# THE MANAGEMENT OF RESEARCH AND DEVELOPMENT FOR RESULTS

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PREFACE

SWST members are naturally interested in the way their work is managed; yet papers on this topic rather seldom appear in our literature. When Dr. D. L. Bosman, who visited many of our laboratories in 1962 and 1968, showed me his report to the South African Council for Scientific and Industrial Research, it seemed a particularly appropriate opportunity to offer a discussion of research and development management to the Society. He has kindly permitted us to edit, and condense slightly, the original report.

Dr. Bosman describes R & D management concepts that are practiced in many organizations today. While they differ in many respects from more classical forms followed in some research organizations, they illustrate trends in administration that, to some degree, apply even in fundamentally oriented laboratories. The degree to which managers have formulated systems of research and development administration, much like business administration, is striking.

The paper may be of greater interest to the forest products research scientist than to the experienced R & D manager. It provides a view of the way managers function in their task of designing, financing, justifying, and operating programs of research. However, all members of research organizations have roles in this management process, which can only benefit from an understanding of the mechanisms at work. Forest products R & D is not unlike other fields of scientific endeavor in this respect.

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It is fast coming to be realized that research and innovation in the application of research results to industry play a vital part in a country's economy; that to be successful Research and Development (R & D) projects must be selected for their potential economic value; that they must be managed for results; and that the results must be applied in practice for the good of industry, the consumer, and the economy of the country. The R & D management process is likened in this paper to a business management process.

## INTRODUCTION

The Organization for Economic Cooperation and Development (OECD)[10] gives the following definitions of Research and Development:

> The basic definition of R and D used in surveys in most Member countries, are essentially similar. . .It is of course possible to make much more elaborate definitions and there has been a long controversy on this subject, but the view taken here is that the brief and simple definitions below are generally the most practical. *Fundamental research* is work undertaken primarily for the advancement of scientific knowledge, without a specific practical application in view. *Applied research* is work undertaken primarily for the advancement of scientific knowledge but with a specific practical aim in view. *Development* is the use of the results of fundamental and applied research directed to the introduction of useful materials, devices, products, systems and processes, or the improvement of existing ones.
>
> Inevitably, a great deal depends on the judgment of investigators and respondents in making this classification, and the frontiers between basic and applied research and development may often be difficult to establish.

The purpose of this report is to make available to those working in the field of R & D information and the details of some of the personal thoughts and experiences of one who is interested in and has worked in this field, which may assist them in managing R & D for results.

Although in the past R & D has been considered by some people to be a necessary service that should be available to government and industry, there have been a number of instances in which it has been patent that only its prestige value was considered of prime importance. However, during the

past few years the thinking in regard to the value of R & D has changed considerably; it has come to be recognized that a vital relationship exists between the economic development of a country and the amounts it spends on research.

The present thinking is that the results of applied (as against fundamental) research should be regarded as products that benefit from the application of known modern management principles to the research effort that precedes their achievement. Instead of being merely research-orientated as previously, both sponsors and managers of R & D have now become results-orientated, i.e. very much aware of the importance of the results of research and their development to the point where they can be applied for the betterment of the economy.

It is a basic premise that to be successful, R & D projects aimed at assisting producers and consumers: (1) must be selected to ensure that research achievements in these projects will result in maximum economic gains in the industry as well as products of satisfactory quality at low prices to consumers; (2) should be managed for results, i.e. managed in such a way that the set objectives are achieved as efficiently as possible; (3) should have results applied in practice as speedily and effectively as possible.

This report is based on the practical experience of the author; on discussions with R & D managers during a study tour of Australia, Japan, North America, England and Europe; and on information gleaned during attendance at the 6th R & D Management Program organized by Ohio University and the Battelle Memorial Institute.

If an R & D project has an objective that is (a) specific and understandable; (b) quantifiable (i.e. that any progress made can be measured); and (c) realistic; then it can be managed for results.[8, 9] Most research projects are of this nature, and if some skill is used, they can be broken down into manageable tasks.

Managing R & D for results is a process of formulating objectives and planning and controlling research to achieve these objectives. This can be accomplished only by the application of human talents and by facilitating resources. It entails the conscious application of the process of: (a) forecasting or formulating objectives; (b) planning for the achievement of desired results; (c) organizing of the R & D effort for maximum effectiveness, (including initial staffing requirements, directing by motivating and controlling, seeing that staffing is always adequate, and education); (d) continuous communication between (i) management and project leaders; (ii) project leaders and R & D staff, and (iii) staff of the R & D organization and the user of the research results; (e) implementing the research so that there is maximum benefit to the sponsor.

When R & D is undertaken, with or without consciously managing for results, a situation similar to that of a business venture develops, whether the consumer of the R & D service is the same organization, a private person, or the general public. Costs are incurred in supplying the service, which, to be successful, must be exceeded by the value of the service to the consumer.

According to Drucker's (1964) description of the economic task, it is contended that there are three different dimensions to the R & D process: (a) its present activities must be carried out effectively; (b) its potential must be identified and realized; and (c) it must be adaptable to change for a different future. The three tasks must be covered by one unified strategy; otherwise the R & D process cannot be accomplished.

Although the R & D management process is fairly well developed in the United States, it did not appear to be consciously practiced to any large extent in the organizations visited by the author. It is expected, however, that its application will spread rapidly to all parts of the world, first, because both in industry and government the value and use of research are being understood more clearly; and second, because a bigger return on investment is usually obtained with the application of scientific management meth-

ods. At the same time it must be noted that everywhere closer control of research expenditure is being demanded; and although this will make it more difficult to undertake indiscriminate research, it will eventually lead to a still higher return on investment.

Management must be recognized as a separate discipline, especially in an atmosphere of interdisciplinary coordination; and in such an atmosphere, it should be consciously practiced for results. In this respect it is of the utmost importance that it should be results-orientated (objectives-orientated) rather than activity-orientated. This statement refers to the selection of balanced teams of researchers as well as to the achievement of results. Activities do not lead automatically to results. Results are achieved from activities which are well planned, controlled, and executed.

Management is partly an art and partly a science. The former is mainly inborn and can be improved only by experience. Scientific management systems or methods can be learned from formal studies. Drucker says "Knowledge organized in a discipline does a good deal for the merely competent; it endows him with some effectiveness. It does infinitely more for the truly able; it endows him with excellence."

Of the two basic types of research, applied (directed) and fundamental (nondirected), most research projects are of the first type. In the United States, relatively little nondirected research is being done, although it must be realized that the concept of the term "nondirected research" means different things to different people. According to Harris (1968) only 12% of U.S. research funds are spent on fundamental research.

This report does not deal with fundamental research, which by definition is nondirected, and therefore presumably cannot be managed for results. It is, however, realized that a balance must be struck between the two types of research and that any great breakthrough in science or technology is more often than not based on results of such nondirected research.

## THE R & D MANAGEMENT PROCESS

### *Forecasting (Formulating Objectives)*

Forecasting deals with the analysis and understanding of a problem, an industry, or a country, with special reference to opportunities that lead to purposeful decisions. A prerequisite of formulating R & D objectives is, therefore, to have an understanding of the existing structure of R & D organization as well as government policy and industrial trends locally and overseas. In view of the continuous changes that take place, continuous studies and analyses are required and objectives must be reviewed frequently.

Harris (1968), in his talk at the Ohio course on "The role of research in government" gave an interesting example of the type of information that is essential in formulating R & D objectives for government departments and private industry. It must be realized, however, that to some extent the information depicts the U.S. Government's R & D planning at the highest level, as planning at one level influences forecasting at another level.

In the matter of financial trends, Harris states:

> (a) The total U.S. Government R & D Budget for 1968 was $17 billion of which 75 per cent was spent in private industry, 15 per cent in Government organizations and 10 per cent in Universities. The total private industry research budget for 1968 was $8 billion. (b) Of these Government funds 24 per cent was spent on applied research, 64 per cent on development (e.g. building a first prototype) and 12 per cent on fundamental research. (c) From 1955 to 1965 the Government research budget increased by 13 per cent annually whilst from 1965 to 1968 the figure was 7 per cent. An increase of approximately 50 to 100 per cent by 1978, compared with 1968, is expected. (d) In 1961 91 per cent of these funds was spent by the Department of Defense, the National Aeronautics and Space Administration and the Atomic Energy Commission and only 4 per cent was spent on health, housing, etc. In 1969 these categories are expected to account for 85 and 8 per cent respectively. (e) The main fields where it is expected that research will be expanded in the immediate future are: transportation, environment, education and urban development.

With reference to policy trends he suggests:

(a) Greater use will be made of science in planning, technological assistance and evaluation. (b) The method of investigating and solving problems on a multi-disciplinary basis will expand rapidly. (c) For quite a period short-term studies will still receive more attention than long-term studies. (d) Government organizations are increasingly making use of R & D orientated groups for advice. (e) The U.S. Congress is becoming skeptical about the large scale spending of money on research.

In R & D, objectives are formulated by top management in terms of *what* is required and *when* it is required, and the decisions are motivated in terms of *why* it is required. *How* the objectives are achieved, i.e. the planning, organizing, and directing that deal with the conversion of the insights and decisions into effective performance, is left to middle and lower management.

Drucker says "The pertinent question is not how to do things right but how to find the right things to do and to concentrate resources and efforts on them."

As stated in the introduction, it is important that the objective be specific and understandable. A classical example of the incorrect and correct formulation of an objective is the NASA objective "Complete capability in space," which was changed to "Land a man on the moon and return him safely by 1970." The first objective is not specific, not quantifiable and not realistic, while the second objective is specific, quantifiable, and realistic and has already been achieved ahead of schedule.

The Timber Research Unit (TRU) of the South African Council for Scientific and Industrial Research (CSIR) has established a Techno-economic Division, a principal function of which is to assist in determining priorities for projects. This is accomplished by providing information on the trends in the timber industry and by indicating the economic implications of problems considered of primary importance to the timber industry.

The following are examples of the findings of this Division regarding R & D:

(1) According to previous estimates, an overproduction of timber for the next 20 years was expected in South Africa; but according to a 1968 study by this division, an overall shortage of timber can be expected, which will become more acute after about five years. The importance of this information, both to the timber industry and the TRU in formulating objectives is obvious.

(2) Because the demand for structural timber in South Africa had not increased during 20 years, the TRU made a study of the structural timber market. They found that in 1966 there was (a) a potential additional market for structural timber equal to one-third of the 1966 market, mainly in the industrial roof construction field, and (b) that 90% of this additional demand was for structures in spans of over 40 ft.

Using traditional methods of construction, timber cannot normally compete with other structural materials at spans of over 40 ft, and to assist the industry, the TRU therefore embarked on a research program to investigate the development of long-span trusses that can compete economically with other structural materials in this market.

It is becoming more evident in the countries visited that skillful use of R & D can and should play a leading role in a country's planning and technological development, e.g. by multi-disciplinary, techno-economic research teams, who aim at exploiting opportunities rather than solving existing problems and assisting management at the highest level with forecasting. These teams can also be used in planning and appraisal as well as with the application of results.

Comparing the distribution of effort, South Africa spends 20% of its R & D funds on fundamental research compared to 12% in the United States. For applied research, the figures are 50 and 22% and for development 30 and 66%. When we consider that in South Africa extensive use is made of overseas research results, it seems that a

major opportunity must exist there in the field of development—the application of research results to practice or innovation.

### *Planning*

Planning is the preparation of a program of future activities by which one may feel fairly certain that definite objectives can be achieved.

According to Dale (1968), only 20% of all research leads to anything useful and one of the best ways to increase the chances of success of research projects is to ensure that more effective planning takes place. Ineffective or insufficient planning is often the cause of failure.

There are many planning techniques available; and generally the more involved the research project, the more sophisticated will be the planning. In some cases Critical Path Method (CPM), Program Evaluation and Review Technique (PERT), and other advanced techniques can be applied with success.

Mee also suggests the use of "Causative Thinking" in planning. This entails setting a date in the future for the achievement of a goal and then thinking back to today and determining what should be done on each day up to the date set for the achievement of the objective. Just as in the case of formulating objectives, plans must be reviewed regularly and replanned when necessary.

As an example of a planning technique that has been applied successfully in the TRU, before embarking on a new research project, the project leader writes a development study. This consists of a survey of the relevant literature and recommendations on how the results of other research workers can be applied under South African conditions. It also includes, or is followed by, a detailed research program based on causative thinking, listing all the tasks that must be carried out to achieve the objective, and a timetable with the estimated time of completion of each task.

Experts in the field of planning are of the opinion that effective planning should be carried out at all levels of management. This ensures: (a) that only organizations with a suitable environment and the necessary accommodation and equipment for research are used; (b) that only personnel of the necessary calibre and with the required interest to direct and carry out successful research projects are chosen for the work; (c) that only those projects with the best chances of success, keeping in mind their relative merit, will be selected; (d) that, as far as is possible or feasible, detailed programs of research will be planned with estimates of time for completion to enable effective coordination, appraisal and control of projects; (e) that there will be close cooperation with production and marketing elements of industry, consumer groups, or other potential users of results, so that they can be applied with maximum effectiveness and the minimum delay.

### *Organization*
### (*including initial staffing*)

Organization is the process by which the structure and allocation of jobs are determined. It involves the grouping of those activities that are necessary for the accomplishment of plans, and the attainment of goals, the assignment of these activities, provision for the delegation of authority in this regard, and the coordination of these activities.

According to Dale each of the following dimensions must be considered when organizing a job; (1) the setting up of the ideal structure of work relationships (the mechanics of organization); (2) the adaptation of the available staff and the existing channels of communication to meet the requirements of the proposed task (the dynamics of organization); (3) the adaptation of the structure to financial objectives (the economics of organization); (4) the adaptation of the structure to changes in technology and scientific advances (the technology of organization); (5) the impact government policy will have on the organization of the job (the institutional dimension in organization).

Although formal organization charts are

usually drawn up, an informal chart (on paper or in mind) also usually exists and it is this one that is normally used. Most projects limited in purpose and time cut across functions. The most effective systems in practice are, therefore, often a combination of functional and project organization. Dale warns that administrative sections should be kept small; otherwise they tend to become an end in themselves.

Mee (1968) refers to the "synergistic effect" in the measurement of the work done by two or more working together as one of the new important developments in management. Two or more people working together will achieve more than the sum of the work of the individuals working separately. A group effort can increase the total output by up to 30%. The TRU has organized its projects so that as many projects as possible form part of a central theme in the unit in order to utilize the synergistic effect.

It seems that this argument can be taken even further, and the ideal case of exploiting the synergistic effect would be an organization that could select one or more projects, depending on the size of the unit, as central themes or focal points with the maximum number of staff working on them. As an example of this ideal case, the low-cost housing development undertaken some years ago by the CSIR, National Building Research Institute could be quoted. Virtually a whole institute concentrated on one important project with a multi-disciplined team. This was an outstanding success, acclaimed in many parts of the world.

Great advantage can also be obtained if the groups are made up of staff trained in the required variety of disciplines, as this provides the team with the maximum of available knowledge. In the TRU, the ten project leaders comprise three timber technologists, two chemists, and one civil, one mechanical, and one production engineer, an industrial economist, and a physicist.

Participative or support management is a system that can also lead to improved results. In this case the manager's approach will be that, provided the results aimed at are achieved, the workers will be allowed to participate in decision making, i.e. policy control is centralized and decision making is decentralized.

### *Initial Staffing*

The process of selecting staff during the period of organization to initiate a project is known as initial staffing. Staff members selected at this stage are mainly managers (leaders) and specialists or, in certain cases, whole divisions or sections of an existing organization.

Most of this section can be dealt with under the heading "Staffing (continuous)." There are, however, some aspects of importance which must be mentioned here. The selection of a suitable manager is one of the most important tasks in attaining an objective; in fact, success or failure is dependent to a large extent on this one task.

A good manager must be results-orientated rather than activities-orientated. Mee (1968) refers to the "Zeigarnik" of a person. By this he means a compulsion for closure of action i.e. that if a person has a high "Zeigarnik," he will try his utmost to complete his tasks as soon as possible. This attribute is, therefore, a very necessary attribute in a manager.

### *Directing*

Directing is the process by which performance of subordinates is guided toward a common goal or goals. Directing can be subdivided into (1) motivating, (2) staffing (continuous staffing and education), and (3) controlling.

(1) *Motivation.* Motivating staff is the method by which staff are influenced to want to do what is expected of them. Motivation (Jones 1968) can be achieved by: (a) brief communication at all levels so that people feel part of the job; (b) establishing a desire or need in the staff for rewards or position in a race to achieve some goal. Closely related to awards is the aspect of punishment—that of easing a staff mem-

ber out to a less important position; (c) developing a team spirit, e.g. by odd-hour assignments and by regular briefings; and (d) making people feel that they are taking part in the leadership of a project (participative management).

Although highly motivated people can work at 80 to 90% of capacity people working at even 20 to 30% of their capacity do not get fired today (Hersey 1968). Good management and motivation are required to keep people working at maximum capacity.

To understand the basis of motivation, it is important to know what environmental factors there are—for instance, there may be factors that satisfy or dissatisfy, factors that are not necessarily diametrically opposed to each other. Dissatisfiers are usually of short duration e.g. factors such as company policy, administration, supervision, salary scales, working conditions, which when they irritate cause dissatisfaction; when there is agreement on them, they neither satisfy nor motivate to any large extent; they are just accepted as normal. Satisfiers are usually long term in character. In any task they are those factors that give a feeling of achievement, bring recognition of work done or bring responsibility and advancement; they are the factors that are important in motivating staff.

(2) *Staffing* (continuous staffing and education). Staffing is the process by which managers select, train, promote, and retire subordinates.

In the research organizations visited use is made of interviews and references (e.g. from university professors) and a study of history. Although all these methods are essential, it is felt that an aptitude test to measure the potential of staff, especially young people, can considerably increase the chances of successful selection.

Most of the research managers visited, especially in the United States, said that they did not think potential R & D staff would agree to being subjected to an aptitude test. In the CSIR this is obligatory for all new staff, and on the whole the TRU has found the tests valuable in selecting the right person for the job.

Prof. P. R. Skawran of the CSIR, National Institute for Personnel Research, summing up their approach says: "In order to select the most suitable applicants, i.e. to eliminate applicants who are either intellectually unsuitable or who—as personalities—may not fit into a research team, tests are required which will include: the social and educational background, the intellectual ability, and the personality of the applicant. The results are followed up and discussed during an interview at the end of the test-procedure."

For junior professional staff positions, tests are applied that indicate mental alertness, abstract intelligence, and arithmetical ability. If a good knowledge of languages or other specific qualities (e.g. theoretical or practical insight into mechanical problems) are required for a particular job, special tests on these lines are applied.

The test for mental alertness tests the adaptability to general problems and situations, and the test for abstract intelligence tests more specifically the ability to detect laws and to reason on an abstract level. The test for arithmetical abilities has been found to correlate most highly with later achievements in the practical working situation.

In the case of senior professional staff of whom administrative abilities are expected, specially designed projective tests, personality tests, and interviews are employed.

Often people with high intelligence are unable to adapt to the work-climate, their colleagues, or their superiors on account of negative character traits. It is the aim in summing up the personality of the applicant to identify such persons.

The reports written on the basis of tests and interviews give first of all a short general description of the temperament and character of the applicant and possible pathological deviations. More specifically they describe the attitude of the applicant towards his work, his work-ethics, his attitude towards others, and his ability to lead.

The reports also indicate in detail to what extent and on what qualities the applicant can be recommended, and they end up with a general recommendation. This procedure enables the officer in charge of the appointment to obtain an insight into factors that have led the psychologist to his general recommendation.

As the success of a research organization depends on the quality of its staff, the selection of suitable staff must be considered a task of first priority. In fact, long-term success is dependent on attracting and keeping the best brains.

Recruitment for retention is desirable, although often a percentage of the personnel that stay are ones who should not have been kept. From a study in the United States, Shapero (1968) found that if people stay 4½ years they will probably stay permanently, and it is they who determine the future of the organization. Of those that leave, 85% stay less than 5 years. Similar studies to determine the net retained knowledge and experience of staff can be of advantage to research organizations in deciding which group of staff members should receive expensive specialized training.

Taking in students for vacation work and thesis work is a valuable method of acquainting university students who are potential employees with the organization. It also gives the organization a chance of putting the students on trial as future possible employees, besides advancing current projects.

Programs of compensation should embody objectives to: attract and retain competent staff, motivate them for effective performance, gain their acceptance that the program is fair and reasonable, maintain a good competitive position as regards retention of staff.

In some organizations outstanding R & D staff receive salaries comparable with those of research directors, or even the more highly paid managers, in an endeavor to keep them in the field where they have proved themselves successful. Standard job evaluation methods cannot be applied to jobs of R & D scientists or engineers since professional employees are individual contributors, each man making the job he is in. In addition, job content changes with each new project assignment and the growth in value of the contributions of engineers and scientists is continuous.

Dale contends that the salary of a person should be related to the supervision he needs to achieve his set objectives and not to how much he knows or how highly he is qualified. Shapero (1968) adds that one should not look for those who apparently are the best men since high academic points do not always correlate with success. He feels that the only thing that correlates with performance is an interesting and challenging job. He also feels that there are advantages in taking a man on his second job.

It is important to know the "Zeigarnik" of the different people working under a manager, i.e. he must know to what extent they have a compulsion to complete their tasks.

People with a low "Zeigarnik" can be of two types. The first type are those with a low inherent driving force, the second those who have a compulsion to "polish their results" to perfection. It is important to know ahead of time to what degree of accuracy results are required and then to supply the results to that level of accuracy. The perfectionist has a compulsion to keep on repeating tests to give results with higher and higher accuracy, independently of the required accuracy or the financial implications.

Lorsch (1968) puts this rather differently—he says that assessment of a staff member must include "talking to him closely to get his pulse-beat."

Continuous education, one of the most important aspects of successful R & D, can be carried out at the levels of management staff, R & D staff, and technical staff.

*Management training* can take the form of (a) formal training in management at universities, (b) attendance at short R & D training programs, e.g. the two-week R & D Management Program of Ohio University

and the Battelle Memorial Institute, which was found to be excellent, and the two-week Summer Session on R & D Management at M.I.T. This session usually covers the results of recent research and studies in behavior of individuals and groups; project organization and management in the research and development environment; the interaction of the research and development organization with other intra-company organizations and with the external environment; the effect of government action on company R & D organization and activity; (c) an internal lecture series or management training program similar to those conducted by large business organizations.

*Training of R & D staff* can include (a) lectures on logic, reasoning, the scientific method, report writing, fast reading, new methods of measuring, and testing and methods of analysis, (b) advanced degrees at university with theses based on day-to-day research.

*Technical staff training* can include new developments in electronics, mechanics, equipment, and testing methods.

It is thought that continuous education (especially at senior staff level) should be aimed more at acquiring new attitudes and skills than in improving or maintaining existing ones.

(3) *Controlling.* Controlling is the process of measuring current performance and guiding it towards some predetermined goal. Controlling is done on the basis of appraising progress, i.e. measuring the quantity and quality of results in relation to the initial objectives and plans.

It is difficult to measure the quality of research, and it is often only in the practical application of research results that its value, which is a measure of quality, can be established. The TRU, where possible, uses its Techno-economic Division to establish the potential monetary value of research results. As an example a chemical treatment process of timber was found to reduce warp during seasoning. A techno-economic study indicated that technically the treatment could be incorporated effectively in sawmills but that economically the added costs were not worth the improvement in quality. The use of the system was, therefore, not advocated to the industry.

Quantity can be measured more easily than quality. If the best possible staff is obtained and they work at a high capacity, both quantity and quality can, with reason, be expected to be satisfactory.

In this respect it is worthwhile considering the following laws of work: (a) Parkinson's Law (1964) (the first law of work)—work expands so as to fill the time available for its completion; (b) Bosman's Law (the second law of work and the author's)—effort expands to complete the task on hand; (c) the law of multiplication of subordinates (Parkinson); (d) the law of multiplication of work (Parkinson).

In a recent letter, Parkinson agreed that Bosman's law (which is the converse of Parkinson's law) is equally true. It seems that these two laws are complementary, i.e. they account for all people at work. Without the necessary motivation or control, staff tend to follow Parkinson's Law towards a lower capacity for work, possibly at the 20% level mentioned earlier in the report. With effective motivation or control, staff can achieve a higher capacity, which may even soar to the 80 to 90% level. The cost of research is reasonably easy to determine, but it is more difficult to relate it to the total value of the research, thus enabling a determination of the rate of return on investment.

When failures (impractical or uneconomical results) occur, the reasons for failure must be analyzed, and replanning must be done if required.

In the TRU controlling is carried out in the following way: The head of the unit discusses progress with each project leader in the presence of the division head, with other project leaders of that division and often with a representative of the techno-economic division. These group meetings take place once a month and are referred to as "progress meetings" by the staff. A

summary of the discussion, decisions, and targets is made, and copies are kept by the unit head and the project leader.

(a) Progress is discussed in terms of the project objectives and goals (targets) set for that month at the previous meeting. Monthly goals are set by the project leader since he is normally in the best position to make a reasonable estimate.

(b) If the goals are not achieved, the reasons are discussed and kept in mind in setting new targets.

(c) The tasks for the next month are listed, priorities are allocated, time available is thus determined, and new targets, covering tasks and estimated time required, are set.

(d) Time actually spent on tasks or projects is compared with estimated times.

(e) At regular intervals, depending on requirements, but at least once a year, each project is discussed in detail with special reference to its objectives and any plans for the application of the results.

This system has been developed over a number of years and has been applied successfully in the TRU in its present form during the past three years. The stage has now been reached when it has been decided to place more responsibility on the division heads, so that in future the monthly meetings will be conducted in each division by its own head. Each division head in the presence of project leaders will then submit the progress sheets for the projects of each division to the unit head for approval.

In addition to this internal control system, the following steering committees guide the work of the unit: (a) The Timber Research Unit Steering Committee (policy committee meeting once a year) (b) The Timber Seasoning Steering Committee (technical committee meeting every six to nine months) (c) The Pulp and Paper Research Steering Committee (technical committee meeting every six to nine months).

(4) *Communication* (continuous). Communication is the process by which ideas are transmitted to others for the purpose of effecting a desired result.

Communication is one of the most important aspects in management. It takes place between person and person. Penson (1968) says that on an average it takes up as much as 70% of the time of R & D people and up to 80 to 85% of the time of managers. In general communication takes the form of writing (9%), reading (16%), speaking (30%), listening (45%).

Since listening is such an important function, Penson's ideas in this respect are worthy of consideration. (1) Listening is an active process, not a passive one as is often thought, and we have to learn to think hard while we listen. It is important to know that we think from four to eight times as fast as we listen or speak. (2) We tend to judge the delivery instead of the content. (3) We are attracted by easy, lighthearted things, rather than by things having good content. (4) We tend to look for detail instead of ideas when listening. (5) The listener partly controls the speaker's presentation especially if the listener is feedback sensitive.

Informal channels of communication based on personal contact that is on a non-decision level are of great importance in day-to-day work.

The TRU has found that its monthly project progess discussion meetings have greatly improved the level of communication. The division heads and unit head are now kept acquainted with the developments of each stage of a project. It is thought that one manager or director should be able to decide on how up to 30 projects should be managed, depending on the complexity and size of the projects. After this level the projects should be delegated to submanagers or division heads, the manager being involved only in an advisory capacity and taking part in discussions less frequently.

Shapero says that scientists do not make much use of libraries in the United States,

and he advised the use of informal channels and the buying of any books the scientists feel they need for their own office or laboratory. Professor Roberts of the Sloan School contends that there is considerable evidence that technical and scientific literature is not the prime source of information used by persons working in R & D, and that technological knowledge is transferred mainly by people.

In this respect the CSIR policy must be considered advanced since for many years regular overseas study tours have been made by its research staff. A point not often realized is that personal contact leads to discussion not only of successful research projects, the results of which are usually published, but also the details of unsuccessful projects, which can reduce duplication or lead to the reestablishment of potentially important projects.

Participation in international conferences, if they are well planned, can also be of value as a medium for transferring information. In this respect some of the working groups of the International Union of Forestry Research Organizations, e.g. the working group on Structural Timber Utilization of Section 41, under the chairmanship of John Sunley, are considered good practical examples of this way of transferring information that is internationally useful. The groups are relatively small (15 to 25) and consist of internationally selected experts, working in a limited field of research and development. Papers are prepared and made available to all members well in advance of the meeting, at which short summaries of the papers are given. Discussions of the papers, the summary talks, future programs, and international cooperation follow which may last as long as a week. This type of international meeting could be expanded to include all important fields of research and development especially the management field, with great benefit.

## Application of Results

Dr. Naude, President of the CSIR, at the opening of the Rembrandt Industries Technical Centre in Stellenbosch, recently said that it is essential that South Africa should in the future make more use of its own research. One of the most immediately effective methods of putting this advice into practice is to apply the research results already available, which can be taken to include results available from overseas and to plan future research projects with a view to the early application of their results.

Since the inception of the TRU in 1960, it has been one of the main aims of the Unit to assist the timber industry with the application of TRU research results as well as results obtained from overseas. In many projects this policy has involved extended visits to sawmills and other plants where assistance has been given on site. A further important aspect is the close cooperation maintained between TRU and the S.A. Bureau of Standards, who have incorporated many TRU research results in their specifications and codes of practice.

The motivation for the urgency to apply R & D results is contained in the following quotation from "Managing for Results" by P. F. Drucker:

"Neither results nor resources exist inside the business. Both exist outside. There are no profit centres within the business; there are only cost centres. The only thing one can say with certainty about any business activity, is that it consumes efforts and thereby incurs costs. Whether it contributes to results remains to be seen.

Results depend not on anybody within the business nor on anything within the control of the business. They depend on somebody outside—the *customer* in a market economy, the political authorities in a controlled economy. It is always somebody outside who decides whether the efforts of a business produce economic benefits or whether they become so much waste and scrap."

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