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Dynamic Management - Research and Development

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I. Management

A. Evolution of Management

Today, management has become one of the most important areas of human activity because of increasing sole of large and complex organizations in the society. Because of their increasing sole, the organizations have attracted the attention of both practitioners and academicians to find out the answer of the question ' how these organizations can be made more effective. This has led to the development of a new field of study known as management. In today's context, it has emerged as one of the most important disciplines of study and research. The following topics will be discussed under the evolution of management.

1. Genesis of Management

Ever since the Industrial Revolution, factories and offices have been headed by the individuals and group of individuals who performed the managerial functions in the light of knowledge and experience available to them . As companies grew larger, the problem of organization, supervision, and so on, became complex. It was beyond the capacity of the owners to perform a multitude of functions that management imposed on them. Gradually the functions were transferred to managers who were employs of the company. Management became a function distinct from ownership.

2. Definition of Management

Different authors have given their different definitions of management and these are given below: -

TAYLOR has defined management "Management is the art of knowing what you want to do and then seeing that it is done in the best and cheapest way".

KOONTZ has defined management as "Management is the art of getting things done through and with people in formally organized groups".

LAWRENCE APPLEY has defined management as "Management is the accomplishment of results through the efforts of other people".

MC Farland has defined as "Management is a process involving planning, organizing, staffing, directing and controlling human efforts to achieve stated objectives in an organization".

From above definitions, we can see that as the time has passed, different authors have presented their different views on management and the scope of management has got widened.

3. Evolution of Management Thought

The following table tells us that how the management thought got evolved.

Sr. No.	Management Thought	Period
1.	Authoritarian and the Functional Theory	During 18th Century
2.	Evolutionary Theory	During 19th Century
3.	Scientific Management	1900-1930
4.	Bureaucracy Theory	1930-1940
5.	Management by objectives	1960s onwards
6.	Management by exception	1960s onwards
7.	Management by consultation	1950-1970
8.	Management by and participation motivation	1970s onwards
9.	Schools of Management Theory	1970s onwards

B. Principles of Management

The major objective of management is to obtain a better ratio of output to input in each element of the activity.

One of the prime duties of top management is to take decisions. A manager should have enough data at his disposal to be able to take intelligent decisions and to make reasonable choices. No manager can ever have all the facts he should have. Most decisions are based on incomplete knowledge. A number of aids are available to management which help in arriving at optimum decisions, and these are described in 3 (k). The several steps in decisions-making are-awareness of the problems, identification of the problems, their analysis, possible alternatives and their evaluation and course of action. A good decision must provide a satisfactory solution to the pertinent problem. A good decision results from a choice from a spectrum of possible alternatives. It considers the economies of the decision-making process itself, If a problem is correctly studied and the list of alternatives is reasonably exhaustive, then a good decision will lead to a satisfactory outcome. In modern management, the number of alternatives is large as there are many variables. Selection of a solution involves risk, economic effort, timing and resources.

As major problems involve a systems analysis, there is bound to be uncertainty in one or more factors. The scientific method of dealing with uncertainty is through the theory of probability. Probability has an intrinsic connection with the analysis of organizational decisions. Structural and motivational decision-making approaches support the manager in his strategies. Both the managerial functions of planning and execution involve decisions and the theory of probability plays an important part in this. Models are often used in modern management, decision analysis and probability theory. One of the invariable constituents of the factors in a situation is risk. Every manager has to reckon with risk. To a top manager risk has serious implications, but yet has to accept it as inevitable. Calculated risk can be taken on the basis of modern aids to management, but where an uncalculated risk is concerned the manager has to depend on his experience, judgement and hunch. Important decisions should be reviewed periodically and the requisite modifications made. The human brain is the most powerful apparatus for making decisions.

C. Leadership

Leadership is the process of influencing the behaviors of others to work willingly and enthusiastically for achieving predetermined goals.

Tenerbaum has defined Leadership as "Leadership is interpersonal influence exercised in a situation and directed through communication process, towards the attainment of a specified goal or goals".
Terry has defined leadership as "Leadership is the process of influencing and supporting others to work enthusiastically towards achieving objectives".
So, from above definition we can conclude that leadership is a continuous process of behaviour. By exercising the leadership the leader tries to influence the behaviour of individuals or group of individuals around him to achieve common goals. The followers work willingly and enthusiastically to achieve those goals. Thus there is no coercive force which induces the followers to work.

1. Importance of Leadership

Leadership is an important factor for making any type of organizations successful. The importance of good leadership can be discussed as follows.

(a). Motivating Employees

Motivation is necessary for work performance. Higher the motivation, better would be the performance. A good leader, by exercising his leadership, motivates the employees for high performance.

(b). Creating Confidence

A good leader may create confidence in his followers by directing them, giving them advice and getting through them good results in the organization.

(c). Building Morale

Morale is expressed as attitudes of employees towards organization, management and voluntary cooperation to offer their ability to the organization. Through providing, good leadership in the organization employees morale can be raised high ensuring high productivity & stability in the organization.

(d). Raising Producgtivity

Leadership also helps in raising the productivity of an organization. It helps in improving the methods of doing work.

(e). Managing Resistance of Workers

A good leader understands the feelings of workers. So, it also helps in managing the resistance of workers.

2. Qualities of a Good Leader

(a). Physical Features

Physical characteristics like height, physique, health, appearance and rate of motivation determine the personality formation of which is an important factor in determining leadership success.

(b). Intelligence

Intelligence, to a very great extent, is a natural quality in the individuals because it is directly related with brain, for leadership, higher level of intelligence is required.

(c). Emotional Stability

A good leader should have high level of emotional stability. He should be free from bias, is consistent in action and refrains from anger.

(d). Human Relations

A successful leader should have adequate knowledge of human relations, that is how he should deal with human beings. The knowledge of how human beings behave and how they react to various situations is quite meaningful to a leader.

(e). Objectivity

Objectivity implies that what a leader should be based on relevant facts and information. He must assess these without any bias or prejudice.

(f). Motivating Skills

A good leader can play active role in stimulating the inner drives of his follower. Thus a good leader must understand his people to the extent that he knows how he can activate them.

(g). Communicating Skills

A successful leader knows how to communicate effectively. A leader uses communication skillfully for persuasive, informative and stimulating purposes.

(h). Technical Skills

The ability to plan, organize, delegate, analyze, seek advice, make decision, control and win co-operation requires the use of important abilities which constitute technical competence of Leadership. The technical competence of leader may win support from the followers.

D. Effective Manager

An effective manager is one who is positive in his personality, that is, what type of person he is, his managerial process and results of his managerial process. Intelligence, imagination and knowledge are the vital resource of a effective manager. An effective manager may produce knowledge, ideas and information. The strength of a manager is multiplied by the organization and productivity of organization is raised.

1. Qualities of an Effective Manager

An effective manager should possess so much qualities so that a organization can grow. The following table describes the important qualities of an effective manager :-

Table 2: Showing Qualities of an Effective Manager

Most descriptive of Effective Manager	Least descriptive of Effective Manager
Decisive	Amiable
Aggressive	Confirming
Self-starting	Renewed
Productivity	Agreeable
Well- informed	Commiserative
Determined	Kindly
Energetic	Cheerful
Creative	Formal
Intelligent	Courteous
Responsible	Neat

2. Important Behaviors of a Effective Manager

The following are some of the important behaviors of effective managers: -

1. They manage people instead of work.
2. They plan and organize effectively.
3. They set goal realistically.
4. They derive decision by group consensus but accept responsibility for them.
5. They delegate frequently and effectively.
6. They communicate effectively.
7. They are stimulus to action.
8. They show consistent and dependable behaviours
9. They win gracefully.
10. They express hostility tactfully.

So, in addition to above behaviours, they are also so many other behaviours of affective manager.

II. Research and Development

A. Introduction

Research is the application of human intelligence in a systematic manner to a problem, the solution of which is not immediately available. Intelligence cannot eliminate all doubts, but it may minimize the total uncertainty. Intelligence uses the most reliable data available. Technology is the wonder child of pure science, the scientific study of the industrial arts. Development is the intermediate step between applied research and production.

Although research and development are activities of the government, university, industry or railway, the government is the main body which plans R & D in a country, finds funds for it and enables utilization of the results. The science policy followed by a government aims at optimization of scientific research. A general science policy has two objectives, viz., development of scientific research for military purposes, and the development of scientific research for civilian purposes.

If fundamental research is much weaker than development, the country will lack an adequate training ground for research workers as well as scientific support for industrial application of it discoveries. A strong position in fundamental research certainly affords scope for intellectual satisfaction, but weakly applied R & D results in the country losing the potential economic and financial advantages of its strong initial position. A balance should be struck between applied research and development work to avoid waste of resources. Wherever R & D is carried on within an enterprise, balance is ensure by a good management. The rate of technical progress is determined by the interaction of the supply of technical innovations as a product of research and development of technical inventions and of demand for technical innovation resulting from their actual application by enterprises. They are cost-reducing technological improvements, based on new inventions or introduced by imitation, applied directly in production processes of materials, goods and services. The technical innovations are usually the final product of long research processes, followed by practical inventions and leading towards innovations in production processes. Technical innovations have economic meaning only when effectively applied in these processes.

There are three levels of research planning and programming, viz, national level, agency level and laboratory level.

Effective R & D planning should aim at the following:
Classification of the functions and objectives at the three levels.
Continuous involvement and participation of the scientists.
Maximum autonomy to the laboratories.

B. In Government

Science can make dynamic and progressive contributions to cotemporary society. Fundamental research is a creative force in all scientific developments. Applied research harnesses the results of fundamental research for use by the people. A few years ago, the difference between fundamental research and applied research was clear, and methods and projects were distinct, but with the tremendous growth of R & D, the distinction has become less and less clear. The aim of fundamental research is extension of knowledge for its own sake, and that of applied research, utilization of existing knowledge, Free fundamental research is an outcome of intellectual curiosity and aims at probing the unknown and has no application objectives. The oriented fundamental research seeks new knowledge needed for application and may contribute to general scientific advancement in the process. Much basic research has proved useful many years after its acquisition, but one cannot predict in advance the likely use to which basic research can be put. Research and Development can be utilized as the principal tool for increasing industrial productivity. In the present day world, no government can afford to take vital decisions without taking cognizance of scientific advancement and the technological achievements.

Every country should have a national policy for science and technology for realizing their full potentialities. A national science policy provides guidelines to the government to finance, encourage and deploy the scientific resources of the country. While formulating the national policy for science there has to be a balance in the apportionment of scientific resources for short-range and long-range research. When there is scarcity of resources, the question of priorities comes up. Priorities are problems which have to be solved for continued growth. Scientific activity is an integral part of cultural policy. A nation's choice of strategy reflects its social, economic and security circumstances and objectives.

Long-term planning is for developing new technologies requiring long-term commitments to resources. This is done at the national and the agency levels. The element of risk of failure is higher in long-term research . Short-term research is for problem solving for well identified users and to bridge minor gaps in technological needs. Short-term planning is generally done at laboratory level.

Research necessarily is an investment, different in function and output from other investments, and can only yield results when it is secure over a long period from the inquisition of the administrative bureaucracies.

C. In Universities

The great Europeon philosopher, Karl as per has defined the university as a "community of scholars engaged in the task of seeking truth. It is a body which administer its own affairs regardless of whether it derives its means of support from endowments, ancient property rights, or the State. Academic freedom is a privilege which entails the obligation to teach truth, in defiance of anyone outside or inside the university who wishes to curtail it. Because truth is amenable to systematic research, research is of foremost concern to the university. Because the scope of truth is far greater than that of science, the scientist must

dedicate himself to the truth as human being, not just as a specialist. Hence, the pursuit of truth that the university demands is a serious commitment of the whole man. The university's second concern is teaching, because truth must always be transmitted".

Sir Eric Ashby, Master of Claire College, Cambridge University, in a speech delivered at an international conference held at the University of Michigan in 1967 stated "It is right that the campus should no longer be an ivory tower but there must still be ivory towers on the campus, places where scholars can do work which may seem irrelevant and even pedantic, without having to feel apologetic about it. They must be free to do it at their own pace and style even if this does not produce a flow of published work each year. A university which does not offer its faculty and students opportunities for this kind of solitude and detachment is failing in one of its duties to society. And it is the best students who must be initiated into this commitment to solitude; for, as Humboldt emphasized, it is not the uncommunicative solitude of a Trappist monk he had in mind but the insulation of a group of scholars from ephemeral problems so that they may consternate on long –term problems. There is only one technique for this sort of education; the apprenticeship of pupil to master, the continuous encounter, day after day between an established scholar and a neophyte. Clearly, this cannot be done for every student in a system committed to mass higher education; but it must be done for the best. This means that whatever happens to universities in tomorrow's world, they must make some arrangement which ruthlessly selects the few students of high intelligence and insures that their minds are sharpened by constant exposure to mature excellence. Unless this thin stream of excellence is kept clear, there will be no one to train to make innovations in tomorrow's world. This is the university's prime function."

The primary functions of a university are:

- To add through research and scholarship to man's understanding of himself and the world in which he lives.
- To integrate newly, acquired knowledge into the total intellectual structure and to systematize and organize knowledge for each generation.
- To communicate existing undertaking and knowledge through formal teaching, writing, and other kinds of communication to the intellectual public and to train the next generation of scholars through apprenticeship.
- To be the custodian of the intellectual standards of society and to maintain intellectual leadership in the major fields of human knowledge and its long term applications.

The university is dedicated to basic research and tends to relegate applied research and applied scientists to a secondary position. There is tension between basic science and applied science. This extends to facilities, personnel, and so on. The creative aspect of the tension may outweigh the disadvantages as long as really good scientists take to applied science and research. A balance has to be maintained between pure research and applied research.

It has happened that when applied research in universities led to useful new technologies, it served an internal purpose in the universities. The computer is an example in which several universities were interested for providing a better tool for scientific computation in basic research. Even now, the universities are a major source of innovation in computers, specially on the software side. Recently, industry has stepped into the field in a large way.

Some of the methods of encouraging university research are the endowed chair, the post-graduate bursary, equipment grant, recurrent grant and consultant arrangement. Selectivity in funding is worthy of achievement because it is difficult to maintain in a programme financed from public funds. University research may be carried out in two heads, viz. sponsored and unsponsored. Sponsored research is financed by contracts and grants from government and industry. Governments and industries approach universities to undertake projects for them because the latter have specialized professors or specialized equipment. Unsponsored research is paid for by the university funds. A college president prefers a grant support which can be deployed at the discretion of the institution.

R & D has a very large impact on national economy and, therefore, should not be ignored as academic discipline.

D. In Industry

R & D is a total national concept and each industry should have an R & D department to be able to absorb the technology imported or developed within the country. This department will make industry more able to identify research problems as well as make it receptive to new ideas. It generally makes it more forward looking.

Industrial research provides technical insurance to the current products by extending knowledge and furnishing scientific intelligence. It should be the spur of economic objectives. Research should develop new products to sustain corporate growth.

The first responsibility of applied research is to ensure the profitability of the company by maximizing utilization of existing assets and removing bottlenecks. Only thereafter should research undertake improvements, diversification and so on. The industrialist is dependent on the scientist for the ideas. A scientist-manager of an applied research laboratory has to know and speak two languages, viz. the language of the business, and the language of the scientist. If the two languages can meet and develop together, the objectives of the company and the aims of the scientist will both be met.

The growth of a company and the improvement of its industrial position can be ensured by adequate research expenditure over several ears. Long-range projects can only be undertaken if there is continuity of financing of research. Amazing research has been done in sheds with the minimum of equipment. Certain types of research can be carried out with relatively modest facilities. Lavish buildings and equipment are not essential for such research.

The research director should have the powers to acquire equipment up to a certain amount, employ additional staff within specified limits, buy materials and supplies, and enter into contracts for running the laboratory. Above certain limits, the powers may vest in the top management. If allocation of funds fluctuates with the prosperity or adversity of the company, there will be uncertainty in the quantum and trend of research, which will not operate to the advantage of the company.

Research must help planning ahead for new products while the existing products are still yielding high profits. It should be the focal point for the creation of new products. In addition to technical competence, there should be marketing, social and economic components of the system. Scientific research is the starting expense of an investment in technological innovation. If

research is neglected, innovation is inhibited and obsolescence encouraged.

The research activities of a company should be related not only to the other departments within the company, but also to the scientific community outside. A research department should support the company operations, ensure its technical future, make an impact on it and maintain an eminent position within the scientific community.

Industrial research an development have the following purposes:
Profitability.
Improved products, new knowledge and new products.
Professional improvement
Social and human welfare
Large and progressive industrial companies seek improved methods and new and better products through research. In general 60 to 90 per cent of new products are estimated to fail. Therefore, allocation of resources for the development of new products is a difficult problem. Also, product obsolescence becomes more with the development of new products by others.

Research mainly deals with the future, whereas sales and production deal with the present. There has to be a balance between them. Industrial research, to be quickly utilized, must have a direct bearing on the present and foreseeable and future needs of industry. The aim of industrial research is to make it possible to put out better and more products. Genius is valuable to a research worker, but in the modern scientific world, it is the equipment, the environment, the motivation and the determination of the scientists that produce most results. New products do not just occur, they are conceived, designed, produced, tested and then put out.

The several steps in industrial research are:
- Statement of the problem and need for its solution.
- Study of literature.
- Selection of the most promising method of solution.
- Listing of all the factors involved.
- Laying down the methods by varying each factor.
- Experiments being conducted while varying one or more factors.
- Variation of methods by varying the factors.
- Experimentation and analysis of the results.
- The six steps of industrial creativity are:
- Understanding of the problem.
- Collection of knowledge.
- Digestion of knowledge.
- Hypothesis formation.
- Analysis and evaluation.
- Verification by experiments.

The following are some ways of establishing cooperative industrial research:
- Directly between firms.
- Through scientific, professional and technical societies.
- Through trade and development associations.
- Through research associations and institutes.
- Through universities and colleges.
- Through government research institutions.
- Through other research bodies.

E. In Railways

The origin of the railway dates back to 1823. Despite its age, the railways is still a current and economic mode of transport of passengers and goods. For a very long time railways were conceived, built and operated by private individuals and companies. Inevitably, this resulted in haphazard growth of networks of railways, which did not take into account the likely developments of the economy over a long period.

To service the railways and to carry out repairs and maintenance of the assets workshops were set up supported by small testing organizations. These testing organizations were located in close proximity of the sheds and shops so that day to day work could be carried on expeditiously; the scope of work was limited.

Railway R & D is a captive organization since its sole purpose is to serve the railway. The user of the railway is identified and his needs can be recognized and forecast with some amount of certainty.

The corporate objectives, functions, responsibilities, funding and so on, of the railway being in the hands of railway men, railway research is in a uniquely favoured position like defense research.

Before discussing the organization of R & D on the railways, it is necessary to recognize the differences in the economies of various countries. In certain countries, there is a large well established industrial base which can carry out design, development and production of railway equipment and stores. In certain other countries, there is no adequate industrial base for supporting the railway's needs. Only in the former countries, the railways need undertake research, preparation of performance specifications and prototype testing. The railways in the latter countries may have to undertake manufacture of locomotives, coaches , wagons and so on, the private sector and the public sector factories producing other stores. In these countries, the railways have perforce to organize all research and development, design, standardization and preparation of specifications, inspection of major stores and equipment, service engineering and consultancy- all from scratch.

F. Recent Types of R & D Organizations

In recent years a number of types of R & D organizations have grown. They are described in the sequel.

1. Non-profit Organizations

There are non-profit organizations other than colleges and universities which have been doing R & D for some time on the funds provided by private philanthropy, public solicitation, endowment, membership dues and fees. Their greatest asset is their intimate contact with industry.

In U.S.A. 97 percent of Federal expenditure on R & D goes to business firms and the universities and research centre, both contractually and directly administered. Seven per cent of the Federal research expenditure is on the non-profit organizations. These organizations survive on a competitive basis. Their work is mainly in applied research, stopping short of development.

2. Professional Associations

They mainly collect and analyse statistical data and provide their members with bibliographic information, etc. They criticize policy rather than carry out research.

3. Contract Research Institutions

Under this scheme it is possible for any company, big or small, to extend its research or development facilities by adding those of the contract research institutions to its own. Strict confidence is needed.

4. Cooperative Research Institutions

In a cooperative research institution there is comparatively loose contact between the institutions and the members. An efficient channel of specialized information is created between the cooperative research institution and the member companies. Cooperative research economizes in manpower and money and provides scientific service to smaller firms which cannot otherwise develop on their own.

5. Industrial Research Institutes

An industrial research institute is an asset to the nation and is likely to grown as the economy expands. A diversified technical organization has a greater potential for problem solving than individual units or specialists operating separately. Its efficiency is attributed to cross-fertilization. An individual scientist or engineer or a too narrowly specialized group in a single filed however competent, is not the perfect answer to solving complex technical problems. The industrial research institute offers an ideal organization for a collection of technologists, engineers, industrial economists, and so on, to work together rather than separately. It appears to be the most economical way of utilizing the limited resources of technical personnel in a less developed country. Some of the advantages of an industrial research institute are:

- Conservation and efficient use of diversified talent.
- Sharing of laboratory facilities. Equipment and library.
- Complexity and diversity of services.
- Training of specialized personnel.
- Keeping industries up to date.

G. R & D in Less Developed Countries

The single greatest reason for the backwardness of so many countries in the world has been their failure to activate themselves during the industrial Revolution of western Europe in the 18th century. In many cases this was due to colonialism, imperialism and exploitation. After over 200 years of the Industrial Revolution, several countries are still groaning under durable disabilities which they are finding extremely difficult to overcome. To quote Prof. Blackett these countries may be more appropriately described as “less developed” in contrast to the “more developed” or “advanced” countries.

These nations are compelled and are trying, to accomplish in a short time what the older countries took a century or more to do. This “leap across the centuries” cannot be achieved without dynamic planning and sustained hard work and without massive aid from the more fortunate and advanced countries with their enormous wealth of accumulated knowledge and expertise. The wise and deep gulf between the more developed and the less developed countries must be bridged and it is only science and technology which can do it. Although the latter can step up their rate of industrial development, its substances over a long period depends on their ability to create a large and effective industrial base and indigenous technological know-how in the countries.

The gap between the living standards of the less developed countries and those of the advanced countries has its parallel also in science and technology. The result is that a very small fraction of the world’s scientific and technical resources is utilized for solving the problems of the less developed countries and the overwhelming proportion of the world’s intellectual capital as well as the physical resources is devoted to meeting the needs of the highly developed countries.

H. Summary

Research and Development are carried out in government including defense, universities, industries and railways.

R & D can be utilized as the principal tool for increasing industrial productivity. The prosperity of a country is a reflection of its standard of scientific and technical education and research. There has to be integration to research planning at the three levels, namely, the national, agency and laboratory levels. Research at the national level has implications for scientific and technological requirements arising out of the national socio-economic plans. At the agency level it becomes the perspective technological plan, with the problems of the national plan being translated into R & D plans. The laboratories would then prepare detailed normative plans in consultation with scientists at different levels. Individual investigation are then taken up and resources are allocated.

Defence research has registered considerable progress since the First World War. Defence research can only progress if the civil populations are science minded. A large industrial base is required for promoting defence research. It may consume as such as half of the national expenditure. The freedom of defence scientists is restricted when they deal in matters of security. Secrecy in research inhibits discussion, presentation of papers, writing a book and so on.

The main functions of a university are to teach and carry out research. It should ensure excellence of academic atmosphere and protection for the scholars. Research enjoys the best environment in a university. Doubts are being expressed regarding the role of a university, the extent of fundamental research it should carry out and its part n promoting development and production. Science has found a perfect home in the university and a scientist has scope to be a part-time teacher and a part-time research worker. Permissiveness, lack of pressure and concentration of ides and knowledge are characteristics of a university laboratory. University research may be carried out under two heads, namely, sponsored and unsponsored. There are three types of organization of research in universities, decentralized research, centralized coordinated research, and the research institute or foundation.

Universities, institutes of technology and independent research institutions are the main sources of scientists and technologists. These sources have to be nursed. Good teaching and good research are complementary to each other. The faculty in a university has to be kept intellectually alive by research. Basic research has to continually nourish applied research.

For a long time universities have been free from major influence of politics and politicians. This happy feature may not continue for long. National policies and politics are influencing science and technology in particular directions.

The role of research in universities grows as a country progresses economically. New ideas and techniques bring about social and economic changes. The learned institutions have to endeavor to become centers of excellence and constitute integral parts of the developmental structure of the country. They should be socially committed to the national objectives.

Each industry should have an R & D department which can carry on a continuous dialogue with the sources of technology that are either imported or developed within the country. Industrial research safeguards current production by extending knowledge and furnishing scientific intelligence. It helps in development of new products. The primary objective of applied research is to maintain and improve the profitability of a company. Neglect of research will mean inhibition of innovation and encouragement of obsolescence. Industrial research should be coupled not only to the other departments of the company but also to the scientific world outside.

New products have to be conceived, designed, produced, tested and put out. The aim should be to produce more research and engineering and not more scientists and engineers. Today investment in R & D is of a capital nature. Industrial research is the price for staying in business. Any new idea may disturb current production and render existing capital investment obsolete. While an industry encourages and pays for research in a large way, it is concerned with possible obsolescence created by new ideas and, therefore, resists changes, Investment in R & D is no longer based on faith but is considered vital and justified.

Most railways of the world were at one time private undertakings and therefore R & D in railways was not included in the research considered to be in national interest by government. Government did not consider progress of railway technology with any interest. Had th railways come into existence in the present century, it is likely that government would have been involved in railway research. In several countries, railways are now national undertakings and such railways are solely concerned with their R & D Large government funds have been granted to the railways in certain countries like U.S.A. and U.K. Even universities are keen to handle railway research problems. For long years railway technology has been neglected. At one time the railways had the monopoly of traffic which lulled them to complacence. This led to adversity and obsolescence. Other transportation systems, such as roadways, airways, waterways, and pipelines have become serious competitors to railways.

They are, however, a number of favourable factors for the railways. The railways have enormous economic space and capital. With the serious congestion in road traffic in cities, motor car and air traffic are facing tremendous problems which can only be solved by incurring a very large capital investment. The railways have large margins of capacity which are available at low cost. Traffic peaks can be handled by railways with greater ease than any other system of transportation. On account of their size and capacity they are able to benefit from economy of scale. Transport of large volumes of traffic over great distances is one of the special abilities of the railways.

The most important acquisition in starting an R & D organization should be dedicated scientists and technologists. A good scientist or technologist can make valuable contributions if he is dedicated. The tendency in less developed countries is to start with imposing building and considerable equipment and instrumentation and then to look for scientists and technologists. Naturally investment in R & D becomes heavy and does not produce adequate returns.

III. Management of Research and Development

A. Introduction

If the simple principles of management had been understood and practiced, there would not have been all the misunderstanding between the management and the employees. Working with people is not one of the responsibilities of the management-it is the entire responsibility. In the last few years, there has been a grated awareness of the results that can be obtained from human resources, in addition to physical resources. A manager should make a proper distribution of duties to the scientists and endow their work with meaning and dignity, communicate with them, encourage them, treat them honourably, and give rewards fairly. The order of precedence in resources should be men, money, and materials. The science of management depends very much on the human factor for achievements.

Managers face difficulties both from top and below. Often a direction to the scientists below to solve a problem urgently results only in formulation of new problems.

Human resources, when they are motivated fully, appear to have limitless creative and productive potentials. A manager and his scientists are interdependent, and even with the greatest amount of cooperation between them, they must use the organization as the vehicle for channelizing their activities. A human organization is a extremely complex one, and requires a great deal of patience and tact to handle. Leadership considers not only the human factors of motivation but also the organizational factors of the institution.

Every institution has its own personality and this can to a great extent be modified by the personality of the manager. A manager cannot afford to be erratic in his dealings and judgments. There has to be consistency in his thinking and working. Although every effort should be made to avoid conflicts, they do occur. When the dispute is on values, it is for the manager to decide after due consideration. If it is on personality, he is to exert the utmost tact to deal with the situation. Discipline should not be administered from above, but should appear as self-discipline from within the group.

The scientists are involved in the growth of knowledge, while the manager is concerned with the rate of growth and with the matching growth from connected disciplines. The scientist must modify his professional goals to suit his work for the achievement of the Objectives of his company. The company, while recognizing the right of the scientist to work for his professional goals, should ensure that the objective of the company are also realized. The director is the catalytic agent in this process. The scientist in an applied research laboratory is involved in corporate relationships for the accomplishment of the company's objectives. He has to be a member of the working groups, teams and the supervisory cadre, and in addition, take part in managerial relationships. The

management and the scientist have to exhibit adaptive behaviour which often results in strains. The ability with which the strains are borne by management and the scientist, determines the level of thinking and working of the organization as a whole.

Managers have to be trained, and this training would take different forms for different purposes. Although, commonsense used to be the main basis of management at one time, and it is extremely important even now, it is hardly an adequate substitute for specialized training which is required even at the highest level. A super-intellectual may have vast knowledge of social and physical sciences, engineering, mathematics and so on, but he too as to be trained as a manager. Another concept is to consider the manager as a highly intelligent person, who has been a specialist in a particular field, and whose effective role it should be to integrate the work of many specialists. At one time, the former concept was adopted with some success. But latterly, the second concept is catching up, and the latest trends are to train a manager to perform the managerial function of getting the best out of his team without himself being a super-specialist in any particular field.

Rules of organization and administration should be framed and interpreted by persons who are aware of the needs of the laboratory. Users and panels of experts should be associated with laboratories at the stage of planning and identification of problems. Otherwise, scientists may get frustrated because the results of their research may not be utilized. In those organizations in which the end-use of research is well established, it is easy to set up goals.

Management of R & D is similar in many respects of management of organizations concerned with production, etc. The former, however, requires consideration of several important additional factors and situations. The handling of R & D personnel is a highly specialized profession.

II. Principles of R & D Management

The principles of management have been variously enumerated by different authorities. One of these lays down the following which are of universal applicability:

- Ideals.
- Personnel.
- Organization.
- Correct methods.
- Instructions.
- Fair deal.
- Discipline.
- Planning.
- Records.
- Standards
- Achievement reward.

Another set of principles relating to the organization and the individual which the manager should practice is:

- Controlling the technical aspects of the job.
- Solving problems.
- Setting priorities.
- Recognizing motivational cues in the behaviour of others.
- Dealing with emotional situations.
- Handling his own emotions and being objective when necessary.
- Supporting other members of the organization when required.
- Becoming involved with other people as the situation demands.
- Managing conflict.
- Negotiating effectively.
- Synthesizing styles and skills into an integral whole.
- Coordinating and evaluating.

Basically, R & D management is capable and well-informed leadership. The character of a leader is the fundamental material of leadership's style. Every manger is a unique combination of abilities, temperament, training and experience. Management is largely a science, the sharp corners of which are rounded by the art of management. The principles of management can be applied equally to personnel, tools and techniques.

Individual scientists are responsible to carry out their tasks, the senior scientists and managers at various levels performing theirs. Though the director is not personally responsible for the quality and quantity of work of individual scientists, he is responsible for the overall results. He may know less than each scientist of the work of the latter is doing, but he should be aware of the broad parameters of the projects that are being handled and the contribution they make towards achieving the objectives of the company. He should have the quality and courage to accept blame for failure, while giving credit to the scientists for successes.

The constituents of R & D management are, by and large, the same as those of the company, except that evaluation of the results of R & D and an examination of utilization of the results of research and development have to be periodically carried out with a view to assessing the effectiveness and profitability of R & D.

In a relatively small laboratory, or in a large one in which the number of projects handled is not large, the director can keep track of progress of work by meeting the scientists and visiting different parts of the laboratory periodically. Where a large amount of work is being done, the director can keep in touch with the technical work by reading every paper that is intended to be published and all the reports that are prepared. In addition, there should be controls, such as, preparation of systematic monthly progress reports. The director of a large laboratory is a lost man if he involves himself fin details.

A good manager should not impose rules and regulations on scientist which reflect on their intelligence, maturity or understanding. A manager should consult with professional scientists regarding plans and proposals which affect them and their work before decisions are taken. Scientists should be permitted to plan their own work. A good manager should encourage scientists to keep upto date in their fields of knowledge, attend meeting of professional societies, write papers and deliver lectures, but there should be no compulsion.

Some managers think that scientist will have complete freedom to carry out research if he adheres to the procedures of the organization. Another type of manager considers that organization is a necessary evil. The third type would like to make the organization flexible and permit the scientists plenty of freedom, while he himself manages to collect as much information as possible.

A director has responsibilities both to the management and to the scientists. Often, the role of the director is exacting. The

scientists think that he is an obstacle to research because he imposes organizational discipline on them. The top management feels that he cannot personally produce any research, and his colleagues feel that he is not able to find ready answers to all their questions. Despite all these, the role of the director is extremely vital. Without him, the top management does not get the results of research, the managers of the other departments in the company do not get the technical advice they want and the scientists are not able to function as they should. The double responsibilities of the director, and the importance of liaison with his colleagues elsewhere in the firm, call for qualities which it is often difficult to find in one and the same man.

Research management calls for very special ability in the matter of human relations. A good research manager can be recognized by the quality of his relations with his colleagues in other departments and above all, with his research staff. For, a researcher is not a mere operative who is engaged to carry out the specific tasks assigned to him faithfully and who is easily replaceable if he does not prove satisfactory. The fact that research is being done means that something has not yet been found and that nobody known exactly where the trail is leading. The research manager decides the functions of his research staff, i.e. the direction in which they must go, but each research worker is responsible for his own operations and is free to use his own ideas. That is why no research worker can be replaced easily. The manager must know the abilities, the style and the methods of those who work with him if he is to know what responsibilities he can assign to them and what results he can expect. Results cannot be measured by visible activity and by hours spend in the laboratory. A particulars research worker may well appear to be wasting his time, whereas in his own way to perhaps even unconsciously, he is on the track of a precious discovery; fussy supervision and sharp reproofs will only irritate and inhibit him. Research management demands a very subtle psychological sense. Personal troubles may sometimes interfere with a man's work and the manager must make allowances. Research is not blind routine work; the personal and human element plays a vitally important part in it. Creative inspiration cannot be conjured up to order; it can, however, be fostered, and this is the role f the research manager.

An efficient manager must possess sufficient knowledge of modern methods of accounting and financial control. The budget should preferably be activity-oriented and not expenditure-oriented. The laboratory should have an idea of the funds that are likely to be available to it for the next five years or so. Capital funds allotted and committed for purchase of equipment, raw materials, books, journals, buildings, etc., should not lapse automatically at the end of the financial year. A five-year roll-on budge t would provide a good solution.

The relationship between the attitude of a manager towards his work and the effectiveness of his performance are intimately connected. A dedicated manager is an example and a source of inspiration to his scientists.

A manager who take excessive interest in technical details may impede the work of his scientists. No one, however brilliant and knowledgeable he may be, can be an expert in several disciplines. A manager has to function through his scientists. There should be no compulsion but only persuasion. He can attain greatness by carrying his team with him. Knowledge of details need not be a strong point in him, but of management it shall be.

A manager must be aware of the points of view of his assistants in a given situation and he should know how to deal with them. He should be familiar with the principles of motivation and then only can he arrive at an understanding of the thinking and actins of his scientists.

To believe that top flight research can be carried out by mediocre scientists supervised by a genius in charge of management is to deceive oneself and to mislead others.. Excellence can only be produced by an excellent brain. Poor management can throttle genius, but no management or technique or system, however good, can create an excellent intellect.

The performance of the director and the laboratory reflects the productiveness of the laboratory. A good manager drives himself, and has not to be driven. A good manager sets up high performance standards. High expectations supported by appropriate action bring high performance and rewards. An ambitious scientist's performance rises to meet expectations. A manager should concentrate on the strength of each scientist rather than of his weakness. Often there is excess of mediocrity, and scarcity of excellence. Excellence must be nursed and mediocrity discouraged. No company can thrive if mediocre feel safe. Rewards should be based on performance. Each succeeding job should be a reward in itself. When a scientist has established beyond doubt that he has more capacity than his job needs, he deserves to be moved up.

IV. Planning and Coordination

A. Introduction

Corporate Planning for the company as a whole has been studied. Planning for the R & D organization will now be discussed.

There can be no actual R & D planning in the full sense of the expression. Genuine planning presupposes that the operations, available resources and time table have been worked out before hand and are known at each level of research and development. By the very nature of things, research is a field in which the unknown and the unexpected can never be completely excluded, and it will always be impossible to assemble all existing information at the outset and lay down an absolutely hard and fast time table. All that can be done is to visualize the operation sequence and assign work with the maximum flexibility so that the targets can be gradually attained. Planning can inhibit creativity and innovation is used rigidly.

B. Importance of Planning

A wise manager of R & D recognizes that planning is essential to maintain the profitability of the company. It is even more so when the company is losing.

The R & D organization must clearly understand the spirit and letter and implications of the corporate objectives and corporate plans of the company. It is imperative that R & D plans should be in conformity with these and be capable of being dovetailed into their time table to the extent feasible. Like corporate plans, R & D plans also are short-term, medium-term or intermediate-term and long-term.

Short-term plans are concerned with the day to day problems of operation; these are pressing and brook no delay in solution. They may cover a year or so. Intermediate range planning involves

giving a shape of reality to a long-range plan. A rolling plan is an intermediate-range plan which is refined at the end of each year by making use of the performance in that year against the target to predict future performance and excluding that year but including another year at the end of the truncated plan. Such a plan is likely to be specially useful in conditions of rapid changes. In a long-range plan it is necessary that top management should lay adequate emphasis on research to meet the specific needs of the operating departments and the market. Long-range planning is an industrially created function. Nothing can substitute of long-range plan in good organization. There has to be increased liaison between the R & D organization of the company and research departments of universities and other research institutes and government. Utilization of modern tools for predicting market demands and mechanization of new departments for development of new products should have a prominent place. Efforts have to be made to bridge the gap between the scientists' point of view and that required for achievement of the objectives of the company. Top management can see the potential unsatisfactory performance of the company and take timely corrective action. A good top management maintains a proper balance between the other departments and R & D. While top management should be patient and attentive, research management should be informative and practical.

It is R & D management's duty to prepare drafts of the three types of R & D plans mentioned above bearing in mind the interests of the company as a whole. Top management must give a final shape of these plans in consultation with the managers of various departments including the R & D manager. Some of the essential steps to be taken in framing the plans are:

- Identification of key problems.
- Top management orientation.
- Establishment of a planning organization.
- Review and evaluation of planning experience.

All planning should begin at the top. While short-range problems have to be allotted top priority, intermediate and long-range problems should not be neglected. Planning requires management to identify, and therefore to influence, the factors affecting business successes. It enables management to prevent unforeseen events from dictating their activities. Planning assists top management in its education and those at the next lower level to think in terms of the business as a whole and not the way in which its objectives can be achieved. It gives an orientation to the company's activities. There are a number of a basic requirements for R & D planning. They are a favourable environment, a clear understanding of objectives, knowledge of organization, knowledge of the company's external relationships, reliable forecasts and a system for collecting, evaluating, systematizing, and integrating information.

R & D planning prepares a company to meet the future with confidence. The process of planning starts with an overall view of the company and its practice. Planning has to take into consideration the total system design. It involves predictions about the future. Planning is the laying down of the methods to guide the strategy and tactics of the R & D organization. Plans, schedules and goals have essentially to be coordinated. Plan coherence requires coordination of individual components rather that their subordination. Programming and planning create the preconditions necessary for effective utilization of the assets of the company. A planner should be constantly alert to new opportunities that come from changes. In an unstable economy long-range plans will have to be re-examined at more frequent intervals. Qualitative planning is the starting point for other operative policies. R & D planning for the future is rarely a total loss. There are several advantages in planning R & D, however tentative it may be. The effectiveness of scientists is increased. Resources are used to best advantage. Norms of performance are established. Activities are result-oriented and purposeful. Perspectives are also in view. The company will not jump from one crisis to another.

C. Planning the Budget

Management and control of expenditures which create or maintain or expand production capacity are major functions of a company. The conversion of finance into resources of various type is essentially an irreversible process. Management and control of expenditure are carried out by means of a budget. Most organizations have a revenue budget. Most organizations have a revenue budget, a capital budget, and a depreciation fund, The first takes into account the earnings and the likely requirements of funds for payments to staff, and for maintenance and operation expenditure. A capital budget covers the anticipated expenditure on items of a capital nature, such as, buildings, machinery and equipment, and expansion. Depreciation fund provides for timely replacement of assets.

Budgetary requirements are formulated at lower levels and sent to the top where the requisite scrutiny is exercise in the light of actual expenditure in the previous years, trends of expenditure, likely variations due to modifications in emoluments of personnel, in costs of maintenance, materials of operation, and requirements on capital and depreciation account. Discussions may be held by top management with lower level managements including R & D before the budget is finalized. Ordinarily the budget is for one year.

Once the budget is sanctioned by top management, the manager of R & D has to manage and control the expenditure within the allotments. Control is exercised by the manager by calling for monthly, quarterly, half yearly and yearly statements. There must be some amount of variation permitted as inflexible application of allocation of funds may create personnel problems and weaken research effort. Variations in expenditure should be used as an indication for review of projects. The budgetary report should reflect variations and reasons therefore. Time data are as significant as money data in many cases. While it is necessary to correlate expenditure to the work done and to keep within the sanctioned budget, the valuable time of scientists should not be wasted in making them do detailed costing of research problems, which information may not be actually used.

So far as short-term research problems are concerned, the annual budget may, by and large, serve the purpose. For intermediate-term and long-term research projects, it is necessary that some commitment is made by top management with regard to the likely availability of funds. Once a project which takes a few years is undertaken for R & D, there should be no uncertainty in the availability of funds, personnel, equipment and facilities to carry the work through the completion. Even an understanding on this point between top management and R & D management will do.

D. Planning Equipment

Research projects require machinery, equipment and instrumentation of varying degrees of sophistication. Procurement of these should be done after collecting all the available literature on each item. Acquisition of equipment involving a high degree of sophistication and electronic components presents unusual difficulty due to their rapid obsolescence. In an applied research laboratory the acquisition of equipment should be project-oriented and not prestige-oriented.

E. Personnel Planning

Personnel's planning is important in revealing a company's requirements and in assessing the existing management performance which enables future needs to be identified. Management by objectives provides an impartial yardstick for assessment improves performance and helps identify training needs.

It is always the concern of a company to see that management is efficient and there is adequate supply of promising talent rising up in the organization to provide new blood. Only in recent years has management development realized the two aims in improving managerial performance and organizing management succession. Periodical assessment of individual performance and provision of suitable training in areas of weakness are the necessary steps. The training may be to eliminate an existing weakness or to strengthen performance and qualifications to meet future needs.

By and large, the scope for promotion is much smaller than the scope for improvement, and, therefore, there is necessarily competition. Men have to be helped to realize their full potential so that they can serve the company better. What the company needs and what the individual executive needs can be found from the facts. It will then be possible to base planning on known requirements. If the existing personnel cannot meet the requirements, new blood will have to be inducted.

The macro and the micro approaches in personnel planning are interdependent where a complex of companies, a government or a country is involved. Personnel planning has often had to be done by the pressure of outside competition. The collection of information on man power needs in a large company is a colossal task.

New techniques in manpower planning afford accessibility of information, feasibility of a company's personnel structure, the emergence of trends and the possibility of more accurate forecasting. The planning involves all skills for the company's function in the formulation of future policy.

The personnel planning of a company has to be taken into account in the personnel planning in the R & D organization. The needs of the R & D organization in this regard are different in many respects from those of the rest of the company. It is the duty of the manager of R & D to bring this fact in the correct perspective with due emphasis to the notice of the top management. An understanding top management will permit the requisite relaxations and departures in the rules for personnel planning in the case of R & D.

The optimum use of human resources is one of the main problems facing management today. Man has to be studied in his organizational setting for better management and research with a view to obtaining greater clarity of objectives. Personnel planning in an R & D organization must enable the placement of suitable scientists in positions in which they can make the most contribution, their development to fit them in higher positions in the hierarchy, grooming of scientists to deputize for them and take their places when necessary. It must provide for maintenance of continuity of research work and information systems, making up the wastage by timely recruitment and training of new recruits, and induction of fresh blood at appropriate levels to keep up the scientific and technological standards and provide for forward looking research and design policies.

A personnel development programme is an integral and vital constituent of personnel planning. It should enable each scientist to develop to his full stature. There has to be adequate motivation, opportunity and means. The scientist will then put up improved performance, and have greater learning power and prospects of advancement. Personnel development will lead to higher productivity and better morale. Training should be an integral part of every scientist's work. Some principles of personnel development are:

- Improvement of oneself is the basis of personnel development.
- The environment should be favourable for development.
- There should be opportunity for all.
- Present performance should be improved.
- The aim should be to improve everyone's capability.
- Personnel development should be planned.
- Management should help in such development.
- Not only should a scientist learn on his job but also he should get regular training.
- Personnel planning should aim at ensuring:
- Reasonable salaries.
- Attractive service terms.
- Retention of highly qualified scientists.
- Availability of motivation.
- Availability of incentives.

In an expanding situation sufficient opportunities exist for promotion to meet the aspirations and abilities of all personnel. Where, however, the rate of expansion has slowed down, career opportunities diminish. A mechanism has to be developed to ensure continued recruitment of fresh young scientists and promotion of the able ones for retention of qualities of excellence within the organization. Recognition of obsolescence should be part of the mechanism. It is suggested that these objectives can only be met by a well-designed man-power planning procedure and by retaining and redeployment of personnel not totally essential for the time-being within the scientific research organizations. Much individual hardship and undesirable protection of those who have passed the peak of excellence can be avoided by promoting a culture of acceptance of greater mobility to positions related to research and science and in which other qualities may also play an important part. It should be recognized that the problems that are presented in a static or slowly expanding organization are quite formidable and without due attention being paid to them can lead to a decline in quality and morale. The system of advancement should be such that seniority should not be the sole criterion. All attempts should be made for instituting mechanisms for general awareness throughout the laboratory organization of the merits of individuals through seminars, publications and project meetings, all of which would contribute to a peer-rating system. It is recognized that the present culture in many laboratories is based on the continued

functioning of a scientist within the same laboratory, often for a life time. A culture which would accept mobility between laboratories would provide opportunities for stimulating lagging scientists and for promotions based on merit rating within the entire organization. Lastly, in research organizations closely allied to the user's organizations, considerable opportunities exist for retaining scientists to function effectively in other jobs, and this should be taken advantage of. Where such close links do not exist, suitable mechanism for temporary attachment to industries, etc., should be set up which would allow lateral movement out of the laboratory.

Long years of work in the same laboratory on similar problems may induce staleness or fatigue syndrome in some scientists. That is why the policy in many good applied research laboratories is not to retain technologists in the research organization for more than about five years. There are, of course, exceptions. These exceptions are technologists, who, though they have attained a high level of expertise, continue to maintain elasticity of brain and outlook, and keep their minds open to new ideas from wherever they may come. These observations may not hold good in the case of basic research laboratories, because the theories put forward by a scientist, however eminent he may be, can be challenged by other scientists: in these laboratories continuity over long years is advantageous. In applied research, on the other hand, each problem has its own peculiarities which have come into existence on account of local conditions. By and large, applied research investigations do not take a long time and therefore the technologists need not have continuity over long periods.

There should be avenues and methods for career planning and development of personnel in laboratories. Positive career planning involves forecasting and identification of areas and needs of institutions, keeping records of careers and abilities acquired during development and planning of training programmes. Human development can also be achieved through programmed assignments of study and research work on sabbatical leave once in five or six years and attending national and international conferences. Effective and flexible measures should be adopted to refresh scientists in their fields of specialization with a view to compensating for obsolescence. Periodical deputations to other departments, laboratories, industries, etc., would greatly help in this regard. Career development should form a cell within the organization of every laboratory.

F. Scientific and Technical Coordination

An important line of coordination which enables a director to control research and to bring it to a a halt or press it forward as desired is scientific and technical coordination. A scientist, as he becomes more and more of a specialist in a progressively narrowing field, tends to work in a watertight compartment, and assumes that his problems, his thoughts and his investigations are of supreme importance to the exclusion of everything else. To him even the importance of the impingements of his work on allied disciplines pales into insignificance. It is here that multi-disciplinary project teams come in very handy and ensure scientific and technical coordination.

Specially in the case of those institutes where research is based on the principles of projects and research teams, it is helpful if the director is assisted by a service or a committee responsible for the scientific and technical organization of the projected research. Departmental chiefs and team leaders would be ex-officio members of such a service or committee, which would in any event lie somewhat outside the normal structure, whatever its name or implications (management committee, coordination committee, etc.) The objects of scientific coordination are:

- To consider the research subjects proposed.
- To form research teams and to set the target for each member of the team.
- To stimulate progress in research.
- To make the best use of the results achieved.

The object of the indispensable administrative coordination should be to relieve the research workers of non-essential duties and help in the execution of research work and not to put a brake on it. Like scientific coordination, administrative coordination calls for the exercise of judgment and leadership. Coordination, however, can only be perfect if it results spontaneously from the cooperation of all those who have responsibilities in the field of research. This means that those who sit on the coordinating bodies do so as of right and in the light of their individual responsibilities. As a corollary, it is better to decentralize responsibility for research as far as possible and to leave a wide latitude to the departments or teams. It is obvious that the coordinating bodies can only act effectively if they are properly informed about the progress of work. The basic way to do this is by means of fairly frequent periodic reports. One of the important objectives of scientific and technical coordination is to encourage scientists to come out of their shells and have more communication among themselves. Apart form breaking the ice, they will broaden their field of knowledge: there is then greater likelihood of more stimulation and cross fertilization of ideas. Stimulation also comes form diversity in the work content.

G. Administrative Coordination

An R & D organization is basically meant to carry out research and development. The persons to produce the results are the scientists. In addition to scientists, an R & D organization has administrators, and establishment, finance, stores, audit, workshop and maintenance officers. The sole raison d'etre of all the latter is to establish a congenial climate and provide all the services and facilities required by the scientists. The purpose of framing the rules of business is to provide the scientists with their requirements for effective and efficient performance of scientific work. The supporting personnel have to fully realize this: there must be good personal relations between them and the scientists.

V. Creativity and Teamwork

A. Introduction

Creativity could be a product of heredity and environment. Every person is creative to some degree. Creativity is a new combination of thoughts or things. It is a combination of past experience and patterns for the future. Creativity comes out of conceptual unity, originality, sparks form the subconscious, openness in thinking, and self-actualization. Creativity in research comes form a large collection of skill, technical knowledge and know-how, and relative importance of the scientific problems. Creative thinkers are not produced by planned education-they just happen. Formal education may not encourage creative thinking but may, on the other hand, retard it. The more creative a scientist is, the less submissive to authority and less conforming to tradition is he

likely to be. He is usually more energetic and autonomous, and more confident about himself. Creativity is a function of people but not of organization or condition. A creative scientist is unhappy if he is not creating something. He stamps his work with his own personality but science itself tends to objectivity. Often, eccentric unconventional people are creative. Inexperience may be an asset in certain circumstances. Much knowledge may be dangerous thing, particularly when it concerns all the reasons why a thing cannot be done.

Great discoveries are usually not accidents. John Dewey says that "in all ages, man has made discoveries, but it has been reserved for this age to discover the process of discovery."

Each discovery is based more or less on previous work, and leads to new advances. Scientific progress results from a chain of discoveries. The subconscious plays a great role in finding solutions to difficult problems. Inspiration may be due to working of the unconscious. It is a fact of the history of science that great ideas, great discoveries and great theories have often emanated form people at unexpected moments. The filed in which a great idea has come to a scientist has been invariably the filed in which he has specialized. For instance, a chemist has not propounded a great theory in hydrology nor a biologist in mathematics.

A new path is shown by inspiration but it is not the end. The validity of the ideas has yet to be established by experimentation and conclusion. A scientist discovers some facts, then an idea is born in his mind, he reasons and experiments and finally a new explanation or process appears. No scientist should have excessive faith in his theories. Many discoveries and inventions have given rise to a host of new works of different nature and importance Systematic observation plays a remarkable role in scientific discovery; a scientist has to learn how to observe. Varying coincidences and circumstancial evidence have led to great discoveries but these are exceptional. Errors of observation, of calculation or of interpretation are harmful to scientific research. Sometimes errors could also be fruitful.

Creative talent cannot be stagnant. Creative groups either grow or die. Creative groups would like to choose their own projects for investigation. Although an idea may have little relevance to a project under execution, it may have value in starting a new investigation. Without a creative leader, a group may become an extinct volcano.

Some discoverers have had to fight a tremendous battle against accepted beliefs and routine. An innovator may also have to fight single handed against society, including the scientific community. Creative work can be accomplished individually as well as collectively.

B. Ideas

Long years of scientific education are not necessarily a prerequisite to original thinking in all cases. New ideas can only be born through imagination and effectiveness. They are generally modifications, extensions or adaptations of old ideas. At any stage, knowledge is limited and the unknown unlimited. Imagination can always give birth to new ideas. Therefore, imagination is more important than knowledge. It is the procreator of knowledge and new ideas.

Now man can be ordered to produce new ideas. Bright ideas are the spontaneous products of a futile mind, and no scientist can be forced to produce them. Ideas breed ideas in R & D work. Imaginative minds perceive in them possibilities for the future. A bright idea can be stifled by lack of inspiration or attention, or can be killed by over planning. A progressive R & D organization acknowledges the rights that the employee has to patentable ideas.

Survival will only be possible in a scientific and technological age by bringing in new ideas all the time. Problems arise out of change and these have to be solved by fresh thinking. Today work is going on in a world of unprecedented change. The time interval between new ideas is so short that there is not enough time to develop fully one idea before another comes up. In a large R & D organization, it is essential to create a formal machinery for interchange of ideas. A good organization can easily generate far more research ideas and programmes than can be followed up due to constraints of resources and time.

C. Sources of Ideas

Sometimes R & D personnel assume that tall bright ideas take brith in their own organization. While an R & D organization does put out a large majority of ideas, quite a few come from staff in production, sales, marketing research and management departments. Ideas also emanate from universities, and even laymen. Yet the R & D organization has proved to be the best means for encouraging, guiding and coordinating activities to produce new knowledge and inventions. Organized research may well establish its claim as an instrument of industrial survival.

D. Requirements for Creativity

The main concepts of creativity are logic, idea linking, problem solving and free association. The creative process consists of sensing, preparation, illumination and verification. Of the two factors in creativity, viz., heredity and environment, the first consists of the basic physical man, the learning process, feelings, expression of complexes and the ego.

A creative scientist is receptive, flexible, intellectually curious and is able to formulate problems to collate information. He should have adequate experience a store of knowledge, along with ability to work in a team. Often creative scientists turn out work of great scientific value and such scientists do not fully agree with the organization. Creativity does not like restraints. Creativity can be accelerated by fostering a high level a motivation, energy and drive. A creative scientist cannot create when he is unhappy.

Enthusiasm, either of a single person or of a group, does not mean isolation. It only indicates attachment or involvement of the workers in their scientific work. The leader of a creative group should have appreciable freedom of thinking and action. Much of the creativity in a laboratory comes from the scientists. In a large laboratory, it is not only the director but also every senior scientist who functions as a manager.

There is great hunger for ideas which is the impulse to progress. The four aspects of creativity are:

- Sensitivity to the existence of problems.
- Readiness in offering solutions.
- Flexibility in solving problems
- Ability to recognize the more feasible, acceptable and suitable solution.

These could perhaps be further analysed as follows:

- Retentive memory.
- Love of adventure.
- Imagination
- Concentration
- Curiosity.
- Ability to reason.
- Intelligent skepticism, scientific knowledge and experience.
- Combinational conception.
- Ability to improvise.
- Motivation and incentive.
- Cooperation and ambition.
- Determination.

E. Team Work

In the conventional method of running an R & D laboratory, scientists work in isolation from one another, the work of each scientist appears to be fragmentary, and communication is poor. Scientists may be unable to identify themselves with the project as a whole. The work may appear to be tedious and uninspiring, with little incentive. A complicated problem is best entrusted to a team of scientists rather than to an individual, however eminent, because to individual can have adequate knowledge in several disciplines. A scientist may channelize his thinking in a narrow groove and miss a simpler and more satisfactory solution.

Science and technology have permeated most fields of human activity. Scientists and technologists from various fields of activities are brought together. They have all to cooperate to achieve a particular objective. No individual, however gifted, can solve all the problems he is facing in his investigations. Team work is essential. A scientist has to understand the work of his team and, in addition, do his own work. A scientist can achieve quite a lot in R & D working by himself but can achieve much more by working in a team. Science is team work. In team work, there is great need of mutual understanding and trust. Even Newton admitted that he could see further than others because he stood on the shoulders of others. Team spirit should be encouraged, specially among the younger people, without encroaching on individual personality so that different lines of enquiry can be made to converge and the best results obtained. A research team is an excellent institution as it permits an individual to think freely and the group to pronounce a wise judgment. Even in an R & D institution with a fairly rigid organization, it would be possible to encourage freedom of thinking and working by forming research teams who could be given plenty of latitude.

A project team lays a limit upon the men who might be good organizers because they have to pay only a limited part in the project. Good organizers may like to go out of a project team and serve their superiors or as leaders of projects .This is personality problem. A team can be trained to work better together. The members have to recognize all the obstacles of communication, cooperation and team work. A team as a whole should be committed to success of the project. True cooperation cannot come from any formal relationship, it is to develop by human relationship. The inter-disciplinary team is a beautiful creation of the systems approach to organization. For example, a team investigating a physical phenomenon might have to include on its personnel a doctor, an agriculturist, a bio-chemist, and so on. This demonstrates that problems in modern science and technology have no disciplinary frontiers: the problems are transcendental in nature and call for expertise from hitherto unimagined sources. It is not necessary for a laboratory to have scientists of all disciplines that may be required for an investigation. It is quite conceivable that in particular cases experts form other laboratories or universities could be associated with the team in question. Mixed teams are a phenomenon of modern science and technology; it will become almost an inevitable feature in complicated investigations in future.

As a scientist advances, he may become a project leader and manager of the team. In a team, the leader should be closer to the members of the team rather than to his own superior, and then the team will be the most productive. The project leader should report directly to the manager of the group without an intervening sub-manager. Although each member of a team belongs to a different discipline or division, the manager of the team provides the coordination, planning, direction and control. There should be mutual respect in functions and in personalities between scientists: this can be promoted by training and by personal conduct. There is, however, a great dearth of good leaders for research teams.

Groups or sections of a laboratory may feel that their role towards tendering services to the other sections is secondary. Inter-disciplinary projects cannot be properly progressed unless all the sections cooperate and assist one another. Each group has a dual role to perform, firstly, to progress its own research activity, and secondly to assist the other groups.

In some cases the person responsible for initiating a project is made the project leader. In large scale development projects, the director of the laboratory nominates the group leader in consultation with the other scientists. When success is achieved by a group, the credit should be given not only to the group leader but also to all members of the group.

In R & D, team work will progressively replace individual efforts. A laboratory of scientists working as individuals progress arithmetically, whereas team work progresses geometrically, so to speak. Efficient team work requires that it should be well-knite, there should be inter-penetration of attitudes and ways of thinking, sharing of knowledge and of interest.

The laboratory is a basic unit forming a sub-system in a large network of R & D activity. Major activities and achievements of one laboratory are bound to affect the other laboratories in the same field.

F. High Level of Research and Creativity

Often there are strained relations between management and scientists because management pays more attention to the logical organizational work rather than to the social organization of team work. Absence of petty annoyances, just staff policies, forthright explanations of problems, adequate salary conditions- all these contribute to strengthening of team work. A wise choice of problems for investigation, selection and promotion of technical, scientific and administrative staff, happy relations, good morale and adequate facilities-all these make for creativity and productivity in research. A well organized high level research laboratory is characterized by a high level of research creativity and originality: innovational opportunities are the essence of growth.

VI. Conclusions

A. Dynamic Management

Man's greatest real hope for the future is man. It is not easy to predict the future of man. Faith and optimism are more or less synonymous. There should be clear faith in the growth and development of man. Man is the least efficiently used asset. Most people have a wealth of untouched talents that require only opportunity and motivation to release them. Appraisals covering a long future may be misleading. It will be revealing if occasionally one views oneself as others see him. The man of genius looks ahead, thinks creatively and establishes a straight path through the jungles of confused thinking.

A manager who creates problems where none exists does damage to the company. One who solves a problem that comes to him and waits for the next will never reach the top. A dynamic manager does not wait for problems to face him, he goes to find them.

There is no single system or formula of success. Tomorrow's problems cannot be solved with yesterday's knowledge and skills. Immaturity and inexperience should not be mistaken for freshness of mind. A great danger of inexperience in any situation is not a wrong decision but a decision put off. Leadership of a modern company is a most difficult and demanding task in the entire management hierarchy. As Drucker has said, "dynamic growth is more productive than static perfection."

A dynamic manager must have demonstrable integrity. He should have good character. There are no substitutes for integrity and character.

Modern civilization has an immense stake in the competence, skill and responsibility of management. A predominant occupation of the modern would is management. Increase in the G.N.P. of a country depends very much on the quality of its managers; life in a civilized country depends on how efficient managers are. As an economy continues to grow, organizations also grow larger, more complex and more difficult to manager by old time methods.

There is need for changing the relationship of internal social environment in a company as it grows. There has to be equal concern for the human and the technical needs of the enterprise in effecting integration of individual needs and organizational goals. Cooperative effort has to be strengthened so that the individual attains even greater importance in technological endeavour. The collaboration of people poses a great challenge to an executive. With the growth of a company, new people are recruited and this means more problems of coordination, communication and motivation. Productivity and performance will depend more and more on the management of men than on the operation of machines. The employee's feelings of pride and self-esteem have to be nurtured, otherwise he will leave.

A democratic manager encourages participative methods and leadership is shared. Subordinates should be given a proportionate share of achievement of satisfactions. What the manager wants for himself must be conceded to his assistants too in any appropriate measure. In a country where food is scarce, men work for food alone, After this need is satisfied, other needs come up. There will always be conflicts between individual needs and organizational goals, but the friction can be minimized by good management. A manager coacts with his employees and does not order them about. The competence of a manager depends upon the depth of self-knowledge and the clear understanding of others and only then will he get their cooperation. Business practices have to be blended with human motivation.

Management discipline and the management process, both need the science and art of management. Management needs much more than technical skills; it requires, above all, the ability of handle human material. Management problems are so complex, specially in the context of the systems concept that objective analysis of data from various sources is essential. Despite all the available mechanical and mathematical aids the manager's judgment is still of the greatest importance in integrating the results of all the analyses and predictions in arriving at the correct decisions. Planning has to be approached from the systems point of view. Then only can an integrated and rational view be taken of complex problems. Intuition has a large part to play, but it has to be base don logical thinking. Intuition helps a manager to view facts and inter-relations in their correct perspective.

All policies are framed on the basis of judgments. Judgment has to be aided by all the available real-time data which modern technology can provide.

The aim of good management is to sweeten the relations between the management and the workers, increase productivity, maintain and improve the profitability of the company, and expand the company's activity. A manager has to maintain to correct balance between economic, technical and psychological factors. In the last few years a new spirit in management has arisen. The busiest and hardest-worked manager may not necessarily be the best manager. He should be the master of his own time to sit back to think, plan, organize and execute.

A successful manager should be conscious of the human beings working under him and he should always endeavour to help them develop to their full stature, If a manager thinks of the success and failure of each of his assistants as his own success and failure he is sure to produce a favorable impression on them.

Enthusiasm, initiative, and loyalty cannot be purchased; they have to be earned. A cold-hearted professor may transmit much knowledge but he may be forgotten. A great professor may transmit the same knowledge to his students and in addition he passes on the impress of his own character and moulds his students. His students will remember him for ever.

A manager should not only contribute his best but also endeavour to obtain the best from all those under him. Every worker should be made to feel that he is as responsible for the success of the enterprise as the top-most manager.

The freedom of action of the individual seems to be progressively getting restricted by laws, contacts, unions, and pressures of all kinds. The progressive trend is towards a manager abandoning personal principles of management in favour of conformity to organizational methods of management. The nature of organization has become extremely complex, requiring new dimensions of managerial competence. Organization today is dynamic. Even great managers are sometimes frustrated due to their inability to cope with organizational demands and complexities.

If there is more frustration than fulfillment in the functions of a manager, he would look longingly on the autocratic management of the past. He just cannot adopt similar methods today and he is not prepared yet to follow today, tomorrow's methods. The demands on management are so great that managers, in order to be completely successful, have to be near demi-Gods. The key to the whole problem lies in creating a dynamic organization and adding dynamic management to it. A manager can develop himself to his full stature only if he understands the organizational dynamics thoroughly. The authority of a successful and dynamic manager is unquestioned and unchallenged.

A dynamic manager may burn his candle at both ends, but he can refuel himself with the thought that he is a source of inspiration to his men; this inspiration could give him all the energy he needs. Self-renewal is helped by keeping one's horizons wide, developing one's potentialities, and risking failure. There is human response to great leadership.

When one gives his knowledge, his strength, his inspiration, he gets these back multifold so as to be able to give more and more of these to his assistants. The soul and spirit are greater sources of power, they produce inspiration and stimulation.

The new concepts of management today are:

- Management is the main function of modern society. It has to be used everywhere, at home, in school, in college, in the factory, in the hospital, in the civil service, etc.
- Entrepreneurship and innovation are among the main duties of management.
- Management should make knowledge productive.
- Not only is management concerned with tools and techniques, beliefs and principles, but also with culture.
- It has to work with the cultural heritage of the country.
- Management creates social and economic developments. Under-developed countries are under-managed countries.

The quality of life can be improved by improving the quality of society's management. A manager manages his business, manages managers and manages workers. If man has to perform greater tasks tomorrow, means must be found to simplify the tasks. There will have to be more and more technical aids to management and less and less of intuition in management. Management techniques are becoming internationalized on account of multi-national industries coming up. Management will become the central activity of the civilization.

Elementary training in management should really start in college. The subject should be included in undergraduate courses in science and engineering. The aim is not be produce "instant managers" but to create an awareness of management problems to reduce the ultimate training time required to acquire facility in management.

A psychological problem of the technologically advanced countries is the so called de-humanization problem of the technologically advanced countries is the so called. It is easy to keep the intensity of the competition within tolerable limits by providing motivation and incentives which operate on planes other than raw comparative behaviour. De-humanization will become a serious problem requiring intensive research to find solutions. Today there is a conflict between the scientific culture and the humanistic culture. A dynamic manager endeavours to fuse the two cultures.

B. R & D and the Market

Research should be linked very closely with the market place. Only essential research should be carried out when R & D budget is limited. All companies would like to make research pay. According to Dr. Arthur Bueche, Head of R & D of the General Electric Company, U.S.A., the key factor for getting value for money was integrating R & D into the main stream of business where strategies are formed.

R & D directors should spend more time becoming familiar with the company's problems-its customers and long-range planning, as well as its technical and manufacturing problems. They should be given jobs in other sectors of the company where they can establish contact with their colleagues in other functions of management. All levels of staff in R & D should know that their department is interested in the present and future business of the company. The R & D department should be a place where management staff are always welcome. One way of ensuring this would be to use the laboratories as a sort of part-time marketing tool-by showing important customers and visitors round the laboratories as part of sales presentations, as is commonly done in Japan.

C. Glimpses of the Future

In those recently emancipated less developed countries which have adopted the democratic way of living, there is over-doing of democracy with strong socialistic leanings. Rights take precedence over duties and responsibilities. The emphasis is on questioning the actions and even the motives of those in authority. In the newly acquired concepts of public ownership, employment oriented policies, regional preferences, heavy capital investment due to inflation, and a labour policy which pampers labour without, at the same time, laying the responsibility for productivity on labour, are some of the factors which cripple economic progress. In addition, there are exaggerated notions of welfare of workers, strangle-hold of the top bureaucracy on the day to day affairs of the undertakings and accountability to parliament. Even the enlightened professionals and administrators in these countries have become prisoners of the system in which compliance with rules, regulations and procedures is more important than achievement of the objectives. It is a pity that the people in the less developed countries have been doing the very things that inhibit progress, while there is dire need for adopting policies and practices which can contribute to economic prosperity.

Most of the less developed countries have had a colonial history. In the early days, colonies were managed by administrators from the colonizing countries, and later, administrators from the colonized countries also joined. Thus a tradition was established in which administrators occupied the highest and most important positions, and scientists and technologists were relegated to secondary places. Even after achievement of independence, the less developed countries in general continue with the same tradition. Whereas in the industrially advanced countries the pride of place is given to scientists and technologists, in the less developed countries there is the spectacle, in this age of specialization, of administrators knowing little of the dynamics of development, formulating policies in such varied fields as science and technology, education, health, food and agriculture, industries and commerce, irrigation and power, transport and communications and functioning as advisers and guides: the less advanced countries have still not shaken off the traditions of a colonial past in this respect. In

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these countries the best men are reluctant to specialize in science and technology because scientists and technologists, however eminent they may be, occupy a less important place in national life. On the other hand, there is a scramble to secure administrative positions. Fortunately, there are unmistakable signs in many of these countries that this pattern is undergoing change. There is mounting dissatisfaction with this state of affairs among the people. Forces are being generated which are bound to gain strength and sweep away the cobwebs and establish a system which will work more efficiently. More and more technocrats are replacing administrators. This is a hopeful trend.

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