the aim, there was no alternative to imposing a general standard of quality throughout the Service through the machinery of centralized recruitment. But once the standard had been set and had become known, and the research establishments had settled down, it was possible to consider alternatives, During the past ten years, there has been a steady movement away from direct recruitment to permanent appointments by the Civil Service Commission, in favour of the research establishments finding their own recruits, trying them out on the job for a year or two in a temporary appointment and then submitting them to the Civil Service Commission. (The number found below standard in quality by the Civil Service Commission has been very small.) This alternative now accounts for about 70 per cent of the total recruitment to the scientific and experimental classes. First appointment of young school-leavers to the assistant class has always been temporary.

Promotion

There are two types of promotion: (a) from grade to grade within a class; and (b) from class to class. The principles of equity and fairness, together with public accountability, which so strongly permeate the Public Service, have resulted in elaborate - and, it should be added, humane - procedures for dealing with promotion.

A confidential report is made annually on every person 6/ by his immediate superior and is countersigned by that superior's supervisor. If the report is unfavourable, the employee is told about it. Every employee is considered for promotion when his performance in his current grade begins to show that he will be able to do the job in the grade above it. At the appropriate time, he is interviewed by a panel (similar to those of the Civil Service Commission) of senior scientists or engineers, who make the decision about recommending his promotion. Great efforts have been made to get away from the notion that promotion comes automatically with age and seniority - the above-mentioned "fluid complementing" over the first three grades of the scientific class is an example of one of the devices made in this connexion. If a man who is up for promotion is dissatisfied with the panel's decision - that is he has not been recommended for promotion - he can appeal against it on the official side (the Civil Service side). He can be reinterviewed, if necessary more than once, by a panel with different members; he can also request support from the staff association.

Grade-to-grade promotion

Within the classes, the system of grade-to-grade promotion seems to have worked reasonably well for the man who is average; but it appears that the elaborate procedures have sometimes acted as a hindrance to the man who is outstanding. He moves up the grades more rapidly than his less gifted colleagues; but opportunities where he can be especially rewarded for particular merit are lacking. At the other end of the scale, it appears that the constantly moving promotion machinery inexorably carries upwards the least deserving man. An elaborate machine devised to deal fairly, humanely and openly with the vast bulk of average men will probably have its failings when it comes to deal with men at the extremes of ability.

Class-to-class promotion

The machinery for class-to-class promotion is similar to that for grades, and it is faced with its most difficult task in the case of promotion from the experimental to the scientific class. Promotion from the assistant to the experimental class is easier because the junior grade of the assistant class is considered in part, a training grade for the experimental class - school-leavers becoming assistants at sixteen years of age continue their studies and compete on good terms with school-leavers at eighteen years who are entering as assistant experimental officers. But the junior grade of the experimental class is not in any sense considered a training grade for the scientific class. School-leavers entering the experimental class at eighteen years of age may take university

6/ Excluding members of the scientific class above the career grade, on the grounds that they are so few in number that they and their work are known.

degrees in their spare time; and each year a significant number of university graduates are recruited directly to the experimental class, but for any of them to get promoted to the scientific class has turned out to be more unlikely than might have been expected. 7/

The division of the Scientific Civil Service into three classes has turned out least satisfactorily in the case of the experimental class. In fact, there are class boundaries in other environments that are drawn a good deal more arbitrarily than those which enclose an élite of scientists and engineers distinguished by their capacity for generating fresh ideas. But that does not alter the problem of coping with the really high-quality experimental officer, capable, on the barest of suggestions from his scientific officer, of getting a series of difficult experiments done perfectly - yet not capable of putting up those suggestions himself. He may feel that he could have put up the suggestions. He does not want to go out into industry where he could possibly earn more money and have better prospects. He wants his chance - indeed, feels he deserves his chance - to enjoy the scientific freedom and authority of the scientific class. Furthermore, he very naturally wants to enjoy the prestige of the scientific class. Few people object to being inside an élite class, but many object to being kept out of it; to those who find themselves just outside, the boundary is particularly galling. 8/

There are a fair number of experimental officers of this kind, and even more who, while not so good at their jobs, to some extent identify their own position with that of their superior in the scientific class. In the experimental class, there exists a feeling of "frustration" of an intensity unknown in either of the other two classes. The possibility has always presented itself to management of reverting to the pre-war condition, when the current two classes were one. In 1965, an official committee seriously considered the possibility and decided against it, on the grounds that it would again diminish the attractiveness of the Scientific Civil Service to the top-level scientists and engineers, and it would necessitate costly operations in job evaluation. 9/

7/ Comparison with the Civil Service proper shows that though not specially justifiable, nearly one-third of the administrative class began in the executive class; of the scientific class, about one-tenth began in the experimental class. The fact that relatively few of those from the executive class catch up with the direct entrants to the administrative class in reaching the most senior posts does not affect the main issue.

8/ In a society that is steadily striving harder for egalitarianism, the concept of an élite is beginning to offend. Actually, the word "élite" is ceasing to be used in describing the scientific class.

9/ United Kingdom, Tennant Committee, The Organization of the Scientific Civil Service (London, Her Majesty's Stationery Office, 1965).

With the introduction of the unified grading structure recommended by the Fulton Committee, all class boundaries will disappear. The change is especially welcomed by the staff associations concerned with the experimental class. Although the senior administrators in the research establishments have arrived at only an unofficial opinion on the change, a majority seem to think that with the change the really high-quality member of the experimental class will certainly do better, but the rest of the class may be disappointed. They view philosophically the costly operations in job evaluation, which are considered in a subsequent section of this paper.

It should be observed, however, that the United Kingdom, a developed country, is proposing to unify its structure after twenty years of experience of having a distinct group of scientists and technical personnel in its Civil Service. A developing country may not be convinced of the appropriateness of a unified structure in its own case; or alternatively, it may already have its scientists and technical personnel contained in a distinct service on the British model. A unified grading structure may be thought to solve some problems; but it produces others. It would appear that each developing country must work out its own solution to the structural problem.

Training and career management

It is very difficult to separate the element of career management from such elements as arrangements for training and arrangements for promotion. On the whole, the Scientific Civil Service has no formal schematic system for career management. A great deal is done in an informal, unschematic way; but it is clear that this is unlikely to suffice in the modern climate of increasing "professionalism". It is interesting, however, to see what has been done.

In the preceding section, it was observed that the junior grade of the scientific assistant class is considered, in part, a training grade for an experimental class. The young school-leaver entering as a scientific assistant is given training (in the laboratory or workshop) in an experimental or engineering technique, and he is given time off - for example, one day a week - to go to the local institute of education and study for examinations which may qualify him to compete for the experimental class. He gets advice on the matter from his laboratory superior, who may be an experimental officer, as well as from the institute. Nobody would advise a boy to leave school early if he were not forced to; but if he is forced to leave, the Scientific Civil Service does its best for him.

The first grade of the experimental class is not regarded as a training grade for the scientific class, but a certain flexibility is introduced by the award of "bursaries" or scholarships to a small number of persons in the grade to undertake full-time university education. The younger a candidate is at the time of selection for anything, the greater the chance of a mistake being made - the selection of human beings is far from an error-free process. In this particular case, trouble arises when the assistant experimental officer has obtained his degree, but does not appear to have sufficient creativeness for the scientific class.

Beyond these two levels there is not very much in the way of formal training other than of a vocational or local, departmental variety. Formal training usually means "courses" of one sort or another. The most important of such courses are those in management held at the Administrative Staff College for a certain number of senior members of the Service. Senior members of the Scientific Civil Service are nominated by their departments to attend; and nomination is considered something of an honour, since it is generally given to scientists who have already shown some innate ability for management and are therefore expected to play important management roles. The courses are strenuous, and most of the men who have taken them agree on their having been beneficial; but in informal conversations, most of them say the really interesting and useful thing is the opportunity they get outside working hours to compare their own management problems with those of men who come from other areas of society. Being scientists, they are naturally excited by unexpected parallels and resemblances. The Fulton Committee has recommended that there should be more management courses for members of the Scientific Civil Service, particularly for those who will be given major administrative responsibility.

With the foregoing exception when career management above the grades of entry comes up for consideration, the situation is informal but that does not mean it goes by default. Furthermore, it may be argued that in the Scientific Civil Service the situation is less open to criticism than that in the Civil Service proper for the following reasons: (a) the Scientific Civil Service is small; and (b) it is composed of closely knit project groups, or teams, of mixed classes and grades.

If one considers point (b) first, the way in which the typical scientific or engineering laboratory works entails not only that a group of people will be working on a project and that the group will consist of men in different classes and different grades, but that the members of the group will be in close contact with each other and will know each other's work. In this set-up, it is relatively easy for a man to be inculcated with a sense of responsibility for watching over the careers of the men who work under him in the laboratory or workshop and for discussing their problems with the man above him. One might call it a human responsibility rather than a formal one, though the formal one exists and is the basis for the formal reporting system.

Given this kind of set-up on the "laboratory floor", that is, the actual work situation, the spirit that informs it can spread upwards, and often does so, throughout a research establishment. The head of the establishment will not know personally the scientific assistants; but he will know principal scientific officers who do, and the particular sense of responsibility can permeate the whole establishment.

Coming now to point (a), given a total research and development organization that is small enough, or at least below a certain threshold in size, this particular spirit can extend to the top. The head of the whole organization, if he is the right sort of man, can know personally the senior men in his research establishments, know what they are doing, know many of their juniors; and, most important, know, through this chain of personal responsibility, about the persons for whom there are particular difficulties in career management, whatever their grade, for example, persons who are in need of different kinds of training, of changes in objective or of special consideration in promotion.

In the present author's opinion, a separate group of scientific and technical personnel can have the advantage of this kind of management, given the right sort of man as its head, up to a threshold of 2,000-2,500 personnel, working in five or six research establishments. One may mention as evidence the unusual success, from this point of view, of the running of the Royal Naval Scientific Service during the Second World War. It was about that size and was run on those lines - possibly helped by the esprit de corps that the Royal Navy seemed to engender. Currently, the Research and Development Department of the nationalized electricity supply industry - outside the Civil Service - probably comes nearest to it. But it seems useful to offer the idea for consideration here because the group of scientific and technical personnel set up by a developing country is likely to be small enough.

All this is, of course, not to say that career management along informal, "familial" lines should be taken as sufficient in itself, but only that these lines are the first choice in circumstances when the job can be done along them. In any case, they will benefit by being supplemented by formal schematic devices, with their built-in checks against personal vagaries and weaknesses.

Management techniques

At the working level, in the institutes where the research and development are actually done, the scientists and engineers, in effect manage themselves. The head of a research establishment, his division heads and his group leaders are all scientists and engineers. In addition, the head has responsible to him a small unit of administrators (some of whom may have had a scientific education), headed by a middle-grade Civil Servant upon whom he can rely for advice and whose unit does the establishment's administrative work in connexion with personnel, costing, accounting and so on. There, the head of a research establishment is effectively the head of a single organization, of a single hierarchy: he has significant autonomy in settling its policy and in allocating its budget.

But at headquarters, in the parent ministry, the balance of authority and responsibility between scientists and administrators changes over. Under its minister, who is a politician, the ministry is headed by a top-grade Civil Servant, a permanent secretary, whose responsibility for operating policy and for making decisions (delegated by the Treasury) on finance extends downwards through his administrative hierarchy, taking in also the hierarchy of scientists, engineers and technical personnel whose head is the ministry's chief scientist or chief engineer.

Scientists and engineers argue that the managerial role of the scientist and engineer is clearly going to grow, as it has in industry, and it should therefore be encouraged, promoted and accommodated as rapidly as possible. If their argument is accepted - and there are signs of its acceptance becoming increasingly widespread - then it brings out a problem of management in the Civil Service that is pressing, as well as important. In fact, the present author considers it the most important management problem the Scientific Civil Service has to face; and it is discussed at length below.

Relationships between scientists and administrators

Organizational relationships

The organizational structure of the Civil Service proper makes apparent "the dominant role" of the administrative class. The Civil Service head of a department is a permanent secretary, that is, a member of the administrative class. The two major responsibilities of this class - the one for formulating (under political direction) the department's policy and operating it; the other for public accountability, that is, finance and such matters as pay scales and complements - cannot help but give it a dominant role.

The pattern of organizational structure varies from department to department, but the principle is more or less the same for all. Under the permanent secretary, the work of the department is parcelled out between divisions, of which two are functional divisions referred to as common services: finance and administration; and establishment and organization. The heads of divisions are administrators in the next grade lower, except in the case of divisions doing "specialist" work; and their heads are specialists of a comparable grade; thus, the head of the research and development division (if such exists) is a scientist, and of the engineering division, an engineer. The importance of the finance division and the establishment division (manned by administrators) being called "common services" should not be overlooked: they are common services in that their field of "service", with its responsibility and authority, interpenetrates all the other divisions through structural ties of varied forms - joint hierarchies, parallel hierarchies, connecting links at the top and interwoven combinations of all three.

The permanent secretary, as head of finance division, is in charge of the finance of the department. He can delegate some of his authority. In the case of the Scientific Civil Service, authority is given to heads of research establishments to spend up to agreed sums in a year - a maximum of, say, £50,000, but more likely £25,000. If this sum is sufficient for what the head of a research establishment judges to be the establishment's needs, then he feels himself to be, in the financial sense, his own boss. If, however, he thinks it would pay to put new effort into a new research and development project, or more effort into a current one, at a cost that goes above his £50,000, then his case has to go up, through his chief scientist at headquarters, to a group of generalist administrators and specialists whose head is a generalist administrator, the permanent secretary. This is an interface where strains arise; 10/ it was recognized by the Fulton Committee, which questioned the Civil Service assumption that senior scientists and engineers who were experienced in running costly projects on the technical side had not developed comparable judgement on the financial side. The Committee compared the Civil Service's tactics with those of industry, where scientists and engineers often take the major part in financial decisions made at the top.

Currently, senior Civil Servants are turning their minds to the matter and are producing a crop of ideas for discussion. For instance, there are questions

10/ Some years ago, this situation led to a chief scientist's moving out to be head of a research establishment in order, as he saw it, to feel that he was his own boss. The situation has already changed somewhat since that time.

whether, instead of the permanent secretary of a highly technological department facing the Public Accounts Committee (to whom he has to justify the department's financial expenditure) alone, he should face it jointly with his chiefs of research and of engineering; and whether, with a unified, differently managed Civil Service, one should plan for the permanent secretary of a highly technological Department to be a scientist or engineer.

The main function of the other common service, the establishment and organization division, is again with a responsibility for public accountability: to control the numbers and grades (called the complement) of people employed in the department, which involves elaborate manpower calculations; and to keep a centralized hold on recruitment, promotion, training and detailed matters of pay. 11/ It has the further functioning of promoting efficiency of working, which it does by what are called "organization and methods studies". It is obvious that control of complement, especially if it is as highly developed as it is in the Civil Service, offers a means of control second only to that of finances. With the two means of control operated in conjunction, as they are by finance and establishment divisions in a Government department, the generalist administrators have a pretty firm grasp on specialist divisions. For instance, just as the head of a research and development establishment has a financial budget that he may not exceed, so has he a complement; he can neither recruit nor promote independently of the establishment division machine. It is fair to say that the machinery is usually operated with good will; but again there lies behind its existence the assumption that scientists and engineers are unlikely to be able to exert this degree of control themselves, and it sometimes tends to be looked on as a necessary evil.

As far as the encouragement of more efficient working is concerned, organization and methods studies constitute a sphere of activity that has been seriously neglected. It is limited in the first place to the lower levels of work in the Service, and the people who do the studies frequently lack the basic qualifications and experience. To make penetrating suggestions about how to do a job more efficiently, a man probably has to be able to do the job himself (as is the case, also, for accurate job evaluation). Organization and methods studies will, in due course, become much more professional; as a consequence, this sphere of activity will have to be supplied with much more money and many more highly qualified people.

To sum up, one might say that the organizational relationships between scientists and administrators in the Civil Service are governed mainly by an organizational structure devised, reasonably, for the exercise of financial and administrative control. Any organizational structure for this purpose is going to work within the structure, in this case an intricate, hierarchical class structure, of the organization as a whole; and it will tend through controlling the organization, as it is, to preserve and strengthen the structure, as it is. Thus, however well the organizational structure does the job, it can scarcely avoid the charge of becoming remote and inflexible in the generalist sectors of the Service, let alone in the scientific and technical sector.

11/ It is, of course, the Treasury, not even the department, that has both the first and the final say on pay and conditions of service - the Treasury in agreement with the staff side (i.e., unions).

A change-over from the current intricate hierarchical class structure to the seemingly simple unified grading structure would ameliorate some of the current interface strains; but it could not help producing exacerbated forms of some of the difficulties that organization and methods studies have had to try to solve. Combining the scientific and experimental classes of the Scientific Civil Service was rejected in 1965 in part on the grounds of its reducing the attractiveness of the Service to the best scientists and in part on the grounds of its necessitating the setting-up of a permanent machine for job evaluation.

Currently, job evaluation in general, like organization and methods work study, is not held in specially high esteem. As concerns job evaluation in scientific research and development, the people who do it cannot command respect unless they are highly qualified for the job, through training and experience. Everyone is agreed that obtaining such persons would entail a major effort in training. In fact, qualified scientists and engineers would need training. These personnel, however, are in short supply in the first place. Furthermore, when creativeness and inventiveness are being evaluated, they must have such intimations of what creativeness is like that only come to those who themselves have a streak of creativeness, especially if they are going to study top-level jobs. The current attitude of senior scientists and engineers in management is mildly sceptical and ironical. They ask who will do their jobs if they all must be job evaluators. But it does seem that for a country, especially a developing one, to use a structure that depends so much upon job evaluation and job study, it must have plenty of qualified scientists and engineers. The alternative would be to use non-scientists, non-engineer personnel technicians whose grasp of the job would be lacking.

Working relationships

One cannot discuss the subject of working relationships for long with administrators before one of them points out, with admirable restraint, that not all scientists make good administrators. With a somewhat cool glance at the Civil Service, one might abandon restraint and say, "Nor do all administrators". The administrator's comment is fair, and there are few scientists and engineers who would disagree with it. Their argument would be that some scientists and engineers do make good administrators, and that by sorting out scientists with a talent for administration and putting them into situations where the talent could be developed, administrators equal to any generalist could be produced.

But the argument is not really as simple as that. The nature of the set-up in the Civil Service is that the young generalist administrator is brought along as such wholly, right from the beginning, whereas the young scientist or engineer is brought along as an administrator only incidentally - he must be doing his job as scientist or engineer to qualify, as it were, for being a scientist, for "understanding" what research and development are about. But, on the other hand, it seems the young administrator would be a better administrator of scientists and engineers if he were not so wholly concentrated on generalist administration rig from the beginning; and working relationships would be more satisfactory, more effective and more fruitful if the generalist administrator and the scientist or engineer were not considered - in fact, were not turned out by education, training and all the rest of it - to be different kinds of beings.

One may ask in what way they are different beings. One could begin by pointing out that both scientists and administrators are typically: (a) intellectuals; and (b) men of action. (Although this refers mainly at the top levels, the generalization continues to hold some distance down.) Science is essentially an intellectual activity, in which spells of conceptual thought, of hypothesization - based on intuitions about physical reality - alternate with spells of action for investigatory or corroborative purposes, that is to say, experimentation. One has only to be among a group of high-level scientists, intellectuals though they are, to realize how active they are, how energetically disputatious, how ready to set about doing something to resolve their ideas. Administration, equally essentially, demands a capacity for intellectual abstraction, for manipulating conceptual thought - for arriving at a thesis about the most reasonable or the most desirable course of action. One has only to be among a group of high-level administrators, very clever men as they are, to realize how active they, too, are, how determined to carry their theses into action - by getting their way in committees, as a beginning.

But there are differences. The most essential difference hinges on creativeness. There is an element of creativeness in the work of the top-level administration, in generating new policies, but its range is of necessity narrow; and, in fact, most administrators spend most of their time and energy on working out the consequences of changes of policy which originate with the minister or the Government and on implementing existing policies. It is well to recognize this element of creativeness, but it is impossible to find it comparable with the element of creativeness in scientific research and development; the latter is of a quite different order of magnitude and, for its generation, demands a quite different order of freedom from rigid controls.

There is a further essential difference, in the extent to which ideas can be checked against reality by experiment. In checking ideas against reality, the options in experimenting are (theoretically, at least) wide open to the scientist, but only fractionally open (even theoretically) to the administrator. Not surprisingly, the difference gives the scientist a confidence beyond any that the administrator may have, a confidence and a scepticism - confidence in anything that has stood up to the test of experiment, scepticism about anything that has not.

Thus, there is a real difference in what the scientist or engineer does and what the administrator does; and that difference tends to turn the two into different kinds of beings. Furthermore, in their work they are grouped separately, and, having the usual human weaknesses, they fall into behaviour dictated by group feeling and group loyalty, which are not, to put it tactfully, always rational. On this level, it is scarcely surprising that when the more innately confident group finds the other group put there to control it, the working relationship seems to include bouts of internecine warfare.

It should be mentioned here, incidentally, that the experience of the Second World War had a beneficial effect on the British Civil Service; in the shake-up, administrators found themselves having to take an easier line with newly imported university scientists who were used to working independently while those scientists found themselves having to take an easier line with curbing administrators. In a developing country, with a long-standing Civil Service which did not have a serious shake-up during the Second World War, one might expect the working relationships of administrators and scientists on the group level to go through greater stresses. Every organizational structure tends to ossify - from that of the single human body to that of the corpus of a society. A Civil Service that is proposing to build up a sizable group of scientists and engineers should know that it is probably going to have to call on greater reserves of flexibility and concession than it has ever needed before - whatever type of new organizational structure it chooses.

In the Civil Service, management training has thus far been, to a very great extent, "on-the-job" training. If a prospective manager is going to be trained either on-the-job, or off-the-job, then, as management is essentially a practical thing, on-the-job training must have first preference. But if he is already being given on-the-job training, there is everything to be said for its being supplemented with whatever off-the-job training can usefully offer. It is arguable that in the British Civil Service, because of the way scientific and engineering activities are organized in projects carried out by teams of mixed grades and classes, the scientist or engineer receives a more natural and more thorough on-the-job training than does the generalist administrator. But that does not mean that off-the-job training would not be useful to him. Certainly, it is now generally agreed that for administrators, the Service's on-the-job training leaves a good deal to be desired, especially by comparison with the management training of administrators in industry - in so far as generalist administrators exist in industry. Everything points to an increase in off-the-job training, and plans include the setting-up of a Civil Service college, as well as an organized network of incidental courses in management.

The plans also fall into line - and this point should not be ignored - with the current thinking about "professionalism". As society becomes increasingly technical, it becomes increasingly necessary for its members to acquire techniques. And as techniques increasingly become the subject of theoretical study, it becomes increasingly necessary for a practitioner of a technique to be au fait with the theoretical studies, for both career purposes and practical purposes: that is what establishes him as a "professional". When management was identified as a single activity of great social importance, which could be properly made the subject of theoretical and academic study, it began to follow the line of professionalization in which, as with, say, physics or chemistry, the level of academic qualifications required for its practitioners was going to be raised. Over the past twenty years, the prime qualification for practising research in physics or chemistry has risen from a Bachelor's degree through a Master's degree to a doctorate. Few practising scientists are greatly in favour of the change, and many put forward sensible arguments in its disfavour. Thus, a further argument comes into being for off-the-job training in management. Incidentally, one might observe that because of its scientific content, one may expect scientists and engineers to take to such training more readily than non-scientists.

As concerns organizational structures, there appears to be no proved case for the superiority of one type over another. For the proposed Civil Service change-over from one structure to another, there seems to be very tempered enthusiasm at the working level of both scientists and administrators, although both sides will bestir themselves to make the new organization work, just as they bestirred themselves to make the old one work. On the other hand, change for its own sake can sometimes be rewarding. Every organizational structure tends to ossify; and which a new one may not have a convincing claim over the old one, some management problems will be solved by it, and, possibly equally important, it will give a convincing display that management's concern for the people it manages is thoroughly alive.

But the fact that no change-over in organizational structure looks as if it will eliminate the strains that occur between administrators and scientists or engineers seems to imply that the problem must be attacked at a deeper level. (An administrator and a scientist may be placed - on the strength of evaluation of responsibility, creativeness, difficulty of work and so forth in their jobs - in the same grade of a unified, classless structure; but everyone knows that one is an administrator and the other a scientist: putting different animals in the same pen does not make them the same animal.)

What must be done is to engineer a situation in which the interface disappears. To this end, it seems that specialization and compartmentalization must be minimized early, and the detection of talent for management must be maximized. Among those who are concerned with these problems, there appears to be a regular swing of the pendulum between putting "the job" first and putting "the man" first. The current phase is that of concentrating on "the job"; there is consequently the risk of some loss because of insufficient attention to "the man". There is evidence enough that some scientists and some engineers can be good administrators; they are, as it were, "the man" who must be detected. Having done that, plenty of techniques are available, both on-the-job and off-the-job.

Possible recommendations for developing countries

Based on the experience in the United Kingdom, developing countries should consider:

(a) Judging the relative merits of setting up what is specifically a distinct group of scientists and technical personnel rather than merging them with the rest of the Civil Service. Consideration might be given to such criteria as:

(i) Attractiveness of a separate Service for purposes of recruitment, internal promotion, special recognition of talent for innovation;

(ii) Counter-attractiveness of separation from the main body, resulting in difficulties for scientists and engineers moving into key administrative jobs;

(b) Recruiting scientists and engineers on a Service-wide basis, rather than exclusively for departmental careers;

(c) Determining that opportunities for advancement to the top levels of the Civil Service shall be open to scientists, engineers and other specialists;

(d) Establishing a "merit promotion" plan for outstanding achievers, independent of particular job level, age and seniority factors, and based primarily on achievement in work performance;

(e) Use of fellowships and other devices to attract very promising scientists to enter the Service on short-term contracts in the hope that they would remain in the Service;

(f) Providing administrative management training for scientists, engineers and other specialists at middle and senior career levels;

(g) Providing planned mobility for scientific and technical personnel of nation-wide scope by such means as an integrated pension scheme.

SOME MAJOR ISSUES IN ROLE, EMPLOYMENT AND DEVELOPMENT OF SCIENTIFIC AND TECHNICAL PERSONNEL IN PUBLIC SERVICE

Prepared by the United Nations Secretariat

This study examines some major issues relating to improvement of the management of scientific and technical personnel in the public services of developing countries. Scientific and technical personnel are defined for this purpose as persons with a first or higher university degree or comparable qualifications in any of the physical, earth and life sciences, including medicine, public health and all fields of engineering, who hold public service posts relating to such disciplines. The term "public service", as it is used in this context, encompasses the traditional Civil Service and public corporations and enterprises primarily financed by the Government.

The terms of reference of the subject, namely, the role, employment and development of scientific and technical personnel, are defined as follows:

(a) Role describes the manner in which the purpose and the work activities of such personnel are deployed by developing countries;

(b) Employment covers the range of policies, conditions and employee management relationships, including the salary scale and other employee incentives, essential to proper staffing and retention of scientific and technical personnel within the public service;

(c) Development is the aggregate of activities, both officially sponsored and employee-generated, directed towards increasing the professional competence and managerial effectiveness of the scientific and technical work force.

Science and technology are valued increasingly throughout the world because they can generate such benefits as improved levels of living, better health, improved educational and economic opportunities and similar desirable ends. The "science and technology revolution" is also changing the composition and objectives of the public service, the major instrument available to developing countries for ensuring most effective use of science and technology to establish and meet national goals. The top-level administrators of all national public services apparently face a similar task of strengthening the capability and adaptability of the public service to respond effectively to the number and variety of manpower problems resulting from the continuing and accelerating national impact of science and technology.

A common manifestation, for example, of such impact appears in the typical conflict between the traditional practices imbedded in excessively static Civil Service systems and the continuing need for introduction of more flexible personnel methods. The experience of several countries shows that resolution of such issues depends mainly upon an explicit national policy commitment to initiate development of a more flexible personnel system. The urgency for such action is reinforced where there also exists the situation of loss of essential talent through migration abroad or to alternative attractive opportunities existing outside the public service in the same country.

Within such a setting, this study is directed towards the following objectives: (a) to identify and focus attention on the actual dimensions of some major issues concerning role, employment and development of scientific and technical personnel; and (b) to describe specific policies and practices based on selected national experiences which may contribute to improvement or solution of problems relating to these issues.

Through such exchange of ideas, insights and experiences, it is hoped that a community of interest in sharing international knowledge will support better utilization of scientific and technical manpower resources among developing countries. It is also noted that any national application of policies or practices developed in other countries will probably require considerable adaptation to the cultural, political, economic and other components of the organizational setting in one's own country.

Role of scientific and technical personnel

The roles undertaken by scientific and technical personnel in the public service of a developing country are highly diversified. In general, they relate to the role of the scientist in contributing to national policies and his role in the development of those national policies. Some of the major activities of such personnel are described below. They should have crucial advisory roles in the highest Government councils on ensuring the best application of existing scientific and technical knowledge to the major elements of national development. This is especially critical in developing countries, where limited funds and other resources must be judiciously allocated to ensure maximum effectiveness. They are expected to respond to major challenges in economic progress, medical and public health improvement, education and other areas involving science and technology. One of their major contributions may be in the more precise identification of those problems which are open to application of scientific methods and which affect practically all aspects of national life, such as better use of human resources, land, water and power resources, medicine and public health, animal and marine life, housing and industrial development. Realistic governmental assessment and solution of these problems are deficient without the involvement of scientific and technical personnel. They engage in the planning and conduct of research and development to support and guide national scientific and technical policies, usually involving large financial expenditures and influencing the rate and success of national development.

The functional roles of scientific and technical personnel within the public service may be differentiated into the following activities: (a) the role of the scientist, engineer and other technical personnel in the planning, programming, overseeing and evaluation of duties broadly classified as administration or management; and (b) the role of the scientist, engineer and other technical personnel in the actual conduct of research and development or other scientific and technical activities. Differences in the exercise of these functions have significant implications for the processes of recruitment, promotion, career planning, compensation and other personnel policies which are discussed in this paper.

The extent to which the number of scientific and technical occupations increases more rapidly within a country, as compared with rate of increase of the total population, may serve as a rough indication of the increasing significance of science and technology in national affairs. The proportionate growth of scientific and technical personnel, as compared with that of the total population, has been extremely rapid in developed countries, a trend that may be expected to occur also for developing countries. For example, in the Union of Soviet Socialist Republics, the number of scientific research workers has been increasing by 12.3 per cent per annum, engineers by 7.8 per cent and other workers by 4.3 per cent. The number of scientific workers with degrees from universities or from comparable institutions for higher technical education is reported to have increased by over 400 per cent during the period 1950-1966, from 152,500 to roughly 712,000, i.e. 0.3 per cent of the total population.

In the United States of America, during the period 1930-1960, engineers in the work force increased by 300 per cent and scientists, by 600 per cent. Major professional occupations in the public service increased an estimated average of 17 per cent during the period 1964-1968.

Statistics and projections in this instance are useful only as a reflection of the growing dimensions of personnel problems to be confronted. It may be anticipated that expansion of the scientific and technical manpower sector may raise doubts in many developing countries as to the relevance of the current Civil Service system to the effective meeting of unique situations that will arise. Fundamental consideration may have to be given to whether a public personnel system that was probably designed for the orderly handling of large numbers of relatively undifferentiated positions with typically standard skills and experience possesses sufficient flexibility to meet the new range of needs created by the growing presence of a large number of specialized positions. Unfortunately, there is not yet an available reservoir of successful national experience concerning the orderly introduction of a flexible style of administration compatible with the advance of science and technology. With this in mind, any valid information merits careful evaluation for possible use. It is not expedient to present at this time a lengthy inventory and analysis of every policy, procedure and practice that could be improved; however, this paper does identify and discuss relevant aspects of some major characteristic issues.

Employment

In connexion with employment practices in the public service, the following broad suggestions may be made:

(a) Scientists, engineers and other technical personnel should have the opportunity to participate in policy-making concerning the possible contribution of science and technology to national development. Such participation should also include the development of policies affecting conditions of employment, career prospects and performance standards;

(b) Public personnel policy in most countries has traditionally supported the application of the same personnel methods and practices to all Civil Service personnel. As necessary, revised concepts providing increased legal and administrative flexibility should be accepted in recognition of the wide diversity of occupational skills;

(c) Recruitment and selection of qualified scientific and technical personnel for posts at intermediate and higher levels of the Government should, to the fullest extent practicable, be conducted on an open competitive basis, permitting entry as required of qualified persons from outside the public service to all levels of public service;

(d) Salary scales for scientific and technical personnel in public service should be broadly competitive with those for comparably qualified personnel of needed qualifications in other sectors of the national economy. Official recognition of outstanding merit and performance should be a recognized objective of the system of personnel administration;

(e) Promotion policy and practice should be related to the different functional roles of scientific and technical personnel, such as a career line for those whose assignments are based primarily on administrative and supervisory responsibilities; and a parallel career line for those whose assignments are based primarily on performance of difficult and creative research, its administration and supervision, or other fully professional assignments;

(f) Career planning for scientific and technical personnel should include the same possibility of their advancement, at least in terms of salary and prestige, as might be open to those in administrative positions. Posts at the highest policy level of ministries, departments or agencies, especially those which are major employers of scientific and technical personnel, should be filled on the basis of selection of the best qualified persons, without undue emphasis on membership in a particular class or group of positions;

(g) Active official encouragement should foster a wide range of professional activities for scientific and technical personnel, with the objective of encouraging active development of their professional competence. Those currently assigned or expected to be assigned to posts involving major administrative responsibilities should be provided appropriate training in managerial skills.

Participation in development and administration of Government personnel policies and practices

In most countries, the policies and regulations governing Civil Servants were developed to meet the requirements of the large occupational groups, such as the clerical and administrative categories, where relatively well-defined and standardized activities are performed. Such occupational groups are generally controlled by typically rigid rules applied impartially over the wide range of Government activities. The inflexible application of the same laws, policies and regulations to scientific and technical personnel, however, may have a disastrous effect on the capability of Governments to recruit and retain these personnel, as well as on the standard of work performance maintained. They may find repugnant those traditional restrictions imposed on employment, salary, promotion, professional growth and other basic personnel processes, which appear to them as not being fully in acreement with their special career needs or expectations. A common occurrence resulting from unrealistic limitations is that the abler specialists seek other employment alternatives which are more responsive to their requirements. As a preventive action, it is essential for scientists, engineers and other specialists to participate in the definition and administration of personnel policies and methods resulting in greater flexibility. The ensuring of this kind of professional contribution by the specialist to personnel policy may even be institutionalized. In Japan, for example, the Constitution requires that one member of the National Personnel Authority, which is the central personnel agency for the Government, should be a scientist. This requirement is designed to help bring about an increased adaptability of personnel practices. In the United Kingdom of Great Britain and Northern Ireland, the Civil Service Commission includes a scientist-commissioner who is particularly responsible for recruitment of permanent scientific staff to the Civil Service. In other countries, similar efforts to obtain a greater responsiveness, at the highest echelon of personnel policy development, to the needs of scientific and technical personnel are achieved by advisory committees composed of scientists, engineers and other technical personnel. For example, in the United States of America, the Federal Council of Science and Technology, located in the Office of the President, maintains active liaison with the Civil Service Commission, which is legally responsible for Government personnel policies, to ensure proper awareness of those personnel factors affecting especially scientists and engineers. In the Union of Soviet Socialist Republics, top Government-wide committees, such as the State Committee on Science and Technology and the State Committee on Labour and Wages Problems, make recommendations to the Council of Ministers relating to Government personnel policies, including those governing salaries and conditions of employment for scientific and technical personnel. It is therefore suggested that developing countries might appraise and consider the establishment of procedures that would draw effectively upon the resource of scientific and technical personnel in Government personnel policy areas.

Recruitment and selection practices

In most developing countries, the employment systems used for staffing the public service, in general terms, involve one or a combination of the following recruitment and selection methods:

(a) Appointment immediately upon university graduation with assurance of a lifetime Government career. There is also established a practically closed entry from outside the Civil Service to posts in these occupations at higher levels;

(b) Appointment providing for entry of qualified candidates into the public service at any management or salary level on an open competitive basis. Such appointments may be for a specified time period or on an indefinite basis. There is usually no explicit Government commitment for guarantee of a lifetime career as a result of appointment to the public service;

(c) Temporary employment not conferring any special rights for continuation of service beyond the fixed terms of the appointee's contract.

In examining the relevance of such appointment methods to scientific and technical personnel, it is observed that the underlying concept described in subparagraph (a) is to provide a stable continuing work force on a lifetime career basis. When such appointment systems are supported by periods of organized training for scientific and technical personnel to help ensure knowledge of new developments in specialities and to help prepare them for acceptance of new technical duties, they may be very effective. Without such opportunities for development, the service may not be sufficiently exposed to new knowledge and methods. Under this concept, the entry of personnel with advanced training and substantial experience gained outside of the Government service is blocked, which may deprive the service of needed expert knowledge and skills.

The appointment process described in subparagraph (b) does provide for drawing upon specialized skills and experience acquired either within or outside the public service. On the other hand, candidates cannot be given positive assurance of a lifetime Government career. The fear is also present of undesirable manipulation of the public personnel system, as a result of political and other factors not related to the job, to create barriers to promotion and retention. Its outstanding positive feature, however, is its potentiality for flexible adaptation to the diverse career goals of specialized personnel, some of whom may be interested only in short periods of Government service followed by experience in other sectors.

The third type of employment method, that described in subparagraph (c), provides management with an opportunity for making an appraisal of performance before renewal of an appointment. In some countries, all professional appointments to the public service are negotiated on a specified term contract of from three to five years with provision for renewal after appraisal of performance. In theory, the termination of the contract allows review of the employee's qualifications and performance. In actual practice, however, these performance review functions become routine, frequently resulting in the virtual assurance of re-employment of the holder of the post, regardless of his achievement.

The rapid advance of science and technology imposes a continuing requirement for maintaining up-to-date knowledge as required to permit acquisition of new skills. Consequently, the employment system should provide for acceleration through training of the professional capability of the current work force and also for facilitation of entry from outside the service, particularly at advanced levels, of candidates possessing the quality and breadth of knowledge and experience that could contribute to strengthening of the public service.

It is also very important that the national employment system should not eliminate or restrict unduly the existence of career opportunities for scientific and technical personnel involving administration at the higher policy-making levels of the Government service. Where necessary, managerial training should be provided as a component of the career pattern for scientific and technical personnel to help them prepare for meeting the performance requirements of key administrative posts.

Creative scientific and technical achievement depends upon continued exposure to new ideas and leadership. In application of this concept, the employment system should, to the fullest extent practicable, encourage and facilitate the movement of selected scientific and technical personnel to different kinds of organizational settings both within and outside the service, in order to avoid stagnation and to cultivate broader insights and knowledge. Such planned mobility may be introduced by:

(a) Fellowships and short-term employment contracts for qualified personnel who may also be attracted to a Government career through such short-term experience;

(b) Arrangements with employers in other sectors in the country for assignment or exchange of selected specialists for specified periods of time;

(c) Provision for leave with pay, including study abroad, to support independent study and/or research in fields of related interest;

(d) Co-ordination of pension systems between Government and other national sectors to encourage freer movement of scientific and technical personnel among the different sectors of the country without jeopardy to their accumulated interest in a particular pension programme.

Compensation

The provision of adequate compensation for scientific and technical personnel is a very critical problem in most developing countries. Where such salaries are not broadly competitive with other sectors of the national society, career and personal frustration usually develop among specialized personnel. A basic issue that all Governments must face is whether it may not be self-defeating to adhere rigidly to the same salary policies for scientific and technical personnel as pertain to all other occupations within the Civil Service. Where the salaries offered are excessively low, serious obstacles are imposed on the Government's capacity to staff essential posts in competition with alternative opportunities (not necessarily in the scientific and technical areas) available to scientific and technical candidates. A consequence is the slowing down or eliminating of important scientific and technical work or a serious dilution of quality of performance, as well as of morale. Salary policies for scientific and technical personnel cannot safely ignore existing factors of supply and demand, both national and international competition, and the educational and other financial investment in the training of such employees. Unlike most other occupational groups, scientific and technical personnel are able to seek alternative employment on a world-wide basis. The recruitment and retention of well-qualified personnel are adversely affected in those countries offering substantially less favourable monetary and other incentives than are available either in other sectors of the same country or abroad.

It is apparent, therefore, that careful study must be given to whether entrance salaries are too low to permit the Government to compete effectively with salaries offered by other employers within the same country or by foreign organizations; and also whether the internal promotion policies are sufficiently oriented towards merit, educational qualifications or achievement, rather than based primarily on such mechanical factors as rigid personnel complements or tables of organization involving long service at the same level of responsibility or status, independent of the actual duties performed or the employee's professional contribution. Both types of situation may be prime causes of dissatisfaction contributing to the failure to recruit or the loss of qualified scientific and technical personnel.

It is proposed that management in developing countries should consider the appropriateness to their problems of the arrangements given below for contending effectively with salary administration:

(a) Establishment of a periodical national salary analysis programme, including surveys of salary trends in relation to cost of living and similar factors. Such surveys should be based on determination of comparable qualifications of scientific and technical personnel in Government and other national sectors, as well as the cost of the investment in scientific and technical training. On the basis of such comparative job evaluation, decisions on more effective recruitment would be possible, especially for those occupations where acute shortages of supply continued to exist;

(b) Establishment of a Government-wide unified grading structure in which a specified number of levels or echelons would be set for the total service. Each level would be based on the kind of duties involved, difficulties in performance, qualifications needed and other relevant factors. Special emphasis must be placed on proper evaluation of the difficulties of the duties, the level of education and training required to perform those duties acceptably, and the employee's achievement. Periodical assessments should be made of the demonstrated achievement, as well as of the character of the duties performed. The relevance of the qualifications possessed by the person holding the post to the requirements of the post is a very significant factor in salary evaluation. Broadly competitive salary scales could be determined on the basis of internal comparisons with similar factors applied to other posts and also by comparison with salaries paid to roughly comparable positions outside the Government service. Under this methodology, promotion would not be limited to a fixed number of posts. On the contrary, promotions would be possible when supported by the level of duties and responsibilities performed and by the character of the educational and other qualifications essential for satisfactory performance. A position classification plan, when applied to scientific and technical personnel, must include a component of recognition for creative achievement in science or technology as a major evaluative factor;

(c) Agreement to special salary and other arrangements for recruiting of qualified persons on short-term contracts for highly specialized work of a temporary character;

(d) Separation of scientific and technical organizations or major components thereof from the traditional Civil Service and placement of those groups under an autonomous Government corporation with sufficient independent administrative powers to establish needed flexibility in terms and conditions of service to meet changing requirements. This has been done, for example, with research organizations in Australia and Thailand. In Australia, the Commonwealth Scientific and Industrial Research Organization (CSIRO) does not have to conform to national public service salary scales because of its constitutional position as a statutory corporation of the Federal Government. The CSIRO is not part of the regular public service and establishes its own salary scales. It has a considerable degree of autonomy of administration in the conduct of its operations, following the principle that control of its administrative processes remains in the hands of the research scientists. Similarly, the Applied Scientific Research Corporation has been established in Thailand outside of the regular Civil Service as an autonomous Government scientific research organization operating under the National Research Council. It has independent authority to determine the salary, administrative and personnel policies affecting its scientific and technical staff. Such separation provides also for greater freedom in the exercise of the total range of administrative functions;

(e) In the Union of Soviet Socialist Republics, Czechoslovakia and other centrally-planned economies, the system of salary administration is usually based on the principle of remuneration for work performed, using the following criteria: quantity of work; quality of work; social importance of the work. In determining salaries for scientific workers, their individual scientific qualifications are also given special credit, both in the amount of salary paid and as a condition for appointment to designated posts. Thus, the salaries of scientific workers employed in scientific research institutes depend primarily upon the functions assigned, their academic degrees, their designated grade levels in the institute and their length of service. The official category of importance of the institute (as determined by the Government) in which the worker is employed is also a factor in determining salaries. To illustrate the operation of this method, in the USSR, for example, a senior scientific worker or scientific worker (grade I) employed at a scientific research institute in the first-class category, holding the academic degree of Doctor of Science with more than ten years of experience, receives a monthly salary of 400 roubles. Under the same conditions, a scientist with the lower degree of Candidate of Science would receive 300 roubles. As a further comparison, a senior scientific worker or scientific worker (grade I) at an institute in the third category, with the degree of Candidate of Science and less than five years of work experience, would normally receive a salary of 190 roubles per month.

Promotion

Establishment of an effective and equitable promotion policy comprises such principal components as the rate of employee advancement to higher posts, based on his length of service and other administrative requirements governing his promotion to the next higher category level, or grade designation of higher status; the kind of criteria used in determination of those employees selected for promotion; and the existing range of Government-wide opportunities which are open to the employee for eventual or possible promotion.

As concerns the rate of career advancement, based on both the length of service required before a promotion may be normally expected or a promotion may be effected based on achievement or other work related factors, this rate is obviously dependent also upon the breadth of the range of possible career opportunities that may exist within the Government service for individual employee advancement.

In some developing countries, the Civil Service structure is so constituted that no more than three or four promotions may occur in an employee's lifetime career. In such instances, the personnel system is usually based on a hierarchy of three or four ranks of responsibility with a fixed number of posts assigned to each rank. As a consequence, an employee, regardless of his talent and achievement, will remain in the same rank for a long period of time. A frequent allegation in criticism of such a system is that achievement or personal qualifications receive too little recognition in the promotion process, which is perceived therefore as a deterrent to sustaining a spirit of dedication to the work assignment.

A promotion philosophy based predominantly on organizational procedure, rather than on personal or professional requirements, precipitates additional problems in those countries where a distinct group of scientific and technical personnel exists concurrently with administrative personnel who are predestined to fill all top policy-making and key administrative posts. Scientific and technical personnel are thus limited to those posts which have been located within the scientific and technical service. By contrast, the posts that are regarded as involving policy-making and the direction of all major programmes are reserved for the administrative personnel. As a consequence, scientific and technical personnel as a category, regardless of personal abilities, are deprived of any opportunity for filling key posts at the higher level of policy-making responsibility. Where entry into these two distinct groups is typically upon university graduation, the course of the employee's lifetime career is excessively controlled by a decision made at the time of his entry into the service.

The training, experience and knowledge acquired by scientific and technical personnel during their careers are not, therefore, afforded adequate consideration with respect to their providing eligibility for policy-making posts. It should be noted that the imposition of such limitations on career goals of scientific and technical personnel is not practised among those countries which employ a unified type of Civil Service system. This kind of personnel system provides a common structure for all Civil Servants through the highest levels. In such countries, the emphasis is therefore on an open Civil Service society based on selection by record of performance and qualifications, as compared with a closed society based on the type of appointment acquired at initial entry some twenty-five years earlier.

Special leave and pension arrangements

In some countries, the status and prestige of scientific and technical personnel are officially recognized by providing entitlement to superior leave and other benefits. In the Soviet Union, for example, the official work week for scientists is more flexible than that for other officials. In addition, scientific and technical personnel are granted longer annual holidays with pay, ranging from twenty-four to forty-eight working days per annum.

The Soviet Union also utilizes the specialized knowledge and experience of pensioners. Normal retirement age for men after twenty-five years of service is sixty years; for women after twenty years of service, it is fifty-five, at an annuity of 40 per cent of the official salary at time of retirement. Pensioners may continue to engage in scientific and technical activities through appointment to the post of senior scientific consultant, for part-time employment with a salary supplemental to their pension annuity up to a maximum of 350 roubles per month, including the annuity payment.

Use of dual career ladder and other promotion practices

In connexion with the development of a sound promotion policy for specialized personnel, it should be mentioned that the scientific and technical personnel sector of the public service does not represent a homogeneity of education, training and aspirations. Although such personnel, by virtue of comparable university training, career expectations and cultural traditions, may share similar expectations in their conditions of employment as well as their career goals, many basic differences may exist in their perception of the values of those career goals. This may be illustrated by a comparison of the work functions of the scientist or engineer engaged in conduct of research with those of the scientist, engineer or other technical person occupied predominantly in administrative activities. The research worker sees his intrinsic value to the organization in the quality and importance of his research achievement. His desire for recognition and compensation is based primarily on factors directly concerned with the professional qualifications needed to perform a high level of creative work and on the scientific importance of the results emerging from his personal research effort. His organizational title or supervisory responsibilities are seen by him typically as relatively unimportant aspects of his responsibilities as an employee. As a result, his view on a sound promotion policy is one in which promotion is based on the quality, scope and significance of professional achievement. This view would also be characteristic of the scientist concerned with the direction and organization of scientific and technical programmes.

In contrast, the scientific or technical employee who is primarily concerned with administrative duties may normally fit into the typical organizational hierarchy. Thus, the determinations of his salary and organizational level may be subject to the same criteria as those applied to other occupational groups found in the same administrative structure. His promotion may depend upon his rising to a higher level of administrative responsibility within the organization.

Some countries have made a special effort to recognize such basic differences in career perspective and their reflection in promotion policy. Such methods as those described below have been developed, either individually or in combination, in those countries in order to strengthen the positive incentive of the promotion process in rewarding and motivating employees:

(a) Dual career ladders have been established within the Government service to be used for scientific and technical personnel according to the nature of their major work functions as described above. A feature of this arrangement is that advancement for those engaged primarily in research or development is not necessarily determined by their place in a table of organization or by their being within the numerical quota of posts assigned a specific status level. Instead, the character of their work, the professional qualifications needed and the quality of their performance are used as a basis for career advancement;

(b) A system of "fluid complementing" has been instituted, whereby promotions on the basis of qualifications and performance are made up to a specified organizational rank or status level. Such promotions are exceptions to the standard promotion methods of a fixed number of posts at each such level. This method helps to eliminate the undesirable rigidity of career advancement that is derived from assignment of fixed quotas of higher posts. This method is used in the Scientific Civil Service of the United Kingdom and in some developing countries as an effective means of avoiding the slow freeze of promising scientists during their most productive periods and of providing desirable recognition. An incentive is also strengthened for attraction to and retention in the public service;

(c) The use of "merit appointments", which permit immediate selection for promotion, independent of such administrative factors as length of service or title of the post, of a limited number of persons whose research performance is recognized as outstanding, has been initiated. In such cases, new administrative or supervisory responsibilities are not necessarily undertaken, nor is any change in the organizational location or structure required as a prerequisite of promotion. Professional recognition is also thus conferred on the recipients of merit promotions.

Development

Rapid changes in contemporary science and technology have persuaded Governments to take a more active role in supplying official financial support to training and other measures for ensuring that scientists and other technical personnel shall be kept up-to-date with new concepts and developments in their fields and shall also acquire additional competence in emerging scientific and technical areas. This policy has been particularly evident in the developed countries, where a diversified range of training and other developmental activities for scientific and technical personnel in the public service are now Government-supported. Existing training facilities within the Government service, as well as outside universities and comparable institutions of higher technical education, are used for both part-time and full-time study programmes. In the United States of America, during fiscal year 1968, for example, 49,218 scientific and professional personnel employed by the Government participated in some aspect of in-service training. Approximately 48,000 employees were sent, at Government expense, to universities and comparable higher administrative institutions in that country and abroad for special studies. Of this latter number, over 1,000 were engaged in such full-time professional development programmes for periods of over six months, while receiving their normal salaries and other allowances.

In the USSR, employees on full-time leave for advanced training may receive State fellowships. When their regular positions are at a higher salary than the fellowship, a special fellowship grant may be given. The following benefits and incentives are granted for those undertaking full-time studies: fifteen days leave with pay to take necessary entrance examinations; an annual grant-in-aid for the purchase of scientific publications; an annual paid holiday of two months; and at the end of their studies, a paid holiday of one month.

Employees engaging in part-time training also are entitled to such perquisites as a supplementary paid leave of thirty full days each year to prepare for their examinations, opportunity to engage in practical laboratory work or to prepare a thesis, four months' leave with pay to prepare the equivalent of a master's thesis, and six months or more to prepare a doctoral thesis. Such leave is granted on the recommendation of the scientific and technical ministries and departments concerned, or on that of the councils of institutions of higher education or research institutions.

Institutions of higher education in the Soviet Union also offer, in addition to the programmes described, part-time extension-correspondence programmes. In general, the student enrolled in extension-correspondence courses has infrequent contact with the instructional staff, limited in some fields and institutions to examination sessions. Some programmes, however, allow up to twelve hours of weekly sessions with teachers in lectures, laboratory sessions or consultations for six or seven months of the year. In 1964, approximately 56 per cent of all students involved in a higher education programme in the USSR were enrolled in evening or extension-correspondence programmes. The student's study activities are guided by printed instruction aids and regularly scheduled home assignments.

Faculties for production executives provide a one-year university course for staff who have higher technical education qualifications, have worked for a number of years in the public service and are recommended for further study.

Training institutions are attached to each department of the ministries. Intensive courses of study are organized as classes, seminars or conferences at periodical intervals. They may be special or evening classes open to either compulsory or voluntary participation. Special courses for management training of technical personnel are offered at the Academy of Social Sciences of the Central Committee of the Communist Party of the Union of Soviet Socialist Republics, at the higher schools of the Party and by post-graduate courses at the institutions of higher education and the research institutes.

In a generalized fashion, the following description of professional development activities may serve as a guide for developing countries:

(a) First-degree university graduates in science or technology or candidates with equivalent qualifications accept appointments in the public service. Those desiring to pursue part-time higher studies in an approved after-hours programme are provided with necessary financial aid to pay for tuition, books and related educational costs. Co-operative arrangements are sometimes negotiated between the Government and universities to provide such higher graduate studies at or near substantial centres of scientific and technical personnel. Although the policy is explicit in most Government-supported activities that academic degrees are not in themselves considered the goal for official support, such degrees, when acquired, are recognized in some countries as evidence of increased professional capacity resulting from such studies. Government expenditures in supporting extensive "learn while you earn" programmes at graduate levels have been substantially repaid by the increased supply of better qualified and potentially more creative officials, apart from the intangible values of enhanced morale and motivation;

(b) Government encouragement is given to support of the following activities:

(i) Active participation in both national and international scientific and technical societies, including participation at professional meetings;

(ii) Encouragement of specialists to prepare articles for publication in professional journals or textbooks and to study materials for educational programmes existing within the country;

(iii) Leave with pay to pursue studies in a specialized scientific and technical area of interest to the official, either through a programme of visits or through undertaking such studies on a residential basis at an institution of higher education or a specialized scientific institute;

(iv) Encouragement to accept fellowships providing for travel and study, either by action of the ministries and departments or by external agencies, including international organizations;

(v) Development of planned mobility of selected staff by plans permitting selected scientific and technical personnel to be assigned on a temporary basis to posts in other ministries within the Government or in other sectors of the country. Such rotation provides an opportunity to broaden work experience and increase skills.

Official recognition of professional achievement

A sound career development system should also provide for recognition and reward of excellence in performance, and the acquisition of further skills and qualifications essential to improved performance. Scientific and technical personnel have traditionally welcomed appreciation of their work and achievements, especially from professional colleagues. Official recognition whereby the Government identifies and publicizes superior contributions of public officials is also desirable.

Such Government-sponsored recognition may include a diversified range of programmes including conferring of honorary titles, awards of certificates of outstanding merit, medals, fellowships and especially salary increases. Any of these awards may be conferred in combination with others.

Czechoslovakia, the Soviet Union, Yugoslavia and other Eastern European countries vigorously provide recognition through the formal methods described above, as well as through other media, including substantial cash awards. Recognition ceremonies are typically given wide public attention in newspapers, radio and other communications media.

Annual awards are given; for example, in the Soviet Union, such awards include the Lenin Prizes and numerous State prizes. The highest national award, "Hero of Socialist Labour", may also be conferred for outstanding scientific performance. Merit salary increases also are used widely.

The United States of America employs a variety of recognition methods, including both financial and honorary recognition, for scientific and technical personnel in the Federal Civil Service. Honorary awards are presented at different organizational levels in the Federal Government; the highest being the annual Presidential Awards. The secretaries of all departments and agencies of the Government may confer at any time and in any number Distinguished Civil Service Awards and other honorary awards. Outstanding employees may be given merit salary increases at any time based on proper documentation of their excellence in work performance.

Management training

Misunderstandings between specialists and administrators appear to be common. Differences exist the way in which they value employee work contribution. Their attitudes may conflict especially when engaged in trying to reach agreement on the solution of major administrative problems. Where a lack of appreciation of the working methods and goals of these two groups exists, undesirable barriers in communication develop, leading to wasteful and probably unnecessary frustration. A primary concern of developing countries should therefore be the development of a greater understanding of the management process by scientific and technical personnel through management training programmes, including residential conferences and seminars. In addition, administrators need training in development of greater sensitivity to the problems and work style of scientific and technical personnel. Goals of both training activities rely on exchange of views and better attitudes towards improved co-operation, as well as increased managerial skills.

Such management training activities should be concerned not only with the administrative machinery and major administrative processes of the Government, but with the role of science and technology, the nature of special personnel problems of scientific and technical personnel, and the exploration of administrative policies resulting in a more congenial and productive working environment. They may serve to help meet other goals besides the improvement of communication channels and relationships between administrators and specialists. A typical problem in many developing countries is the determination of significant training to be made available in order to enable scientific and technical personnel either currently in key posts involving major administrative responsibilities or anticipating possible future assignments of this character to increase their management skills. As a rule, their previous careers and their education in pursuing substantive goals in a scientific and technical discipline have provided at best only meagre resources in management expertise. The scientist or engineer, when assuming the post of department head or permanent secretary, finds a main preoccupation with administrative decision-making on a wide range of matters involving the best use of manpower, facilities and finance. Greater attention must therefore be devoted to helping him find the administrative solutions needed for his successful performance.

The importance of such training is being increasingly recognized in some developed countries by the establishment of a variety of training programmes designed for improvement of the administrative capability of scientists, engineers and other technical personnel.

Emigration of talent

A widely discussed issue affecting scientific and technical manpower in developing countries is the continuing loss of their talented personnel through emigration to other countries. International mobility for scientists and other specialists has been traditionally encouraged for increasing professional growth; but when it results in the permanent depletion of available manpower resources for a developing country, a national problem of considerable magnitude arises: A central issue for national policy, then, is the extent to which undesirable migration should be reduced or reversed through positive Government action.

Migration results from an aggregate of social, economic and personal factors. In many cases, the most effective kind of counteraction may not be within the capability of the losing country, particularly as concerns the provision of adequate salaries, modern equipment and the desired range of opportunities for use of specialized abilities that might be available abroad to talented staff. At the same time, many substantial improvements could be introduced to help retain the current work force. The role, employment and development of scientific and technical personnel within the public service of a developing country represent a major area where substantial improvements could contribute effectively to solution of the basic problem of migration. As the Government is typically the major and sometimes the only substantial employer of such manpower, any positive incentives, such as improved personnel policies and practices, that were established or expanded, and, concurrently, any disincentives that were identified and eliminated, would materially enhance the country's power for retaining a greater number of its talented scientists and other technically trained manpower. In this paper an attempt has been made particularly to focus on examples of such positive measures and their use. In addition, the following measures help to strengthen retention:

(a) An active national commitment to increase the flexibility of Government machinery, such as has been presented in this paper, to meet the special career needs of scientific and technical personnel, is a top priority objective;

(b) Establishment of new or expanding research and development centres and other comparable technical facilities to increase the range and quality of utilization of specialized skills;

(c) Co-operative arrangements with international research centres providing for limited-duration assignments of selected national personnel, followed by return to the home country;

(d) Increased participation of scientific and technical personnel in formulation of major national scientific and technical management policies affecting their careers;

(e) Stimulation of greater use of scientific and technical personnel in industrial enterprises and their exchange with those in the public service;

(f) Establishment of active programmes for encouragement of return of needed scientists and other specialists to the home country. An example is the Scientists Pool created in India to provide temporary placement for well-qualified scientists and technologists returning from abroad, where their knowledge can be utilized while engaged in the process of securing an appropriate post.

Conclusions

The leadership of developing countries must seek the highest level of support within those countries to bring into reality those enlightened concepts and methods which appear to relate to improvement or solution of major problems in management of scientific and technical personnel in the public service. There should be no hesitance in calling upon the United Nations and other international organizations for guidance and other assistance in the implementation of needed changes in this component of the public service.

An underlying principle of such efforts is that quality attracts quality. The pursuit of such quality must be both imaginative and forceful. In recent years, some new attitudes and methods have been introduced into national administrative systems with the aim of attaining a higher standard of quality. These new approaches are illustrated in the emphasis now devoted in some countries to supportive measures in professional growth, official recognition of achievement and use of more adaptable and flexible conditions of employment. This trend must be continuously encouraged by Government administrators in the exercise of their responsibility for maintaining a work environment congenial to accomplishment by highly trained scientific and technical personnel.

The following proposals are set forth for improvement of the management of scientific and technical personnel in the public service of developing countries.

1. A national commitment should be adopted for introduction of increased legal and administrative flexibility into the national personnel systems, responsive to such factors as the diversity of occupations, their specialized requirements and, where appropriate, the national supply and demand factors.

2. Scientists, engineers and other technical personnel should have the opportunity to participate in major policy-making concerning their conditions of employment, their career development and the optimum contribution of science and technology to national goals.

3. Recruitment and selection of qualified scientific and technical personnel for all levels of public service should, to the fullest extent practicable, be conducted on an open competitive basis permitting recruitment as required of qualified individuals from outside the public service.

4. Career opportunities for scientific and technical personnel should be equal to those in administrative occupations, including posts at the highest policy levels of ministries and departments. These posts should be filled on the basis of selection of the best qualified persons without undue emphasis on membership in a particular class or group of positions.

5. Promotion policy and practice should relate both to achievement in work performance and to the different work functions of scientific and technical personnel, e.g., by having dual career ladders - one career ladder for those whose assignments are based primarily on performance or supervision of performance of research and a second and separate career ladder for those whose duties are primarily administrative or supervisory in character.

6. The employment system should provide for acceleration through training of the professional capability of the work force and also for entry from outside the service of candidates with advanced levels of experience and training.

7. The employment system should facilitate planned mobility of selected scientific and technical personnel to different kinds of organizational settings both within and outside the service, in order to produce broader insight and knowledge.

8. The salary system for scientific and technical personnel should be competitive with salaries available for comparably qualified personnel in other sectors of the national economy.

9. Careful study should be given and appropriate action taken to ensure that the salaries offered shall permit the Government to compete effectively with other employers in the same country.

10. A periodical national salary review programme should be established to ensure proper attention to salary trends in relation to cost of living and comparable factors.

11. Alternative methods of salary administration for scientific and technical personnel should be evaluated for possible use. Among such methods are a contract employment system, a unified position classification and pay system and a salary administration system independent of the regular Civil Service.

12. Co-ordination of pension systems between the Government and other sectors should be achieved to facilitate planned mobility of scientific and technical personnel.

13. Personnel systems employing a position structure whereby a fixed number of posts is allotted to designated rank levels should introduce increased flexibility for promotion of personnel with demonstrated achievement in work performance through:

(a) Provision of a flexible number of posts at designated ranks of the service;

(b) Use of merit appointments permitting promotion without consideration of assigned duties and responsibilities or work location, on the basis of official recognition of outstanding achievement in the employee's current assignment.

14. Attention should be given to further use of knowledge and experience of retired scientists and technical personnel, for example, through part-time employment.

15. Official support should be provided to the maximum extent practicable to foster a broad range of professional development activities among scientific and technical personnel in order to increase their professional competence and knowledge, including financial support for full-time and part-time education and training, participation in professional societies and other comparable activities leading to professional development.

16. At comparatively early, as well as advanced, career stages, formal training in management should be available to scientific and technical personnel both as preparation for later career posts involving management and for achievement of a fuller appreciation of the human, economic and financial implications of their work.

17. Government should recognize, reward and publicize excellence in work performance through diverse financial and honorary methods, including cash awards, honorary titles, honorary awards, medals and employee advancement.

18. The following measures, in addition to achieving over-all improvement of the role, employment and development of scientific and technical personnel, would contribute to the country's ability to retain a greater number of its more talented scientific and technical personnel:

(a) Increasing the number of opportunities and the quality of resources for challenging and meaningful work assignments under responsive leadership;

(b) Stimulation of greater use of scientific and technical personnel in the industrial and other public and non-public sectors of the country;

(c) Establishment of active programmes for encouragement of the return of needed specialists to the home country;

(d) Arrangements with national and international research centres for limited-duration assignments of selected national personnel, followed by their return to the home country.

HEALTH MANPOWER PLANNING

Alfonso Mejia*

"Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity." 1/ The World Health Organization (WHO), by direct action within its own frame of reference and competence, and by co-ordination with agencies in related fields, undertakes activities, at the request of Governments, in the sense of the definition stated above.

Public health specifically contributes to the protection of human resources and to the improvement of physical efficiency, thus making a direct impact on productivity and on the general well-being of society.

It has been estimated that, because of its large capital investment, operating expenditures and manpower requirements, the health sector in some countries ranks third or fourth among industries, classified in terms of manpower potential. 2/ In this sense, it continues to expand to meet the rapidly increasing demands for health services attendant upon changes in population size and age distribution and upon advances in medicine and other scientific fields.

Those concerned with medicine and the health sciences are becoming increasingly aware of the relation of disease to the social and economic problems associated with the prevalence of ignorance, poverty, excessive population growth and hunger. In this context, greater recognition is being given to the multiple-causation concept of disease and to the fact that the solution of these problems requires a multidisciplinary approach through concerted action, at both national and international levels.

Few countries in the world, if any, currently have enough qualified manpower to satisfy their own demands for health services. While no country can afford to waste its available human resources through inadequate manpower planning, such planning is even more important in developing countries where the short supply of money and skills is often acute. In recognition of this fact, the United Nations and its specialized agencies, in the first programme for the Second Development Decade, have made manpower planning an essential

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1/ World Health Organization, Basic Documents, 20th ed. (Geneva, 1969), p. 1.

2/ World Health Organization, Medical Research Programmes, 1964-1968 (Geneva, 1969), p. 227.

issue in relation to the application of science and technology for the benefit of developing countries. 3/

The concept of manpower as a whole includes, inter alia: (a) a determination of the number of people available for various occupations, and (b) the qualities, in terms of education and experience, that they can bring to such occupations. The notion that all persons in the same category of work or bearing the same occupational title should be lumped together is a faulty assumption and one which underlies most manpower studies. Surveys based on this assumption fail to take into account the wide range of training and skills that such a group represents and the variety of activities they perform. Hence, such surveys have inherent limitations. 4/

Health and manpower planning

Health manpower, as it is generally understood, includes the following categories:

(a) Those already working in health services, i.e., economically active health personnel;

(b) Potential workers in health, i.e., economically inactive health manpower;

(c) Prospective manpower, i.e. those who are undergoing education and training for the health services.

Health manpower planning has been defined as a process of trying to ensure that there shall be enough health workers with the required qualifications to meet, but not to exceed, future effective demands for their services. 5/

The concept of a more efficient utilization of health manpower, although not necessarily stated as a specific objective in all studies, is almost always implicit in most of them. There is currently a conscious effort to state clearly this concept and to build it into the planning framework.

Modern approaches to health manpower planning require the following actions:

3/ World Health Organization, "United Nations Second Development Decade, 1971-1980", paper prepared by the Director-General of the World Health Organization, 1961. Section I discusses the United Nations First Development Decade and summarizes achievements in the health sector, with regional reviews of the health situation. See also Economic and Social Council resolution 834 (XXXII).

4/ "Health manpower and medical education in Latin America", report of a round-table conference held at New York, 30 September-4 October 1963, under the joint auspices of the Panamerican Health Organization and the Milbank Memorial Fund, Milbank Memorial Fund Quarterly, vol. XLII, No. 1 (1964), pp. 11-66.

5/ Timothy Baker, "Human resources", "Survey of health planning", Baltimore, Maryland: Johns Hopkins University, School of Hygiene and Public Health, 1969 (mimeographed), p. 125.

(a) Measurement of the needs and demands for health services and the establishment of goals;

(b) Quantification and analysis of current resources and a projection as to these resources, including an adequate supply of manpower, needed to achieve the above-mentioned goals;

(c) Adaptation of educational and training programmes to the needs of personnel actually engaged in health work or preparing to enter the field;

(d) Definition of a policy and the selection of strategies and techniques for implementing such a policy.

These approaches are important for realistic manpower planning, since they provide the means whereby the implication of education and training may be considered in the context of the whole health planning process, and the projected demand for services may be balanced with the projected supply of health manpower.

Demand analysis

The current concept of "demand" in relation to health services is usually limited to the actual utilization of such services by patients. This concept, however, appears to be inadequate for an assessment of demands that would be expressed if health services were more readily available or more satisfactory. A first consideration, therefore, would be the development of appropriate measures to quantify demand in relation to both health services and manpower supply. In this connexion, the human element should not be overlooked in planning, since the "felt needs" of people might be quite different from biological needs, which are based on morbidity and mortality, and which reflect only the judgement of professional personnel with respect to the segment of the population that has access to health services. Other factors to be considered are the administratively and technically determined demands and economic demands. These and other factors are closely interrelated and must be taken into account if properly justifiable health needs are to be effectively translated into demands for health services. 6/

The estimation of health manpower requirements usually involves some efforts to relate the supply of health workers, particularly physicians, to the demand for their services. To do this, several methods have been used. Among these are studies of the relation of the number of physicians, other health workers or services, as the case may be, to population, mortality and morbidity, patients seen per unit of time, and the prevalence of preventable diseases. Studies of the functions and utilization of health workers, as well as of the adoption of ratios used in other countries, have also been employed in this respect.

No single method is entirely suitable, since each has a limited validity. With regard to mortality, morbidity and utilization, most statistics are

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6/ World Health Organization, Consultation on Health Practice Research, 2-10 December 1968, OMC/69.1 (Geneva, 1969).

insufficient and inaccurate. Moreover, since the standards of one country may not apply to others, the adoption of ratios will not necessarily be useful.

Comprehensive planning and reorganization become vital in the search for the optimum utilization of all health personnel, particularly the physician, who is scarce and costly, both to train and to maintain. The physician, however, although a sine qua non for some types of health care, is not always the only alternative, and effective demand analysis must cover all categories of personnel.

Current supply of health manpower

The measurement of health manpower supply involves many variables which determine the validity of the measurement. Among these is the variable of "who is counted" and the context in which he is counted. This is a particularly difficult task where categories of personnel are poorly defined or where personnel switch from one level of work to another, despite their education and experience, or, in many case, their lack of same. 7/

Health manpower, like all manpower, can be measured in two different ways: (a) in terms of the total number of manpower employed in the health field, and (b) in terms of the various health occupations. The first method refers to all persons employed in the health field irrespective of their educational backgrounds, while the second focuses on those persons possessing knowledge and skills unique to the health field and may include health manpower in all industries, not just the health services. 7/

According to the second method, a determination of the current supply of health manpower requires previously established definitions of the various occupations to be taken into account and of the categories of workers within each occupation. Implicit in this method is the need for a definition of what actually constitutes the health sector, in other words, a delimitation of that sector, a step that is also essential in relation to other aspects of the health planning process and of over-all planning.

Such a delimitation, although simple in concept, poses numerous methodological and operational difficulties. First of all, it requires a clear definition of what is meant by "health service" so that a distinction can be made between the people involved directly in the performance of health work and those who are contributing to a rise in the level of living through work indirectly affecting health, for example, agricultural extension workers. Data on the supply of health manpower vary, depending upon the criteria applied to the delimitation of the health sector. Standardization of criteria in this respect would be valuable.

Delimitation of the health sector also requires a definition of the term "public Service". Although a standard definition of this term has been proposed,

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7/ N.Y. Pennel, "Measuring the supply of manpower", Health Manpower, United States, 1965-1967, United States Public Health Service publication No. 1000; series 14, No. 1 (Washington, D.C., 1968), pp. 1-2.

it is not universally applied and continues to have different connotations in different countries, depending upon the type of organization developed for the provision of services. With respect to the health field, in some countries only basic public health services are provided by the public sector, with private enterprise providing a substantial amount of personal services. In others, all health services are provided by the public sector. Between the two systems lies a broad spectrum combining both systems in various proportions.

The definition of such terms as "scientist" and "technical personnel" is also important to a delimitation of the health sector. As currently used, these terms are generic in that they may be applied to any person having a high level of prestige in a particular branch of science - despite his qualifications and current occupation. According to the International Standard Classification of Occupation (ISCO), Major Groups 07, these terms apply to those who conduct research and apply scientific knowledge to the solution of problems in a large variety of fields, including the health services. 8/

Other categories of health personnel also require definition. Not only does the educational level of the categories vary, even when they have the same essential function, but within each category there is great diversity in this respect. Moreover, in different countries, different labels are attached to personnel carrying out similar essential functions; and, vice versa, the same title is given to persons having quite different responsibilities. 9/

For the benefit of uniformity and for the purpose of international comparability, more concrete operational definitions are required. The ISCO has contributed to this end, and WHO has also made efforts to distinguish between professional personnel and auxiliaries, and, within the professional category, between medical and paramedical personnel. 10/

Projection of demand

Demographic changes are the main factor associated with increases in the demand for health services and, in turn, the demand for health manpower, both in number and in quality. This is not simply a question of more people demanding more services, but a question of demographic structure. According to the age and geographical distribution of the population, the volume and nature of the demand for services will vary. For example, countries with a large proportion of infants and young people, as is the case in many developing societies, have quite a different nature of demand for health services than those countries with a larger proportion of adult population. In the latter countries, provision has to be made to care for a greater number of people having chronic and degenerative diseases associated with old age. These diseases are more difficult to control, more prolonged and, in turn, more costly in terms of services and care.

8/ International Labour Office, International Standard Classification of Occupations, rev. ed. (Geneva, 1969), p. 35.

9/ World Health Organization, Development and Utilization of Human Resources, PC/68.2 (Geneva, 1968).

10/ World Health Organization, WHO Education and Training Activities: A Review, 1958-1967, ET/67.2 (Geneva, 1967).

The possibilities of health personnel being able effectively to provide services to the community and of the population being able to reach such services depends in part upon the density of the population and upon transportation and communications facilities. Travelling may become the principal activity of health personnel in some situations and, in itself, may constitute an important barrier against access of the population to services. In some countries, for example, a physician would have to cover more than 2,000 square kilometres if the population were distributed evenly throughout the area. 11/

On the other hand, concentration of people in the cities implies not only a deterioration of urban life, including health status, but a more widely dispersed population outside cities than can be indicated by average figures. Greater urbanization may influence the utilization of health manpower by stimulating the private practice of medicine, eventually leading to an exaggerated emphasis on curative aspects and on specialization. This situation may also cause more professional personnel to migrate to the cities, thus contributing to the poor geographical distribution of manpower. 11/

How man lives, as well as how long he lives, is largely determined by social and ecological factors that condition his attitude towards scientific and technical knowledge and, therefore, towards the applicability of such knowledge to his personal welfare. 12/ It has repeatedly been shown that low-income and poorly educated groups have a higher predisposition to disease, a different attitude towards health and less demand for services than do higher income groups. Thus, it is reasonable to expect that any rise in the per capita income and in the educational level of a population would make those people more aware of the importance of health and of the possibilities of preserving it. This increased awareness would be reflected in changes in volume and nature of demand for health services, for which additional manpower must be provided.

The scientific and technological development of medicine is contributing to a change in the patterns of fertility, morbidity and mortality. While many causes of disease and death have been eliminated through the eradication and control of some infectious and parasitic diseases, and the discovery of new techniques for diagnosis and treatment, the resulting prolongation of life expectancy has given rise to new types of disease.

It must be pointed out that the extent and nature of such factors as changes in the patterns of morbidity, the final effect of scientific and technological development, the organizational structure of medical care systems and social mobility are very difficult to predict with a reasonable degree of confidence. Forecasting these factors becomes critically important in view of the fact that any manpower projection and changes in educational pattern made now will affect personnel who will still be practising their professions in the next century. 13/

11/ Brian Abel-Smith, "An international study of health expenditure and its relevance to health planning", Public Health Papers, No. 32 (Geneva, World Health Organization, 1967), pp. 13-28.

12/ R.F. Badgely, V. Kasius and M. Schultz, "Social and economic factors and health services", Proceedings of the International Conference on Health Manpower and Medical Education, Maracay, Venezuela, 19-23 June 1967; Study on Health Manpower and Medical Education in Colombia; III Working Papers and Reports (Washington, D.C., Panamerican Health Organization, 1967), pp. 88-93.

13/ United Kingdom, Report of the Royal Commission on Medical Education, 1965-1968 (London, Her Majesty's Stationery Office, 1968), pp. 27-30.

Projection of supply

Factors involved in the projection of the general labour force also influence the projection and utilization of health manpower. Such factors include the number of persons in the working-age group, school enrolment age, school-leaving age, coverage of education, retirement age, life expectancy, type of economy and the degree to which women take part in economic life. 14/ Changes in culture and tradition that are expected to accompany or follow the propulsion of agrarian societies towards industrialization also come into play.

This paper concentrates, however, only on those factors which are more directly related to the utilization of health manpower. Utilization here refers to the degree to which the capacities and skills of health manpower, immediately or potentially available in a country, are or can be effectively used for the improvement of the level of health in that country.

The acute shortage of qualified health personnel paradoxically coincides with unemployment, under-employment or poor utilization. Several factors are responsible for this shortage, e.g., the rapid turnover of professional staff, internal migration, emigration, the lack of adequate incentives, the transfer of health personnel to activities other than health, an exaggerated trend towards specialization and the unrealistic organizational pattern of health services and of education and training for health careers.

Rapidly changing technology and the need to extend effectively the coverage of health services have led to an increasing proliferation of categories of health personnel and functions in many countries. In addition to the direct providers of services - mainly physicians, dentists and nurses - the health team now includes other professional personnel having indirect, but essential, supporting functions, e.g., statisticians, mathematicians, social scientists, systems analysts, medical-record librarians and computer programmers, to name but a few. 15/ At the same time, the systems for the provision of services, the staffing patterns of health institutions, job descriptions and, particularly, education curricula show little change.

The projection of supply implies the identification of elements governing the availability of health manpower, mainly retirement, death and migration, which decrease manpower supply, and the output of teaching institutions, which increases it. Current and future supplies are the final result of the interplay of these elements. Consequently, in order to estimate future trends in manpower supply consideration must be given to the weight of each of these elements and to the factors associated with utilization, particularly the pattern of emigration and the expected degree of participation of women and ancillary personnel in the services.

14/ International Labour Office, Yearbook of Labour Statistics, 1968 (Geneva, 1968), pp. 15-17.

15/ A.H. Siegfried "Sources of manpower statistics", Health Manpower, United States, 1965-1967, United States Public Health Service publication No. 1000; series 14, No. 1 (Washington, D.C., 1968), p. 8.

Emigration

Scientists and highly trained health manpower are among the main contributors to the selective emigration of talent from developing to developed countries. A good proportion of emigrants hold teaching or/and research responsibilities, two fields usually combined and in short supply in developing countries.

The magnitude and nature of the problem is rather well defined in quantitative terms, since the calibre of this migrating stream is delineated and the main donor and recipient countries are fully identified. Much less is known, however, of the real causes and motivations underlying emigration. While some of those causes are obvious and others suspected or taken for granted, a number remain unknown. Follow-up studies are necessary for the measurement of net emigration, including the rate of returnees. It is also necessary to measure the effects, if any, of emigration on the organization of health services and on the general development of contributing countries, and vice versa.

The whole problem is difficult to tackle because of the long-term nature of the measures needed to resolve the many complex factors involved. From the short-term point of view, however, the situation may be alleviated by such measures as the provision of a greater number of local facilities for the education and training of at least the most urgently needed health workers. Additionally, through the organization or regulation of national Civil Services, job satisfaction may be greater as a result of a substantial, justifiable increase in incentives. Concerted inter agency action is needed with respect to advice to Governments concerning the definition, organization and implementation of Civil Service policies.

The WHO assists countries who request it in the organization of health services at national, intermediate and local levels. It also provides advice on selected aspects of personnel policy with a view to effecting job stability and increasing educational and research opportunities for highly trained health manpower.

There is a need for research aimed at the identification of sources of job satisfaction in selected occupations and the measurement of the effect that net emigration has on the development of the donor country.

Participation of women

The proportion of women in health activities varies among countries, depending upon cultural and traditional patterns, together with educational and job opportunities. In the health field, women have been of special concern, both as consumers and as providers of health services.

Many of the activities of the basic health services, such as maternal and child health, family planning and community development, are oriented to the specific protection of women. At the same time, women are active participants in such occupations as nursing care, social work, health education, physiotherapy, nutrition, dietetics, X-ray and laboratory techniques, among others. In several developed and developing countries, there is substantial increase in the over-all proportion of highly trained women and, in particular, of those specialized in medicine and dentistry.

Housekeeping and child-bearing usually prevent women's employment during an important period of their working life, often causing a substantial deficit in health manpower. Since many women are eager to return to employment, active measures may be taken to enable them to resume their place in the health labour force as early as possible. Many countries have increased their highly trained manpower supply by accepting women to work part-time and retraining them through in-service education. The provision of kindergartens, crèches and similar facilities would favour their return to work.

Wider participation of women in the health services, as in any other productive activity, requires that local prejudices must be overcome and general education expanded. Women should be instructed as to job opportunities and should be made to recognize the contribution they can make to the community through selected health occupations for which manpower is in short supply.

The increased trend towards early marriage has drastically reduced the number of unmarried women in the social welfare services of some countries. This is expected to reflect some demographic changes. 16/ Sharper insight into the influences of demographic changes on female labour activity rates requires further research.

Auxiliaries

While productivity of current health manpower could be improved, a significant deficiency would still persist with respect to the coverage of services and the improvement of its quality. Moreover, any measure now taken to increase the number of professional personnel would not have any effect before a lapse of from five to seven years, the time required for the training of some categories.

The optimum utilization of highly trained manpower, therefore, requires increased use of intermediate and auxiliary personnel. This situation applies equally to developed and developing countries, with the difference that in the former group, auxiliaries are usually attached to existing organizations where continuous supervision is available; while in the latter, not only is the scope of their function broader, but professional supervision is usually more remote.

The full scope of the role of auxiliaries is sometimes difficult to determine. It usually requires the definition of functions and activities to be carried out to accomplish specific objectives in a given unit of time and of what is essential within a previously designed system for the provision of health services. This definition of functions and activities should provide the basis for staffing patterns that would permit greater use of auxiliaries,

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16/ Gertrude Williams, "Functions in the social welfare field", paper submitted to the Expert Group on Manpower Needs in the Social Welfare Field and Implications for Training Programmes, organized by the Division of Social Affairs of the United Nations Office at Geneva, in co-operation with the Danish Ministries of Labour and Social Affairs, Hellebaek, Denmark, 13-21 May 1969 (UN/SOA/SEM/33/WP.1 - GE.69-3736).

who can be trained at a relatively low cost and who may be more readily available, particularly to staff the health services of rural areas where highly trained personnel are not willing to go or where their assignment is not justified in terms of optimum utilization.

The application of functions and systems analysis would permit the breakdown of main activities into minor tasks. Such a breakdown would allow different combinations of personnel to be considered with a view to the better utilization of professional personnel and the identification of those simpler elements of their duties which might be performed by auxiliaries. This would also facilitate the task of making the training of all health personnel, including auxiliaries, more job-oriented and, therefore, more realistic.

Mathematical modelling, computer simulation and other techniques of analysis have much to offer as concerns predictions of the probable effectiveness of each combination of personnel.

Health system design

A realistic projection of health needs and demands and of the health manpower required can be obtained only if the health service system is clearly defined. Such a definition may entail a redesigning of the whole system whereby services are provided or a general strengthening of the system as it is constituted.

It has been recognized that the term "system" is "inaccurate if it implies the existence of an organized, co-ordinated, planned undertaking". 17/ It has also been stressed that health services, however, do constitute a cybernetic system in that the various components of health services are subject to random, uncontrolled influences and are interconnected by a complex and almost untraceable pattern of communications. 18/

Because of the large areas of ignorance relating to health services, many faulty assumptions may be introduced into the systems designed for the provision of such services. With an input that is faulty, the "output" of such a system will also be faulty, or, to say the least, will remain only in the realm of the probable.

In the design of a health system, accuracy and adequacy are very relative terms since health needs and demands change according to changes in the physical, cultural and socio-economic environment. For all these reasons, an inquiring attitude is needed if those who are responsible for the administration of health services and of the education and training of health workers are to have adequate guidelines for introducing changes that would effect a rise in the general level of health.

The WHO is engaged in several projects in this connexion and is considering the possibility of embarking on more comprehensive ones. In this context, the training and utilization of auxiliary personnel have high priority.

17/ United States of America, Report on the National Advisory Commission on Health Manpower (Washington, D.C., Government Printing Office, 1967), p. 2.

18/ Vincente Navarro, "Systems analysis in the health field", Baltimore: Johns Hopkins University, Department of Medical Care and Hospitals, 1969 (mimeographed).

Education

Emphasis is currently being placed on the preventive aspects of disease and on the importance of the physical, social and economic environment in relation to health and disease, particularly in developing countries. Unfortunately, this emphasis not always reflected in the content of educational and training programmes, especially in the sense that content does not always take into account local health problems.

The modern concept of the health team is increasingly being applied with regard to the provision of health care. This concept has led WHO to support and promote programmes whereby all health personnel, professional as well as auxiliary, are educated and trained in the same institutions. This should lead to a mutual understanding, among all health personnel, of the respective roles of each category of personnel and the relationship that each health occupation has to the other.

The concept of the health team requires a redefinition of duties as the basis for new staffing patterns that emphasize the optimum use of all health workers, including auxiliaries. This implies not only the organization of team-work to include workers having a relatively narrow specialization, but the diversification of traditional skills with newer skills related to planning, supervision and control.

In the light of the above-mentioned organization of team-work, a new and broad approach must be initiated with respect to the administration, orientation and content of educational and training programmes. If a physician, for example, is supposed to provide supervision and leadership within the health team and in the community as a whole, emphasis should be placed on educating him concerning the administration and management of health services, as well as the techniques of community organization and development.

Health manpower is increased mainly through improvement of the product of existing teaching institutions and the opening of new ones. In either case, consideration must be given mainly to the following factors: the availability of eligible candidates for admission, account being taken of the needs of other sectors of the economy; the physical capacity of institutions to handle increasing enrolments; the availability of qualified faculty; the financial and technical capacity of institutions to operate effectively and to maintain quality of the final product. The last-mentioned factor can be improved through the use of efficient teaching techniques whereby a large number of students, representing all categories of health workers, may be trained by the same teachers and in the same institutions. Moreover, the ratio of attrition between enrolment and graduation may be lowered through improvements in the system of admissions, in the performance of teachers and in techniques for the evaluation of the performance of both teachers and students.

The WHO extends assistance to countries in the establishment and/or extension and improvement of their own facilities for training health personnel. It also assists in the selection of national institutes for the training of personnel from neighbouring countries, the awarding of fellowships, the assignment of visiting professors, the promotion of opportunities for the exchange of information and experiences, and the promotion of national associations concerned with the education and training of health personnel.

The Organization has also been concerned with the training of educators and plans to undertake accelerated interregional, regional and national programmes emphasizing teaching techniques. 19/ The training of high-level personnel at local levels, however, poses a problem concerning the availability of textbooks and other teaching materials. In the Regional Office for the Americas, this problem is being resolved through a library system whereby selected textbooks are rented, loaned or sold to students.

The WHO fellowship programme continues to grow and has been made flexible enough to allow candidates from developing countries to make use of it. Provision has been made to secure both the return of the trainee to his home, if he has been trained abroad, and the utilization of his skills in his own country. Furthermore, with the co-operation of institutions in developed countries, WHO has selected special international centres for biomedical and socio-medical research and for the training of high-level health personnel. As a part of the whole process of preparing manpower for the health services, WHO has also given extensive aid to in-service and continuing education for all categories of health workers. After proper evaluation, such education should be expanded, from the standpoint of both over-all coverage and individual occupations.

Summary and conclusions

In health manpower planning, use is made of some of the methods and techniques applied to general manpower planning. Specific aspects of health manpower planning, however, require special methods of study. While no ideal method exists in terms of universal applicability, selected methods may be adapted to given situations. The availability of data, the existence of trained planners, the level of economic and social development and the extent to which planning techniques have been developed and tested are some of the factors involved in a choice of method.

Available information on health needs and demands, as well as on health manpower supply and the education of personnel for health careers, reflects the degree to which statistical systems have been developed. The quality of this information, in terms of coverage and accuracy, is expected to vary among countries. In some countries, it may not provide an adequate base upon which to build estimates of future trends and requirements.

19/ World Health Organization, "Development of a comprehensive WHO training programme for health personnel teachers", document prepared by the WHO Secretariat (PGE/69.2).

The under-development of rural communities and the lack of incentives may cause a reluctance on the part of health personnel to work in such areas, with the result that highly trained manpower is concentrated in the cities. Such poor geographical distribution naturally leads to under-utilization of health personnel. More research is needed into the motives that underlie such internal migration, as well as those which cause large numbers to emigrate abroad.

The expansion of educational and training activities in the field of health does not necessarily, of itself, lead to an improvement in the utilization of manpower. Such improvement can be effected only through an infrastructure that provides for continuous planning, implementation, supervision and evaluation of all aspects of health services, properly co-ordinated within the general plan for social and economic development. In this context, consideration must be given to demographic changes in manpower requirements and utilization.

Most important of all, perhaps, as a beginning, is the need for an inquiring attitude and the realization that the first step towards manpower planning can be taken with whatever data are available.

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