APPLIED RESEARCH AND DEVELOPMENT WITHIN THE INDUSTRIAL GROUP OF THE U.K. ATOMIC ENERGY AUTHORITY

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WE have previously described[1] the general organization developed for the control of applied research and development within the Industrial Group of the United Kingdom Atomic Energy Authority to provide a development effort for all sanctioned construction projects. The system of organization developed must be integrated with a type of executive management which gives the means of firm direction and control while preserving scientific integrity.

In general terms, the main executive responsibility lies in instituting a type of management which enables a strategic plan of research to be tactically discharged with the necessary standard of scientific and technical excellence. The preparation of appropriate financial and staff estimates, and the maintenance of all records necessary to the forward planning of experimental effort and the periodic reviewing of progress, are essential features.

Allocation of Priorities

The work of the experimental establishments serves both the Engineering and Operations Branches[1]. Broadly, where subject priorities are concerned, it is agreed that existing processes must be kept working before all else; secondly, sanctioned projects must be introduced on time, and thirdly, modifications and refinements recognized as advisable should be added to existing projects as facilities permit. A system of priority classification has been designed to take account of both the subject priority and the latest date before action must be taken by either the Engineering or Operations Branch. Some target dates are irrevocable and must be met; others, if necessary, can be revised as a result of due consideration. Based on an analysis of this sort a decreasing scale of priority can be worked out which introduces the time available for experimental work. Where the importance of the subject justifies it, work required within six months merits the highest priority, for which staff will be made available over all other types of work. The time available for second priority work is arbitrarily fixed, and for third priority work no completion date need be stated.

Some general principle must be accepted for assessing priorities, and those set out above are suitable for some circumstances. The principles must be in conformity with the financial and administrative arrangements, and if this is the case, although they may be arrived at arbitrarily, they can safely be adhered to as a working arrangement. It is useless, however, to have a system of assessing priorities and then to ignore the conclusions reached.

Allocation of Costs

The assessment of priorities provides a convenient method of division into categories so that the costs can be properly allocated.

The cost of development work carried out on behalf of the Operations Branch for the removal of difficulties in, or improvement of, existing processes is borne by the works and recovered as a charge on the finished products. Such investigations, always of a high priority, are undertaken only at the request of, or by agreement with, the works general managers, but are never delayed by excessive formality.

The major amount of research and development effort is allocated to work in support of current sanctioned design commitments, and, for such, the charges are borne by the chief engineer of the project. These charges are recovered by an addition to capital charges which are amortized over a period of years. In this category the nature of the problems and the necessary experimental work are discussed thoroughly by the chief engineer, head of the experimental establishment and chief scientist[1], following which an estimate of the cost is returned to the chief engineer without delay so that he can assess whether the cost is in proportion to his need. If he feels that the expenditure is too great and that some engineering solution is both possible and preferable, the nature of the problem will be reconsidered against the general background of reactor development and, if the work is undertaken, it will be as a research and development charge. All long-term research and all work for feasibility and design studies of projects not yet sanctioned are Research and Development Branch[1] charges. Work of this type is carried out by the Research and Development Branch without prior discussion with other branches.

Work Requisition and Initiation Procedure

The implementation of the priority and cost allocation procedure leads to a system of work requisition and initiation designed to ensure that only work is undertaken which is expected to influence the course of development and to prevent the application of effort in directions which, although interesting, would be less profitable. A standard requisition form is the medium by which requests for work are passed from headquarters to the laboratories, or from the laboratories to each other or to headquarters, and copies are sent to any other interested parties. This outlines generally the nature of the problem and gives a brief description of the background to the investigation.

On receipt of the requisition the establishment responsible for meeting the requirements decides the reporting dates, and issues an instruction sheet to appropriate sections. There are cases where reporting dates must be imposed in the requisition to fit in to a programme approved by the Research Board, or to conform to some key design date. In such cases the reason for this is stated in the "Background to the Investigation". If the requisitioned laboratory, in view of its existing commitments, is unable to meet these dates, advice on relative priorities may be obtained from the functional chief scientists, or reference may be made to the Research Board[1].

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Obviously, any system for requisitioning work or for the initiation of new items of work must not interpose delays. This is avoided by an adequate delegation of authority. The head of each experimental establishment is responsible for the use of his staff. He can start work himself, to a cost of £500–£1,000, without reference to anyone. If larger sums are involved, by discussion with other heads of experimental establishments, chief scientists or the director, work can again be initiated without any formality. Afterwards, instruction sheets, requisitions and cost returns will be prepared. Periodic reviews of progress may also be made to see if the original instructions need amendment.

Planning of Experimental Effort

Accurate planning of scientific and experimental effort ultimately depends on accurate records of effort spent on previous comparable work.

The effort available from each person in a particular period is reckoned as the number of normal working days less an average figure computed from his annual leave allowance and other absences. The number of investigations which can be efficiently worked on decreases as the status of the staff decreases. Excessive diversification is undesirable, and when it occurs the research manager, in consultation with the section leader, decides how many days will be devoted to each job. If the estimates of time allocation are realistic, over-planning indicates that overtime should be temporarily worked, and that for the long term, additional staff or reduction in the number of commitments should be recommended. Conversely, under-planning implies that additional commitments can be accepted or staff can be available for transfer.

The main experimental work must be supported by services from chemical analysis, X-ray crystallography, metallography, etc. The indirect effort involved is more difficult to estimate. When adequate records are available, these will indicate the amount of indirect effort appropriate to the type of investigation involved. To integrate this with the main effort so that the latter is not delayed may present such difficulty that the best solution may be to make an arbitrary allocation of service effort to any particular section, leaving it as the section leader's responsibility to utilize this allocation to meet his priorities.

Staff can only be provided without delay if there is spare capacity, which is rarely the case. Normally all staff are fully occupied and examination is made of the priorities of work in hand to see which jobs can best yield staff to the proposed new one, if this is of higher priority. When this fails, target dates for all work show the earliest date on which staff will be available. New recruitment is regarded as an aspect of long-term planning and seldom enters into decisions related to work to be undertaken in the immediate future. It may be necessary to refer the matter to the Research Board to resolve competing priorities or to agree on alternative measures for obtaining experimental capacity.

Costing of Experimental Work

In the compilation of an instruction sheet, the estimated amount of experimental effort is stated in terms of the grades of staff to be used. Scientific and experimental staff fall into the three categories of senior, main, and assistant grades. Taking an average figure for the salaries of the staff, and a factor computed by the accounts branch from all other normal expenses, the cost of any investigation can be calculated from the instruction sheet. If a second instruction sheet arises from the first, the cost of the second would be an abnormal charge on the first. Similarly, abnormal usage of any particularly expensive item (for example, a rare metal) necessary to some job is clearly indicated on the instruction sheet, so that a particularly heavy charge is carried by the specific job.

The estimates of the scientific effort required for a particular job are compared with the actual returns of effort spent. The basic information is obtained from the sections by weekly returns of the effort of staff against the various jobs. These returns are forwarded to the Accounts Branch and are the basis of the cost figures produced by them relevant to each job on the programme. These cost figures are tabled at each meeting of the Research Board and explanations made of significant deviation from the estimates. The cost of any job is thus currently known at every stage so that its economic value to the project can be kept under constant review.

Management

The management structure of each research and development establishment is similar and is based on definite responsibilities. The success with which an establishment is managed is clearly the responsibility of its head, who is the administrative authority responsible for ensuring that the work conforms to the policy and commitments of the Branch. The management proper of the scientific work falls to research managers, the number of whom varies with the size of laboratory. Generally, each will be responsible for the work of a group of between thirty and forty scientific and experimental workers. The distribution of scientific, engineering and experimental strength varies, depending on the type of work. Where the work has a highly scientific character, the ratio of experimental to scientific workers will approach 1. Where the work is highly repetitive, the ratio may exceed 5. To preserve a career prospect within the scientific class, it is recognized that any number settled as a complement may ultimately reach 50 per cent of the highest grade below that of research manager. To ensure that the earliest possible recognition is given to merit, staff reviews are held twice yearly to a common standard throughout the Authority, at which all eligible staff are considered. The principle of recognizing ability and giving responsibility leads to the early promotion of suitable staff.

The head of the establishment retains the responsibility of ensuring that the method of approach to any problem is selected on valid scientific grounds to yield the information required. It is the research manager's responsibility to see that a high scientific standard is maintained in the laboratories. The head of the establishment, through the planning and progress officer, ensures that the necessary reviews are forthcoming to plan, and that they conform to the required standard.

On receipt of an instruction sheet the section leader must plan his work. The first requirement is to isolate the problem requiring attention, so as to avoid unnecessary investigation. Having first done this and then consulted the literature, he must plan the experimental attack. It is particularly important that he compile an equipment schedule indicating the dates when he requires instruments. All instruments are entered on an equipment register which at

any moment indicates the job number on which an instrument is being used and the section where it is located. Any instrument not on a job number must be returned to the equipment store. Only by a procedure of this sort can the best use of instruments be assured within any one of the establishments or throughout the whole branch. For the latter purpose a Branch Equipment Register is held of all plant and equipment in the five Laboratories.

Reporting of Work

All work must be reported in one of the Branch's three recognized documents. The overall general structure and form of reports is agreed at the Research Board and is standardized for the Branch.

A 'technical memorandum' quotes factually the results of experiment and gives no opinions or recommendations. No special vetting procedure is necessary to ensure conformity to policy; but each memorandum must be addressed for the attention of an individual or body whose query prompted the exercise, or who can take any consequent executive action.

A 'technical note' gives the results of an investigation required to settle some point of policy or design. Conclusions are reached and recommendations made to guide further policy or design decisions. All technical notes are addressed for the attention of one of the Authority's recognized committees, or working parties. Technical notes likely to influence the policy of the Branch, either in respect of the prosecution of work within it or of the attitude which it will adopt to some proposal arising from other groups or branches, are addressed for the attention of the Research Board. Because of the influence that any technical note can have on policy or design involving the expenditure of large funds, it is the head of the Establishment's responsibility to ensure that the note has been properly vetted.

A full 'report' has all the requirements of a technical note with the addition that it deals with a completed block of work. It should be of the standard of a paper to a learned society.

The experimental worker is of course responsible for reporting on his own work, but his draft is subject to scrutiny particularly in regard to its general form. The section leader ensures that all experimental facts and observations have been used in the compilation, and the research manager makes any necessary comment as a result of his wider knowledge and experience. Full reports and technical notes before issue are finally approved by the head of the Establishment, who must be responsible ultimately for the quality of work from his own laboratory.

Distribution of all papers is subject to a number of provisions, depending on the status of the document in regard to its classification. The minimum standard distribution is agreed by the Research Board for each type of document, and additional distribution requires special authorization, depending on the category.

Conclusions

Particularly with applied research, the best work is based on the maximum of meticulous observation with scientific analysis of the results. Observations are amenable to timing and therefore to planning. The inspiration so necessary to the forward development comes to those suitably endowed, with or without a declared plan.

Scientific staff may fail to understand the need for, and therefore resent, the passage of paper and forms between one office and another. This is almost invariably a sign of bad management. The forms are not used as a discipline of the scientific staff but as a means of passing necessary information between the various sections which are concerned. Applied research is almost always a team endeavour involving many different skills, and it is a convenience to introduce a measure of formality into the administration, provided it is under broad-minded control. The formal organization of the scheme must not involve the scientific staff in more than a minimum of administrative work, and they should recognize it as reasonable. They must be allowed to make the proper use of their intellectual abilities without the need to digress every few days to consider administration. In each establishment a technical planning officer and administration officer with clerical assistance are quite sufficient to administer a scheme such as has been outlined.

It must be clear that in giving this outline of some of the methods used, we have not attempted to give a full picture. Only an indication has been given of the administrative and financial framework within which the scientific work can be carried out. It is pointless to construct such a framework and then not to use it; but its use must be, on every occasion, conditioned by the thought that the ultimate criterion of success of a research and development department is in the scientific and technical quality of the work done. The scientific staff must feel that the framework is provided to assist them in their work and not to divert them by form filling, committee attendances and so on.

During the period in which the development of the system of organization and management has taken place, opportunity has arisen to observe the reaction of the scientific staff. In general, scientific staff with experience of the system favour the control which it imposes, although about 1 per cent of recruits are unable or unwilling to work when so controlled. The main requirement is that in any establishment the system of organization must be devised by scientists and be acceptable to them.

In the development of this type of organization, responsibility has been given to all members of staff capable of accepting it. This has bred a responsible approach at a remarkably early age.

[1] *Nature*, 178, 524 (1956).

SOCIETY FOR APPLIED BACTERIOLOGY

SUMMER CONFERENCE

MILK and cheese were the main, but not exclusive, topics discussed at the summer conference of the Society for Applied Bacteriology held in Reading during July 16–18. Several of the papers contributed were by members from the University of Reading and from the National Institute for Research in Dairying, Shinfield.

One of the first papers dealing with milk was by D. J. Williams, J. G. Franklin, Miss H. R. Chapman and L. F. L. Clegg (Shinfield), who described a method for assessing the sporicidal efficiency of ultra-high-temperature sterilization. Membrane filters are used for detecting trace contaminations in the large