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BOSTON UNIVERSITY

College of Business Administration

THESIS

Management Controls for Research & Development

by

Archie H. Harris III
(S. B. Massachusetts Institute of Technology, 1949)

Submitted in partial fulfillment of
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I. INTRODUCTION

In the highly complex and rapidly changing industrial world surrounding us, the place of Research and Development is assuming ever increasing importance to management engaged in the economic struggle labelled "business." Wherever one looks, the fruits of the technological advances fostered by science and engineering are very much in evidence. In the home, living is more comfortable, in the factory, physical effort is replaced by mechanical aids, in the office machinery processes more data with more accuracy and speed at a fraction of the cost. In these and many other areas the forward progress has been something just short of miraculous. Many industrial and consumer products on the market today weren't even thought of two decades ago and the products of the next decade are only now beginning to form as ideas in the minds of the men working with the test tubes, slide rules and microscopes.

To many persons, Research and Development conveys a certain aura of mystery coupled with the suspicion that accompanies those phenomena which are not completely understood. Witness the descriptive terms that are widely used today such as "Ivory Tower," used to describe the physical location behind the door labelled "LABORATORY," and "Long-Hairs," the unflattering title bestowed on the occupants of this

facility. Yet it is understandable when one pauses to take stock of what is before him, forces that surpass one human being's comprehension of power and progress in raising standards of living at a rate considered unbelievable a few short years ago. Certainly any activity which constitutes an annual expenditure in the United States of nine billion dollars can expect to be viewed with awe and astonishment.

Management today faces the problem of coordinating and guiding this wealth of knowledge and creative resources into the complex industrial scene so that the ultimate success of the company can be assured. In many instances Research and Development is but a name to management who strongly suspects that it has a vital role to play and yet great uncertainties gnaw at the group responsible for the decision to enter this mysterious realm: should the company engage in Research and Development; how large a program is justified; what are the risks; what are the returns; these and many more beg answers and deserve answers before management dares to back a company program.

A. PURPOSE

This thesis will explore the many facets of the management problem facing a company that is engaged in Research and Development. The reader cannot hope nor should he expect to find the answers to the questions raised during the search for guidance. These decisions must

be management-based, influenced by the intimate knowledge of the particular company and based on long years of valuable experience. However, once the decision to enter an R & D program has been made with full knowledge of the various aspects discussed here, then the management may have more confidence in the activity and be in a position to guide and control it with the recommended tools.

Compared with other phases of the industrial world such as marketing, finance, production and methods, relatively little material has been published about R & D. Much of the available literature deals with specific segments and a large part of the management phases are concerned with the actual operation rather than dealing with the executive level problems of maintaining control within the over-all organization.

Admittedly, much of this deficiency is attributable to the relatively recent entry into the industrial picture of Research and Development as an organizational entity. While the basic function is not new the formal relationships of R & D have developed only as individual companies became aware of its importance to the success of the business. With this recognition, the stature of the activity has grown rapidly and, having proved itself, has achieved its proper status in the well balanced management relationship.

B. SCOPE

The discussion that follows is intended as a guide to a company not now engaged in formal Research and Development. A fixed pattern cannot exist for each company since each has problems and needs peculiar to itself. Thus, the company already operating an R & D program has benefited by its own experience far more than can be expected from a limited discussion such as this.

What is known about the role of R & D, its past success and its future potential, will be discussed primarily for the benefit of the management which does not have first hand experience in operating such an activity. The management must establish its objectives before it is possible to design tools to guide and evaluate this new operation. In order, due consideration must be given to the initial decision to activate an R & D program. It must be a long term decision, for experience has proved that the most effective results come from a sustained program over several years' time rather than from short intervals of intensive effort. Secondly, the organization of the function and its relationships to the rest of the management team will be reviewed. Only after this point is reached can the discussion of control tools for top management be considered. Finally, the actual controls needed to enable management to fulfill its responsibility of keeping abreast of the R & D activity and controlling its progress in line with the over-all corporate needs will be proposed.

II. THE DECISION TO ENGAGE IN RESEARCH AND DEVELOPMENT

The competent management team arrives at the final decision to enter into Research and Development only after careful thought and consideration of the many problems to be encountered. The germ of the idea that such a program deserves serious attention may originate at almost any point in the company, in any department and at any level of the organizational structure. Whether the idea comes from a Board of Directors meeting, a field sales manager or a production foreman, the suggestion will ultimately arrive at that position responsible for making the highest level operating decisions in the company. This must occur eventually for the decision will affect every subdivision in the organization and without the enthusiastic support of the top executive, the success of the program will be, at best, dubious at the outset. Similarly, the question requires consideration from every possible point of view and such an evaluation is not practical at any but the highest management level. Thus, depending on the individual company, the decision will be that of the Board, the President or Executive Vice President.

This decision should not be treated lightly. Careful thought and thorough answers must be given to each of the classical questions that the executive is accustomed to asking and he will find himself asking many new questions before the decision is reached. Due consideration

of the effect on the major company functions of Sales, Production and Finance is needed. Without adequate thought and careful planning, the company may discover, too late, that it has opened a Pandora's box of insoluble difficulties.

Careful decision-making must not be confused, however, with avoidable delay in collecting the information necessary to conclude the matter. Time is an extremely valuable commodity in a competitive environment. Postponing a decision unnecessarily may prove to be just as dangerous as failure to consider all aspects carefully.

A. WHY BEGIN AN R & D PROGRAM

Many arguments will be advanced in defense of initiating an R & D program. Just as many and equally well-founded counter-arguments will be heard. Taken individually or collectively, both sides considered together or separately, these arguments may form a very convincing case one way or the other. Underlying all of those well thought out points of discussion is the fundamental question of why the company is in business in the first place. In a freely competitive economy, the primary business motivation is to provide goods and services to the consumer at a fair price, sufficient to make reasonable profit and in turn provide an adequate return to the stockholders on their investment in the enterprise. While this fundamental principle may be tinted in varying

shades by government controls, subsidies, monopolies and other minor adjustments to the theoretical free economy, nevertheless, it still remains the motivating force for business. Since management is responsible for carrying out this business objective, it must eventually base all its decisions on whether or not their actions will continue to accomplish this goal.

Having established the criteria for the basic framework surrounding the decision-making process, an inspection of motivations to reach the desired end point is needed.

1. Keep Abreast of Competition

In the economic struggle called free enterprise, no greater force exists than the demand of the consumer. A company's competitors can be expected to be just as sensitive to this pressure as the company itself. Feeling the effect of this pressure, no concern can afford to ignore it, for each competing company may stand ready to satisfy this consumer demand. The time-tested, though slightly worn adage "Build a better mouse trap, etc." is just as valid today as it was in the dawn of the Industrial Revolution. Time is always on the side of the first company on the market with a new product. Given a virtual monopoly, even if but for a short time, the producer has freedom of pricing according to the economics of supply and demand without need for concern over the competitive forces of meeting the market price.

As is demonstrated in the example below, keeping abreast of the competition usually means being a step ahead on occasion, for to be behind is an infinitely more difficult handicap to overcome. Thus, the desire to engage in Research and Development may stem from outside forces in the competitive market which dictate that unless a company is prepared to be in the fore, it may all too quickly find itself trailing in the race to obtain and hold the needed share of the market.

A brief sketch of the following example demonstrates this point most forcefully. In the early 1940's, the pen industry was startled to see the first significant change in years in the instrument designed to transfer ink to paper. Not since the fountain pen was first marketed had the consumer been exposed to a revolutionary innovation like the ball point pen. Given a strong assist by an excellent promotional campaign, the ball point pen, marketed by Reynolds and selling at twice the price of good fountain pens, set a record of sales growth that was truly phenomenal. A corresponding decline in fountain pen sales was inevitable. Then something happened. The fountain pen manufacturers recovered from the initial surprise and began to market competing items. One firm bought out Reynolds at his peak in an effort to ride the crest but the plateau had been reached. As new wares appeared, prices began a steady decline until, in a short space of time, competing lines could be found in 5 and 10 cent stores. The ball point pen eventually succumbed to competition's forces to keep prices in line with value.

The lesson to be learned is that by being one step ahead, the original manufacturer was able to capitalize on the novelty of the product, recover all of the original developmental costs and clear a profit to the business that has been estimated at several million dollars. In the meantime the competition was faced with declining sales and the problem of catching up to the leader.

Certainly an R & D program won't always come up with a ball-point pen but the opportunity exists and in the meantime keeping abreast of the competition will more than pay for itself on the balance sheet.

2. Develop Growth for the Future

The present always demands more attention simply because the problems are known quantities and can be dealt with in quantitative terms. The future is much more uncertain and the decisions concerning it are infinitely more abstract. However, every company expecting to be in business for some time to come must prepare intelligently and thoroughly. Planning for future growth must take into account how this growth will be achieved.

In an economy that is constantly expanding not only from the increases in living standards but also because of a tremendous population growth, the nation must expect to produce more in each succeeding year. The demand will compel it to do so. And, at least in the

forseeable future, this must be accomplished by a proportionately smaller labor force. Increased longevity and the ever increasing wave of children are rapidly swelling the ranks of those outside the productive age bracket of 18 to 65. Thus more must be produced by proportionately fewer people. The answer must lie in technological advances which will increase the per capita output to a rate consistent with the demands of the economy.

As will be demonstrated later, the time for formation of ideas and projects in the R and D stages is already past if the next economic wave is to be met successfully. Individual companies which desire to be ready to benefit from the cycle crest must be preparing now their new products, increased production capacity and improved marketing methods. Research and Development will be the prime mover and even at this time competing companies are marshalling their forces for the imminent surge.

3. Product Diversification

The term Product Diversification has become almost as magical as Research and Development in the past decade as a cure for business ailments. Viewing from the practical side, however, it does tie in quite closely with the discussion above on growth, with several added features. In addition to providing new outlets for a company's

expanding resources, it offers the added advantages of protection against obsolescence of existing products or product lines. It also tends to minimize the effect of recession or dip in a particular product's marketability. Diversification broadens the company base and permits more effective utilization of available resources, skills, facilities and marketing outlets. Suitably chosen, it may also reduce competitive pressures or at least dilute them to more manageable limits.

Recently, the more attractive source of new product lines has been through acquisitions and mergers but the role of Research and Development must not be underrated as a prime supplier of new products, even totally new lines which previously did not exist. Complementary lines appear to be preferable because previous experience is readily available within the existing organization for this growth mechanism. However, totally unrelated products may prove to be the best selection for the particular circumstances. In either event, R and D can be and should be a prime source for the new product's development from idea to reality.

B. WHO SHOULD CARRY OUT THE R & D PROGRAM

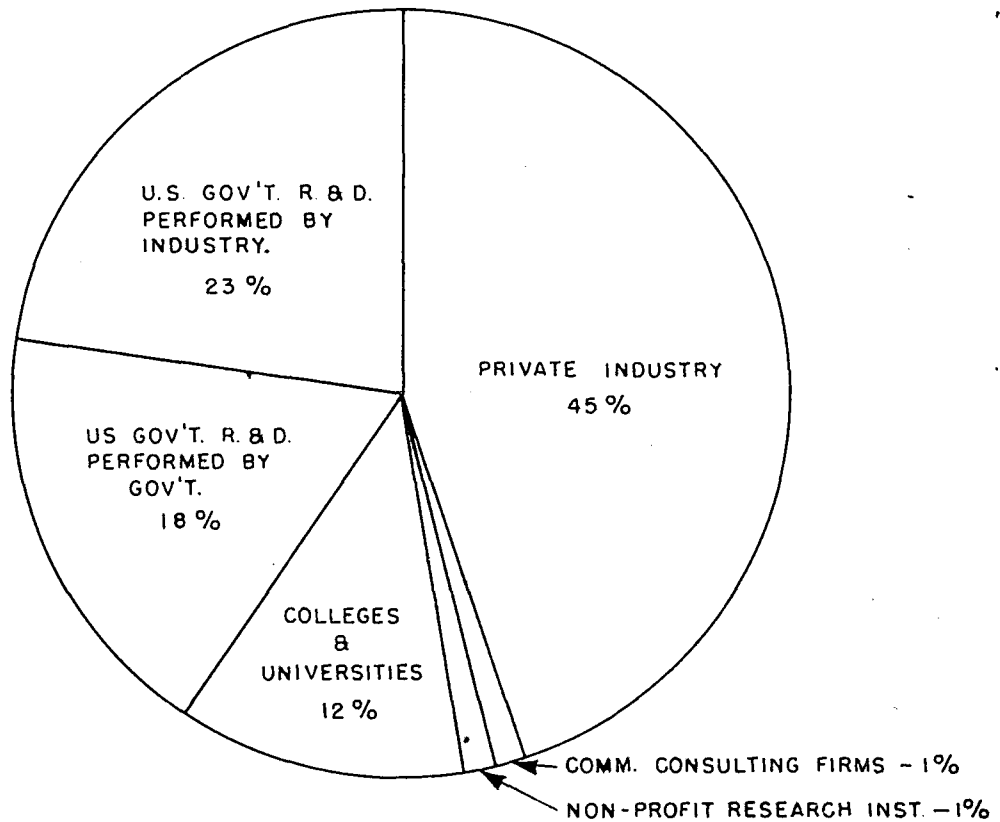
The Research and Development program of a company is not unlike many other aspects of a business organization. Depending upon the particular company's requirement, it may be fitted into the over-all

operation in a variety of ways. No one way is best, as long as the basic needs are met. The resulting organizational arrangement may vary widely from company to company and from industry to industry.

One of the principal points to bear in mind is that R and D is an activity calling for highly trained and experienced personnel. Just as some companies may deem it advisable to have their entire promotion and advertising program carried on by an outside agency, so may a firm elect to contract with a technical consulting organization for all of its R and D work. On the other hand, like the company that employs a team of competent investment men to handle all of the securities and investments, so may a fully staffed R and D department be employed on the company payroll.

The combinations of choices are many and as stated previously, the final selection of method best suited must be based on individual needs. However, it is important that as many alternatives as possible be explored. Hence an examination of the more widely used is in order. For a breakdown of how the national Research and Development funds are distributed among these categories, see Figure I.

FIGURE I
DISTRIBUTION OF U.S. RESEARCH AND
DEVELOPMENT EFFORT 1953



TOTAL 1953 R. & D. EXPENDITURES \$ 5.4 BILLION
TOTAL 1956 R. & D. EXPENDITURES \$ 9.0 BILLION

SOURCES:

N.S.F. SURVEY 1953-54
N.S.F. SURVEY 1956

1. The Internal Organizational Unit

The most widely used arrangement consists of a formal Research and Development program carried out by a company's own employees. The requisite facilities and equipment are a direct company expense and the organizational unit is completely self contained. The results of this team's efforts are used entirely within the company, except for the more fundamental knowledge exchanged through professional organizations, technical paper presentations and the like for the general advancement of the science. Patentable developments become the company's property and protection against competition is reasonably assured.

There are numerous advantages and some disadvantages to this arrangement. Without examining relative merits, a brief statement concerning each is needed. Assume for this discussion that the company is operating a completely self contained Research and Development department staffed solely by its own employees, and that the results of the programs are solely for the company's own benefit.

From management's point of view, this represents the arrangement over which maximum control can be exercised. Projects may be initiated and terminated at the direction of management with a minimum of delay depending upon corporate requirements. The proper controls for safeguarding the technical content from outsiders may be exercised to prevent leakage to competitors. Automatic control to a certain extent

of the level of R and D expenditures is assured. As will be demonstrated later R and D costs are a major function of the number of scientists and engineers engaged in the effort and rapid expansion by rapid additions to staff is not as likely if a well balanced team is to be maintained. It takes time to recruit talent. Similarly, long term continuity of an R and D effort is assured if the temptation to reduce a total program involves terminating permanent employees.

Other notable advantages to the internal unit plan include the opportunity to select and build the right type of staff consistent with long range corporate objectives. Having to view the long term certainly places more responsibility on top management for sound decisions in this entire matter in the first place. Under this arrangement, management is similarly in a position to keep actively informed of progress and new developments so as to take advantage of changing situations almost as they occur.

Having a staff of its own employees also has the advantages of securing and maintaining the personal allegiance of the R and D worker which assures that his total productive performance will be solely in the company's interest. Likewise, the personal relationships between departments will permit the R and D function to be coordinated more closely with the rest of the organization. Internal operational knowledge of this kind will most likely develop active cooperation between departments.

Viewing the other side of this arrangement does present some corollary disadvantages, however. Because an internal unit is so closely oriented to the company as a whole, it may have difficulty achieving the necessary flexibility. For example, if a totally new product line is needed, the necessary technical talents may not be available in the existing staff. As mentioned earlier, recruiting takes time. This is particularly true in the first few years of an R and D department's existence when the staff is small and it is just not possible to maintain initially all of the talents the company may be able to use in the future. The limitation of available personnel also poses a problem if a short range intensive project is required by corporate needs. The manpower just isn't there. Yet it would be totally impractical to hire to meet the need and discharge the same people a few months later upon completion of the work.

While on the subject of personnel, another drawback presents itself when considering the internal organizational unit. Having a similarity of talents, conditioned by the same environment and possessing a unanimity of purpose, a staff may display a lack of originality, new ideas or the "fresh point of view," which is a serious handicap to any group whose primary motivation is from within the person. While it is true that many novel points of view may come from the other sections of the company, the technical approaches to problem solution will more likely originate from the technical man, hence the importance of that different line of approach.

In the financial area, which will be considered in more detail below, the continuity of a level of activity may prove to be an undesirable feature of a totally contained internal department. The cut-back of a going activity which has been skillfully developed and which possesses a high degree of coordination may seriously disrupt the progress of the remaining staff. It will find itself short of needed talents and background. The possibility of such a situation may more or less commit the company to a continuing level of activity in excess of its long term needs. Similarly, this aspect may lead management to develop a hesitancy to increase the operating level when the short term needs indicate this expansion to be desirable but the long term planning can't justify this sustained increase.

Viewing this arrangement as a whole, it has been developed that maximum management control is possible under this alternative. There are accompanying advantages but certain disadvantages are inherent also. The relative weights assignable to each must be dictated by the individual company situation.

2. Outside Specialists

The discussion of outside specialists generally titled by the profession as "Consultants" is considered immediately after the internal organization because there are a number of similarities connected with this manner of performing Research and Development.

Consultants may fall into two broad categories each of which should be considered separately since their functions and methods of operation are different. On the one hand is the independent or individual consultant and on the other is the consulting firm comprising a number of individual persons. Each will provide professional services of the type desired by a client company under a contractual arrangement for an agreed upon fee. This fee may be expressed either in terms of a per diem or in the case of a defined project may be at a fixed payment for the entire effort. It has been generally conceded that the reputable consultant's fee is reasonable and in line with the professional service received by his client.

The independent consultant is either in business for himself or holds a teaching post which permits him to do consulting work in the time not taken up by academic duties (usually in a college or university). His services are available on a per diem basis and he places himself at the client's disposal during this time. Any expenses for travel, materials, telephone or such incurred directly for the client's benefit by him are billed separately. As the client prefers, he is available to work directly with the company's own personnel in his particular area of specialty on the client's premises if necessary. Thus it is apparent that the arrangement may offer certain important advantages.

For example, it is possible to supplement the internal R and D organization with a particular talent not available inside the department as well as to expand the number of personnel engaged in the activity. This is particularly attractive to the company with only a short term need for either of these additions to its staff. The arrangement may be terminated as specified contractually at a fixed date or with suitable advance notice, normally one to four weeks to allow sufficient time to complete the consultant's current phases.

Equally attractive is a more continuous arrangement where the consultant, possessing an exceptionally well suited background in the company's area of interest, may be retained to spend a few days a month reviewing internal progress, coordinating the over-all program or supplying a fresh source of ideas and different point of view. This particular use of an outside consultant obviously leads to a closer working relationship than the short term one-time use and permits utilization of his prior experience with the client company for its continued benefit.

It must be emphasized, however, that regardless of how close the working relationship is, the consultant is still an independent party, bound only by the written contract. He usually serves several clients simultaneously and availability may become a limiting factor. More important is the possibility that his scope of technical activity may be limited by a prior commitment to another client in a given area that is of interest

to the company. As a result, he is bound ethically not to render service in the subject to more than one client without delicate negotiations between the parties concerned. This might prove particularly difficult if competing companies are involved. The reputable consultant is bound ethically to protect the interests of past and current clients at all times. Of course, this is advantageous, as well as a disadvantage, for a company can be assured that its confidential information will not be transmitted to the outside by the consultant.

The other source of consulting is the firm composed of several or many individuals who provide their services singly or collectively in much the same manner as the independent consultant. Their legal organizational form may be either a partnership, proprietorship, corporation or nonprofit institution (not to be confused with educational institutions). In any event, their ultimate objective is to provide professional services of their staff to the client company for a reasonable fee. This service may be rendered by one, two or several members of the firm's staff, depending on the scope of the project under contract.

The consulting firm offers a number of advantages over the individual consultant. The variety of talents available from a group such as this usually covers a broad area of a technical field. In addition, the firm generally maintains its own facilities so that its work for the client can be carried out in properly equipped quarters without creating an acute

space problem at the client location. As the particular project develops, the additional personnel will be readily available to work with associates with whom they are well acquainted. Most important is that the consulting firm will supply experienced internal management and administration of the project team, thus relieving the client of a difficult coordinating problem.

While the usual function of the consulting firm is to provide services of a reasonably well defined scope, it is not uncommon to find individual relationships developing which continue on a more personal basis between a client and the firm's staff member. True, the staff member remains primarily a representative of the firm, but he becomes just as strong an extension of the client's R and D program as the independent consultant.

The question of industrial security rarely becomes a problem when dealing with consultants. As indicated above, a strong code of professional ethics binds consultants to their clients and prohibits unauthorized disclosures of company secrets to the outside. In fact, it can be assumed that more company secrets are lost through employees who move over to competitive companies and are not bound by a strict code, than leakage through consultants.

The principal disadvantages to keep in mind concerning consultants are first, that the talents desired by the client may not be available due to prior commitments and, second, but more important in the long run, the experience gained as a result of the work does not remain with the client's own staff.

3. Trade Associations

Trade associations are not new to the industrial scene. In fact their origins can be traced back to the guilds of mercantile Europe. However, their participation in Research and Development activities has become an important phase of any company's R and D program only in recent years. While it is true that some such associations have monopolistic overtones and a few have even succumbed to anti-trust actions, the usual environment in which they exist make it natural for certain types of R and D activity to be carried out on behalf of its members.

Since the trade association is supported jointly by its members, no one company can expect to have its own R and D work done by the association's laboratory. The association concerns itself with more fundamental activities aimed at advancing the trade's arts and scientific know-how for the mutual benefit of the entire membership. Thus if a company is engaged in business in an industry having a trade association, it should consider the role that the association's R and D activity would play in the company's own program.

The association stands in a unique position to avoid costly duplication of basic R and D work and on a limited basis may provide technical service if mutuality of interest exists. Naturally their work becomes industry-wide knowledge and to the smaller concerns, this becomes a valuable source of new ideas for further exploration in its own department.

Obviously, the management control that may be exercised by any one company on the association's R and D program is nil. The participating members acting jointly govern activities and only through this mechanism can the association continue to achieve its purpose. Company management should, however, take full advantage of the already existing activity in formulating its own program. Here control is possible.

4. Other Outside Activities

Various other organizational units outside the general scope of industry carry on Research and Development in one form or another. For differing reasons, it is felt that these are beyond the scope of this thesis. Suffice it to say that management must be alert to possible developments by these outside agencies.

For example, the U. S. Government's R and D program, while sizable, is dedicated to defense and public health and welfare. Only when the Government contracts with private industry to perform this work does it become a management control problem. When a company undertakes

to do this, a whole host of new problems arise calling for differing kinds of control tools.

Professional organizations whose membership is composed of individual scientists and engineers are primarily forums to facilitate free exchange of nonconfidential developments in respective technical fields.

Colleges and universities have as their primary purposes education and fundamental research. While private companies may act as sponsors of various research projects, the choice of program and control usually rests entirely within the academic administration.

C. TIMING OF ENTRY INTO THE R & D PROGRAM

Up to this point in the decision making process, no reference has been made to the element of time. Yet management will discover that time is one of the most important considerations in an effective R and D program. Just as it is important in an operating program, it also deserves careful consideration in the initial decision to engage in R and D.

Considering first the two extremes, too early and too late, if management should attempt to initiate a program before the company is prepared to integrate it into the over-all operation, the operation is, at best, doomed to mediocrity, and possible failure. Coupled with the financial losses accompanying such a false start, it is not difficult to visualize that such a result would make lasting impressions on management that R and D is to be viewed with skepticism at some future date.

Equally tragic, would be the outcome of a program initiated only after too long a period of waiting to organize the effort when the most opportune time had long past. The result would most likely be a frantic rush of effort and wasteful expenditure of funds with questionable success.

Research and Development cannot be hurried. It does not recognize the time clock or the calendar. Many ideas and developments must germinate for a period of time in the minds of the scientist and engineer and doubling the number of minds will not halve this germination period. Similarly, an extended work week or speeding up attempt will not accelerate progress proportionately. R and D's evolutionary process is not tied to the number of drawings made or the number of models built but rather is the result of careful analytical thought which continues regardless of the length of work day. In most instances it goes on well into the nights and week-ends. It is not uncommon for a sudden inspiration to send a scientist into the lab at some late night hour or week-end. Best results may occasionally be possible only if the project is set aside and left alone during a period of gestation while the personnel turn to some other assignment in the hope that a fresh look at a particularly knotty problem days later will result in the answer.

Admittedly, the unit of time will become an important factor to the management for control later on but that is only because no better unit of measurement for R and D can be expressed. Inspiration is not

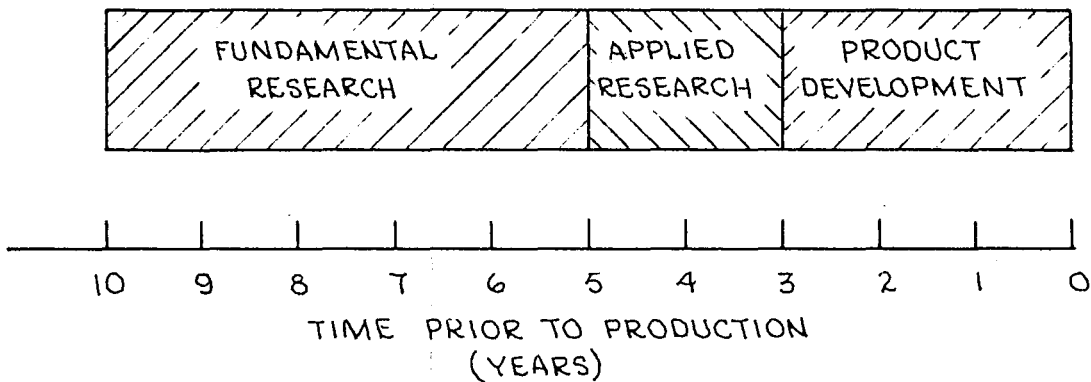
measurable in finite units. An important technical breakthrough may occur overnight or only after weeks of painstaking effort and there is no known way of anticipating which it will be in advance.

Lest the assumption be made that time cannot be estimated for an over-all program, it should be brought out that a skilled administrator, within reasonable tolerances, can estimate over-all time requirements. Experience will dictate what can be expected, but the important thing to bear in mind is that very little can be done to change the time process.

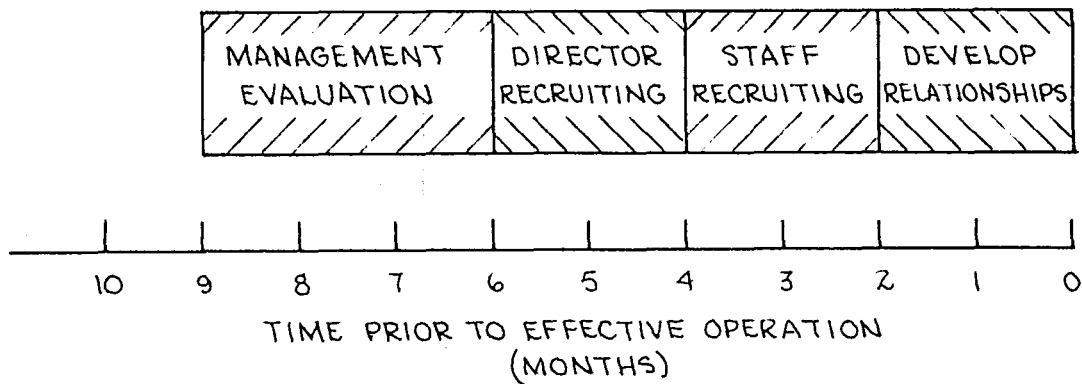
Thus, management is faced with the immediate problem of timing its entry into an R and D program at just the proper point to maximize its usefulness. To enter a program when the company needs it is already too late since it is imperative that proper preliminaries described in further detail below be thoroughly explored, carefully developed and systematically put into operation. A glance at Figure II will give some indication of the lengths of time involved to arrive at given points in the development. Figure II-A deals with Section 1 below, and concerns the time steps in the typical product development program. Figure II-B deals with the organizational aspects of developing such a program to enter at a desired point in the product development program.

FIGURE II
LEAD TIME REQUIREMENTS IN
R & D PROGRAM

A. PRODUCT



B. DEPARTMENT ORGANIZATION



1. Lead Time Requirements-Product

The entire scope of Research and Development for a given product may be subdivided into various time segments, each with an appropriate title. The length of time that it takes to move through each phase may vary somewhat but for proper long-range planning, particularly at the outset of a program, these time lengths are reasonably constant.

Assume that a new product has just entered into volume production with no further design modifications anticipated. That product will have gone through the following phases in reverse order with the approximate time in each phase as indicated.

a. Product Development - 0 to 3 years prior to production.

This period saw the product emerge from the laboratory as a recognizable unit. It might have been a test tube sample or a bench scale model but it resembled the finished product in many respects. Development of this entity proceeded through full scale design to a pilot model which resulted in limited quantity production. The finished product was firmly fixed at this point and moved into production engineering. Almost simultaneously, market surveys were carried out and the decision to prepare for full scale production was reached. Then production facilities were prepared, tools and associated plant were made ready and the production sequence was ready to begin.

b. Applied Research - 3 to 5 years prior to production.

During this phase of the new product's development, one of the most startling and near miraculous changes occurred. Science's vast storehouse of knowledge and techniques was explored from every possible angle in the search for some indication, some glimmer of a new idea that might ultimately lead to a useful, marketable and economically feasible new product. This amazing transition does not take place without false starts, interim disappointments and apparent failures. Many possible explanations for abandonment of certain lines of investigation occur during this relentless search. The mortality rate of projects is high and it requires a shrewd sense of business acumen to know which projects to reject and which appear to have promise.

It is during this period that the maximum in cooperation by the entire organization is most needed, and if present, can be most effective. Many times along the path, business judgment from every aspect of the operation must be applied. Otherwise the boundless enthusiasm of the researcher may gain unjustified momentum down a road which is eventually a dead-end. This can only result in ultimate disappointment, needless expenditures and most serious of all, loss of valuable time, the irreparable damage being the last.

Thus it becomes apparent that a real need for some management control exists in this area which is most subject to pursuit of an

unattainable goal. Proper controls for this phase of the activity will be considered later in the discussion. Bear in mind, however, that the key to fruitful yields in this phase of the R and D program lies in effective utilization of the Applied Research effort.

c. Fundamental Research - 6 to 10 years prior to production.

The warehouse of scientific knowledge referred to above is like any reservoir. As it is drained, it must be replenished or at some future date, the basic learnings needed for further technological advance will not be available.

Fundamental Research, sometimes referred to as Basic Research, is the scientist's continual search for new information in technology. Its sole purpose is to provide new insight into the basic structure of natural phenomena, to learn more clearly the mechanisms of nature and to master techniques for measuring and understanding the forces of the universe. In this fascinating quest, there are no failures, for everything that is learned, even through mistakes, adds to the scientist's knowledge of the fundamentals.

Because of its basic nature, this activity is less directed in ultimate purpose because no one knows the eventual end point of a particular line of investigation. It is generally limited only by finite forces, such as time, available manpower and finances. Every user of the results

of fundamental research has an implied obligation to replenish the warehouse. It may choose to do so by sponsoring university programs or setting aside part of its own R and D effort for this purpose. The proportion of the total expenditure need not be large for there is a thousand-fold multiplication of the basic learning as it passes through each succeeding phase. However, if the economy is to continue to benefit from technology, it must not be ignored entirely.

2. Developing an Effective Program

Once the decision to engage in Research and Development has been made, an effective program will result only after careful, logical planning of each step in the development. This will include the building of the program itself as well as integrating it into the organization. Manpower, money and facilities alone do not constitute an R and D department. These ingredients, like a fine recipe, must be blended in the proper proportions. Much more necessary is a clear statement of purpose, scope and place in the company structure. And finally, the single most important step of all is to secure a competent person to take the responsibility for operating the program.

These steps, each of them time consuming, must be taken before the R and D program can get underway. At this point the program enters into the time-step schedule developed in the preceding section.

It is not unreasonable to expect that a year will elapse before the program is under way and functioning smoothly. Hence this time unit must be added to the product lead-time requirements in order to visualize the total calendar time needed to put the results of R and D onto the production line.

The remaining question to be answered by management is how broad a program should be undertaken. The entire spectrum of R and D has been discussed earlier. Management must decide how much of this it wishes to include in its own activities, what steps it will take to incorporate other sections later on and what portions will be specifically excluded. Normally it would be expected that these cut-off points would be set respectively by studying the Product time Requirements from Production time (0 years) to Fundamental Research time (10 years).

The most likely scope for a company just embarking on a formal R and D program would cover the period from 0 to 7 years prior to production. Note that this just touches the search areas and would be limited to furthering the knowledge in its own related technological areas but omitting the highly theoretical research. The latter would come from academic or larger corporations' Research activities. It would, however, span the entire range of its own R and D needs from applying the knowledge through to the final product development.

This objective will not be realized all at once but should serve as a guide to the ultimate program desired by management. In the building process, however, one fundamental fact should be kept in focus. The ultimate objective of the R and D effort is to reach production-zero time. Unless it is possible for a project to move to each succeeding step in the table outline, the entire effort is wasted. It will stall at any point where a gap in the program exists. Thus unless appropriate management action is taken at the outset of the R and D effort to ensure continuity, the entire program may be a total loss.

D. ECONOMICS OF THE R & D PROGRAM

If Management is to plan an effective program it must have some knowledge of the financial aspects involved including risks and returns to determine acceptable limits on the level of expenditures it is willing to approve.* It must also accept certain known limiting factors concerning measurement of these expenditures. Finally, it must determine what controls it considers necessary to evaluate effectively the results of the program.

* 27, pp. 102-104.

Defining the mechanics of accumulating and allocating costs is not a primary objective of this discussion. As long as the techniques of measuring planned costs are consistent with actual charges the basic control purpose will be met. The financial officer does have the responsibility of reporting as completely as possible, the total costs of the activity and to this extent, management should resist a rather common tendency to camouflage the true costs of an R and D department. The usual omissions are made through improper allocation of general and administrative costs or charging of indirect supporting labor to other disassociated accounts (e. g. , secretaries, file clerks, etc.). All planning and actual costing should be expressed on a time total basis rather than some ill conceived attempt to keep apparent R and D costs unrealistically low.

1. Program Continuity

Research and Development thrives best in an atmosphere of reasonable continuity. A program cannot be started and stopped indiscriminately without suffering deep damage to its over-all effectiveness. Therefore, once management has agreed to a given level of financial support to the operation, every effort must be exerted to maintain that level with minimal fluctuations. This holds true for expansion as well as contraction. It is far wiser in the long run to support a lower level that can continue uninterrupted through all but a major financial crisis

than it is to gear expenditures to gross volume or earnings. The fact is that R and D expense is approximately proportional to the number of personnel engaged in the activity and it takes considerable time to build a smooth functioning team to its maximum effectiveness. Violent disturbances in the make-up of that team can only serve to prevent this build-up and keep the program constantly off balance.

The actual size of the R and D budget cannot be determined categorically. Numerous studies have been conducted to survey R and D costs and the result has been a great mass of data on how much is spent but no answers to the question of how much should be spent. The statistics on R and D expenditures, usually expressed as a percent of sales, vary widely from industry to industry and there are equally wide variations between companies in the same industry. Therefore, averages are not necessarily the right answer for any particular company. In the final analysis, each management team must evaluate its ability to supply the necessary finances versus its needs for later return on the effort.*

Table I does present average R and D expenditures of company owned funds by industry and by company size which might be used as a rough yardstick to pick an order of magnitude. Table II reports total R and D costs including funds from outside sources, primarily the U. S.

* 42, pp. 96-98.

TABLE I

COMPANY SPENDING FOR RESEARCH AND DEVELOPMENT
AS PERCENT OF SALES BY INDUSTRY AND COMPANY SIZE

1953

<u>Industry</u>	<u>Total Employment</u>			
	<u>50-499</u>	<u>500-999</u>	<u>1, 000-4, 999</u>	<u>5, 000 or more</u>
ALL INDUSTRIES	<u>*</u>	<u>*</u>	<u>0.9</u>	<u>0.9</u>
Food and kindred products	*	.1	.3	.2
Chemicals & allied products	2.2	2.2	1.8	2.9
Petroleum products and extraction	*	*	.9	.6
Rubber products	*	*	.7	*
Primary metal industries	*	*	.5	.4
Fabricated metal products and ordnance	*	1.6	.7	.4
Machinery	1.2	1.1	1.4	1.8
Electrical equipment	3.0	1.4	1.8	2.8
Aircraft and parts	*	*	2.9	1.2
Professional and scientific instruments	2.7	4.4	1.7	3.0
Other manufacturing industries	*	*	.5	.7
Nonmanufacturing industries	*	*	.2	.3

* Not available.

Source: N. S. F. Survey 1953-54.

TABLE II

RESEARCH AND DEVELOPMENT COST AS PERCENT OF SALES
BY INDUSTRY AND COMPANY SIZE

1953

<u>Industry</u>	<u>Total Employment</u>			
	<u>50-499</u>	<u>500-999</u>	<u>1,000-4,999</u>	<u>5,000 or more</u>
ALL INDUSTRIES	<u>*</u>	<u>*</u>	<u>1.5</u>	<u>1.9</u>
Food and kindred products	*	.1	.3	.2
Chemicals and allied products	1.7	2.1	1.7	2.8
Petroleum products and extraction	*	*	.8	.7
Rubber products	*	*	.9	*
Primary metal industries	*	*	.4	.3
Fabricated metal products and ordnance	*	1.6	1.9	.8
Machinery	1.2	1.5	1.7	2.2
Electrical equipment	7.2	4.1	4.8	6.6
Aircraft and parts	*	*	7.5	9.1
Professional and scientific instruments	4.1	6.6	3.1	5.3
Other manufacturing industries	*	*	.7	.7
Nonmanufacturing industries	*	*	.5	.5

* Not available.

Source: N. S. F. Survey 1953-54.

Government. Caution is urged, however, to explore the company's own individual requirements thoroughly before setting the final dollar budget level.* That level should be one that can be sustained comfortably through both good and poor operating profit levels. Frequently an R and D program is most needed when the profit picture is unfavorable in order to provide the needed impulse to company recovery. It would be unfortunate indeed to find that an R and D budget cut had to be made because of operating losses just prior to the culmination of a project that could bring operations back to a profitable basis. Equally important is the care which should be taken to avoid expansion at an undesirable rate when operations are exceptionally profitable unless the management is prepared to support the new higher level under possible adverse conditions in the future.

2. Sources of Funds

The costs of carrying on a Research and Development program are usually charged against current income. This is in keeping with good accounting practice and it is allowable under Federal and most State tax statutes. Thus, even though a program has many long-term characteristics, it is constantly viewed in the financial reports as a current rather than a deferred expense. It does on occasion happen, however, that during the course of an R and D project, equipment is purchased or constructed

* 5

that qualifies as a capital asset under general accounting practice. This is particularly true of the more standard items of equipment having many uses throughout the company.

It is left to the financial authority to determine the answer to such questions but for the management control purposes it is recommended that all costs incurred in the course of an R and D program be treated as current charges against the current budget. Appropriate bookkeeping adjustments may be made elsewhere to balance this out. Management needs to know the total flow of funds out of the treasury if it is to accurately judge the effectiveness of its program. This technique also avoids the temptation to use bookkeeping peculiarities to mask large outlays of funds.

3. The Pay-Back

Measuring the return on Research and Development is probably the most difficult and at best arbitrary method of justifying its existence. Yet it is a necessary procedure for management, just as important as measuring the return on investment in production tools or plant. However management must use extreme caution in the weight that it gives to this measure of use of company funds for several reasons. First, the results of an R and D program are infinitely more difficult to measure in finite terms ahead of time than, say, the results of a labor saving device which will immediately replace two workers. The time element

must be taken into account for no return can be expected until after the R and D program has produced a saleable product. Also, the profits from the sales of the new product certainly cannot be attributed entirely to R and D for there has been an increased investment required in plant, inventory, tools, accounts receivable and so on. Finally, comparisons may be to no avail at all for in many cases R and D may be the means to survival of the company altogether. What value does management place on that?

It is far more realistic for management, without the financial crutches of pay back or return on investment to view the over-all picture objectively and determine from experience that the Research and Development effort has more than justified itself. The most logical comparison is to imagine what the company's situation would have been or if looking ahead, what it will be without the results of R and D.

4. The Write -Off

For many reasons, not every phase of a Research and Development program will be 100% successful. The reasons for this may be technical, economic, competitive, obsolescence and the like. It might prove helpful to review a few situations so that management will be acquainted with them and not expect a full return on every R and D dollar expended.

Each project in an R and D program moves through various phases of development as was discussed earlier. During this progress more and more knowledge is being gained about the particular end product. At different points along the development path it is possible that the scientist or engineer will discover some previously unknown fact. This additional information together with existing data may lead the scientist to conclude one of several things, any of which could result in a decision to terminate further development work.

One of the most common causes of such project termination is the technical considerations. It may develop that further work is impractical because a solution to a problem is impossible either at that time because insufficient basic knowledge in the field or at any time in the future for scientific reasons. Economic considerations are equally valid and frequent reasons for abandoning a line of investigation. Costs either of the further development or of production of the product itself may be entirely too high relative to expected sales price or in the light of existing established products. Similarly, it is a distinct possibility that the competition may have jumped the field and successfully marketed the results of its own R and D program with such success as to preclude the entry of an identical or similar product at a later date. It is often better to abandon such a project rather than risk serious losses in a losing competitive struggle. Closely akin to competition is the ever present risk of

obsolescence. A company's own R and D program may produce a project which has a satisfactory chance of success that will make other related projects obsolete. It is better to abandon these many times even though the outmoded project may be ahead of the newest development time-wise.

A strong recommendation must be made here to management that it can expect a certain portion of its Research and Development program to be unproductive. Yet this should never be considered a total loss for the experience gained and the new knowledge will ultimately strengthen the over-all program and increase the likelihood of future successes. While it will appear on the books as an expenditure without direct measurable returns, the over-all benefits will be apparent in retrospect.

Immediate write-off of basic expenses for continuing fundamental research and over-all program administration should be considered without any expectation of relating these costs equitably or accurately to specific subsequent projects. Similarly, projects which are found to be unlikely candidates for success should be terminated as soon as the fact becomes apparent. Not to do so would tie up valuable effort which could be utilized more effectively elsewhere and increase unnecessarily the expense that is finally written off.

E. TERMINATING THE R & D PROGRAM

Prior to the final decision to engage in a Research and Development program management should consider what the possible impact would be of terminating the effort at some future date. The alert management will be continually checking progress and results during the course of the activity and it is logical to expect that the possibility of terminating will occur. This will be true not only if it fails to serve the company's needs but also in the event of serious financial trouble or change of management policy or personnel.

Primary emphasis should be focused on the fact that Research and Development is positively in the category of long-term planning. Thus, if the thought is to place an initial six months or one year limit on proving itself, management is not likely to be convinced any more at the end of the period than it is, by implication, at the outset. Such a plan would only result in undue expense with no likelihood of obtaining a return on the effort. On the other hand, the positive thinking connected with the decision to inaugurate the program on a sustained long-term basis will go far toward creating the proper atmosphere for development of a productive R and D effort. With the proper backing from top management, it is difficult to visualize anything else.

In the event, however, that no other alternative exists except to consider termination of an existing Research and Development effort, it must take into account several points. As might be expected, many of these relate directly back to the considerations covered at the initiation of the program which have been discussed earlier. In addition there are the problems of personnel relocation or severance, with the latter the more logical expectation. Disposition of the technical knowledge becomes a consideration. Unfinished it is of little value, but with additional effort, it may prove extremely profitable in the long run. Finally, the impact on company and industry including the competition must be weighed. Termination of such a vital activity which is thoroughly integrated into the organization can easily result in lowered morale and competitors' enthusiasm over symptoms that all is apparently not well within the company.

Management must do a great deal of soul searching as well as using sound business judgment to decide such a drastic step. Let it suffice to say that at the outset of a Research and Development program, management should be prepared to support it well into the foreseeable future. Otherwise it is better to defer inauguration.

III. ORGANIZATION OF RESEARCH AND DEVELOPMENT

At this point, the decision to initiate a formal Research and Development program has been reached and management now faces the problems of developing an effective R & D department and integrating it into the over-all organization.* The basic steps outlined below have been arranged in a definite sequence for a particular purpose. The place of the activity in the over-all organization must be defined in advance in order to create the proper environment into which it eventually must endeavor to attract a competent director and staff. Unless top management is prepared to commit itself, the personnel will be hesitant to tread on uncertain ground, particularly in a newly created operation. Key personnel are in constant demand and only the most attractive opportunities are likely to interest the calibre of men that the company should seek.

Therefore it behooves management to develop a strong policy to cover the operation of R & D at the beginning. Without adequate attention to this phase, serious difficulties are certain to develop early in the initial phases.

* 9.

A. STAFF VERSUS LINE ORGANIZATION

The two most frequently used organizational structures are illustrated in Figures III-A and III-B. The staff arrangement in Figure III-A offers more flexibility in working relationships than the line organization of Figure III-B. However, particular situations inside the company may offset the advantages of the former and thus both alternatives should be considered. The chief disadvantage of the line organization lies in the fact that the Production Executive is normally charged with the success of current operations and his attention is quite naturally focused most sharply on the present. On the other hand, Research and Development is concerned with the future and, as such, requires far sighted management direction which is more usually available at the top echelons. Similarly, Production is quite likely to be plagued with a multitude of operational problems requiring technical solutions. As a result, the temptation to divert R & D effort to Production Engineering is greatest in the company where R & D is an integral part of the Production function.

As in any organizational arrangement, status is an important factor to the R & D Director and the closer the Department is to the top management, the more likely it is to receive proper attention and respect from all sections of the organization. Individual personalities and company policy will be the final deciding factor. However,

the tendency is to place R & D immediately adjacent to the top executive in the staff organization as shown in Figure III-A.

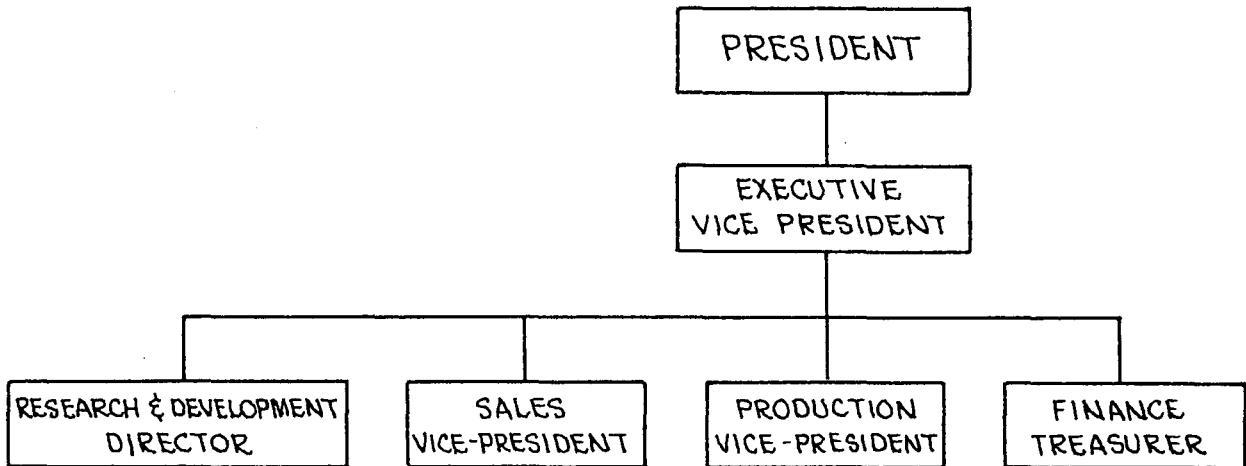
1. Relationship To Top Management

From the outset, a strong two way direct relationship between R & D and top management is essential. When appropriate, the head of the R & D activity should participate in executive meetings, assist in formulating related policies and assume active interest in the over-all company operations. While the responsibility for the conduct of the R & D program rests with him, the burden of providing positive and enthusiastic support to him rests with the chief executive. Without such backing, the R & D program will be in constant jeopardy and the company will risk substantial financial reverses. Even though annual rates of expenditure may be relatively modest, the basic long term characteristics of an active R & D program give strong indications of the fiscal risks involved.

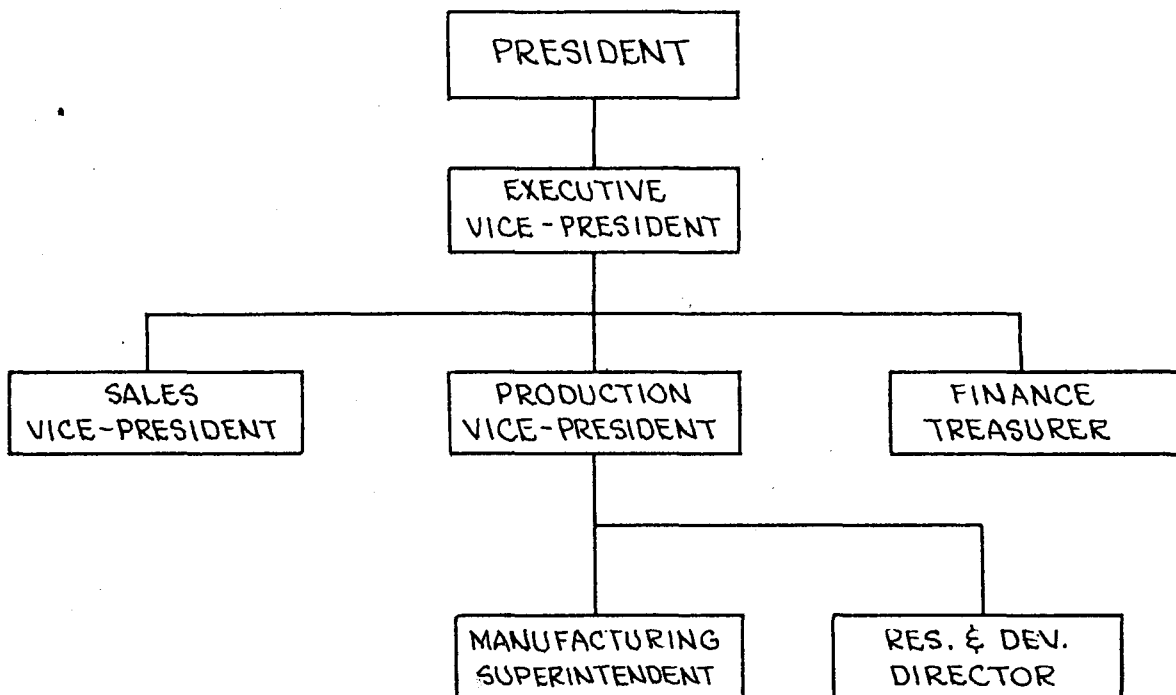
As an operation which will exert strong influences over the future of the company in the products to be produced, the goods to be sold, and the above mentioned financial aspects of these operations, it is only logical that top management establish itself in a position to coordinate, control and direct the operation as required. While this may appear to require a strong mandate for an untested

FIGURE III
COMPANY ORGANIZATION CHART

A. RESEARCH & DEVELOPMENT AS STAFF FUNCTION



B. RESEARCH & DEVELOPMENT AS LINE FUNCTION



activity, the absence of such support would be foolhardy. Once the direction is established, then adequate management controls may be brought along to assure proper operations.

It might appear to be unnecessary to point out at this juncture that free rein within the established policies described above must be afforded to the R & D director. Undue interference in the conduct of the program would not only hamper the R & D activity, but would be a violation of sound management practices. Yet, attempts to direct the day to day activities of a project by top management have frustrated more than one R & D director to the point of incapacity. Such top management activity is unwarranted.

2. Relationship To Sales

While the absence of direct line relationships is indicated on the organization chart, the value of personal relationships between these two functions is immeasurable. In fact, it is mandatory that close working arrangements be developed with frequent free interchanges of ideas, suggestions and recommendations. The knowledge, experience and intuition within the sales department is a valuable source for the R & D program of new product demands, competition pressures, market research information, consumer reactions and the like. In fact, it is not uncommon for the germs of ideas for entirely new products to originate in the field sales operations. They

can also supply the necessary data on acceptable selling price, methods of distribution and compatability with existing product marketing as well as a whole host of related supporting activities.

Bear in mind also that it is to the sales group's advantage to do so since it must keep abreast of new trends in products coming to them in the future which they must be prepared to market. This preparation cannot be done without adequate advance notice to train salesmen, develop outlets and shift marketing and advertising methods to slip smoothly into a new product's distribution. Finally, it is to the company's advantage that this liaison exist for, on the negative side as well as the positive side of the operation, sales often can predict lack of success before too much time and money have been invested in a losing venture which might appear technically sound.

Thus, the value of close liaison between R & D and sales cannot be underestimated and every effort should be made toward establishing an early and lasting tie between these two major company functions.

3. Relationship To Production

Assuming that the staff organization exists, R & D relationships with Production must be encouraged at an early date. Development of this liaison will enhance the success of the program in many respects. Perhaps the most important of these is the value of

exchanging the experience and knowledge built up by the Production Personnel. Much of their skill depends on information not available in catalogues, manuals or hand books, but rests in the minds of those men most thoroughly acquainted with the peculiarities known collectively as practical experience. Given the opportunity, they can judge the adaptability of new products to existing facilities and available skills. Often, techniques and short cuts in production methods can be of great help in determining the economics of mass production. Minor modifications can spell the difference between profit and loss if introduced early in the development stages. Similarly a strong personal alliance will develop if all parties concerned have had the opportunity to make contributions to the final product.

Unless the R & D department is exceptionally fortunate, Production will be their sole source of machine tools, skilled manpower and fabrication space, particularly during the critical developmental stages when a new product is assuming its finished form. Thus, R & D will find itself dependent upon Production which must find time within crowded production schedules to perform this vital service. In the long run Production will gain from such an arrangement for it will have had the chance to experiment and develop skill and techniques that will stand them in good stead when the new product eventually is turned over to them for volume output.

Therefore, strong personal liaison is essential between R & D and Production at an early stage in the program's development.

4. Relationship To Finance

The impact of an active Research and Development program on the financial operations of the company is so great that to ignore development of strong working relationships between the two operations would be foolhardy indeed. Failure to do so could well spell the failure of the program, for availability of financial backing is essential to its continuity. Interruptions for appreciable lengths of time can only increase the ultimate cost, sacrifice competitive advantages, or in extreme circumstances, cause total failure of a project.

The financial planning is all important. The fiscal executive must be kept informed of major expenditures particularly as a project moves into its developmental phases, where equipment, plant and supplies become increasingly large. Adequate capital must be available on time to assure smooth movement of the project to its completion. Even as it ends, the financial problems are approaching the climax since the initial production phases must be financed, inventories built up, salesmen supported and accounts receivable planned before the return of sales revenue begins.

This may appear fundamental to the seasoned executive but lack of advance planning where stock or bond issues are needed, long term indebtedness must be arranged, or working capital is converted to cash, can seriously disrupt the best laid plans of other segments of the company.

Then, too, the R & D department, for its own survival, must have the support of the Financial people. The most effective curtailment of an R & D program can be had simply by closing off the source of funds upon which it is totally dependent. Similarly, the Finance executive, to fulfill his function effectively, has a responsibility to maintain close liaison with R & D in order to keep abreast of new developments, advise on capital availability, prepare pro-forma income statements for new products under development and render reports to top management on the activities. To accomplish these objectives both parties will find it advantageous to maintain close working relations at all times.

5. Relationship To Plant Engineering

While it might appear at first glance that relationships between R & D and Plant Engineering would be primarily technical due to the similarity of their respective operations, it soon develops that the chief advantages to be gained from a close liaison are chiefly economic. Due to its broad experience in working with production

requirements, adaptability of existing facilities and equipment and design of new plant, the department is in a position to offer constructive assistance in determining costs, time requirements, feasibility of alternate plans and a host of related information. The technical training of the personnel will be invaluable to understanding the developmental problems involved in any new venture; they should be ready to make recommendations in keeping with the over-all design where modifications would provide an economic advantage in production.

Interchange of personnel between the two functions may prove beneficial in the long run for exchanging points of view as well as being a practical broadening experience. However, caution should be exercised in initiating such a program, particularly when the R & D function is relatively new. Professional jealousy may enter into such a move if the staffs are not well known to each other and have not had the opportunity to develop a mutual respect. Similarly the type of talents may not be suitable and an ill-considered transfer might be extremely discouraging to the man involved. Finally the interruptions, loss of experience to the old group and breaking-in time in the new group may prove more costly than the value of the training to be received. This caution should not extend to the other extreme however, to the point where there is virtually no intermixing of the personnel

in their everyday work. The common technical background will provide an excellent point of departure for developing close working relationships. This will be extremely advantageous.

6. Relationship To Industrial Engineering

The broad scope of Industrial Engineering including Production Engineering and Methods Engineering, which are of primary importance to the R & D program, make it almost mandatory that close working relationships be established. Again, as in the case of Plant Engineering, the initial benefits are economic rather than technical. The same caution should be used in approaching an interchange of personnel but the knowledge and aid available from this department are too great to be overlooked.

Closest liaison will undoubtedly occur as a project approaches the end of its developmental stage and serious study is being given to economics of production, techniques and skills required, flow of work, etc. Even before the new product is ready to be turned over to Production for quantity output, mutual study and discussion of problems likely to be encountered in the future will lead to early solutions and incorporation into the final design of the prototype at a fraction of the cost of trial and error later on. Likewise the introduction of the Industrial

Engineer to the new product will give an opportunity to study and plan his program in parallel with the R & D efforts thus shortening the vital time interval between completion of Development and initial quantity production.

The need for a close working liaison between Research and Development and Industrial Engineering shows opportunity for advantages to both groups and of course the company as a whole.

7. Relationships Outside The Company

The very fact that the company has established a formal Research and Development program will be of immediate interest to many persons outside the company. It will behoove the company and the R & D department head to establish this fact quite widely and as rapidly as possible in order to capitalize on the advantages presented by the move. Wherever possible first hand contact with the man responsible for the effort will be of most value. However written literature will serve almost as well to heighten the stature of the company and its management.

The most important group of those outside the company of course are those with direct financial interests, the stockholders, bondholders and banking people.* They want and deserve to know about such a forward looking innovation. It will encourage them to look to the future

* 22, pp. 2517-18.

and give them confidence in the continuing or increasing success of the company. Thus formal announcements, probably in the annual report, are definitely in order, followed by regular progress reports of the effectiveness of the undertaking.

A similar group of persons outside the company will be equally interested in the news and accomplishments of an R & D effort. These are the potential investors, those who carefully scrutinize every phase of a company's operation. Investors looking for growth stock in their portfolios consider R & D a major indicator of the likelihood of a company growing in the years to come and they purchase stocks accordingly.

Likewise keen interest will be shown in the new venture by competitors who must keep abreast of all new developments in their area of operations. The relationships outside the company must be conducted with due care for safeguarding the nature of specific projects to protect the company's interests and safeguard any competitive advantages it may hold. Conversely, the company will want to keep informed on its competitors' moves in new product developments. Thus, advantages as well as disadvantages exist in this area of outside communication.

Finally, the technical liaison outside the confines of the company must be developed if the R & D program is to benefit at the

earliest possible stage from new discoveries in the basic research continuously in progress at the universities and similar programs in the industry. Professional Society participation is extremely helpful in keeping abreast of new techniques, materials and similar scientific advancements. True, the technical literature available abounds with such new knowledge but this source must be supplemented with personal contacts in the field.

In the area of relationships outside the company, top management and the R & D department must share and complement each other in the efforts in this direction. The burden of actually implementing and more important continuing such relationships will undoubtedly rest upon the technical people concerned.

B. THE DIRECTOR OF R & D

At this point it is possible to begin forming some impression of the head of a company's Research and Development effort. As is indicated by much of the preceding discussion, he must be an extremely versatile and unusually talented individual. While individual companies will differ greatly in the initial policy declarations and consequently the type of person needed at the outset will vary, it is obvious that the person selected must have the capacity to become a rather unique combination of scientist, administrator,

and salesman. Quite often this is not as simple to accomplish as it may sound for the qualities at times appear to be in direct opposition to each other.

Above all else, the head of R & D must be a person who is a source of inspiration to those working for him. Recall that this deals with basically the production of new ideas which is solely dependent on the mind of man to produce them. It is not possible to supervise a project team in the accepted business sense, but rather the leader must provide the spark, the incentive and instill the desire to do so. Creativity comes from within and cannot be forced by a second party. It must be enticed.

It follows logically then that the Director of R & D must be a unique member of the management team. As such he deserves and will expect that his position in the management structure will be commensurate with his ability and responsibility. Unusual care must be exercised in each of the steps that follow during which he will be selected, oriented and be given his management role. Naturally, there is a dual responsibility indicated since he, too, must bring great concentration of effort to bear on the assignment handed to him.

1. Selection

During this critical period, the ultimate success or failure of the Research and Development program will be dependent on how effectively the company carries out the process of selecting the one individual to head the effort. A team of the best technical talent available will fall into the category of mediocrity if a weak hand is at the helm. On the other hand, an apparently ineffective group can develop an outstanding record with the right man at the head. Therefore, every available aid should be used in the process of selection of the R & D Director.

Unless one man already in the company or personally known to the management is so obviously suited for the position that no question exists, it is advisable to consider several candidates in order to form some bases for comparisons. In addition to the usual personnel office recruiting activities, it is highly desirable to enlist the aid of outside sources. Since the candidates obviously must be technically trained academically, college alumni placement bureaus can be extremely helpful in suggesting names to be contacted. Equally valuable are the recommendations of faculty members of university departments which tend to keep in personal touch with their more outstanding alumni. This is particularly true in the case of scientists and engineers. In any event, do not overlook these academic sources for the valuable references which will be sought later when the final selection is imminent.

In recent years, the services of professional recruiting agencies have become more and more useful and effective in recruiting men with specialized experience. This type of agency will do more than the old-fashioned employment agency which simply brought job-seeker and employer together. Some of them specialize in only a few areas, and if circumstances seem appropriate, it would be well to investigate and consider the service that they can perform. Because of their contacts and experience in their specialty, they can narrow down the selection to a few candidates, essentially performing the search and preliminary screening. The final decision, of course, rests with the employer.

Once the recruiting process has reached the point of personal contacts, it is most important that the matter be given the highest priority among the top management. The period of interviews, references, conferences, comparisons and final selection must be accomplished in as short a period of time as is possible. Remember that one man is being sought who is unusually gifted and the number of suitable candidates falls far short of the number of positions seeking such a man. Thus procrastination may easily result in losing the very man most qualified to another employer.

The interviewing process itself must be skillfully and carefully planned. The candidates will be viewing with mixed feelings the

situation that they are exploring. On the one hand will be the reluctances naturally encountered in considering any position that is newly created and untested to the company. At the same time, the attractiveness of a new opportunity that will challenge the limits of their capabilities will be most intriguing. The proper presentation will be needed to minimize the former and to emphasize the latter, together with assurances that the new post has full management backing.

The final selection and acceptance by the successful candidate will be an important milestone to all concerned. If the task has been well done, the balance of the problems will be infinitely smaller and less difficult to overcome.

2. Responsibility, Authority And Accountability

One of the most difficult tasks that can be handed to any new member of the management team who is filling a new post for the first time is the time-worn instruction to "carve a niche for yourself." Its primary implication is that strong opposition, as characterized by the stone wall simile, may be expected from every direction. This is definitely not the most favorable atmosphere into which to introduce the new R & D Director. It indicates that the management is either not willing to commit itself on a policy and procedure statement or, and just as dangerous, it has not taken the effort to do so. Either way, the conclusion must be the same, the program is not important

enough to the company to merit the attention to the relatively meticulous detail necessary to formulate a statement of the responsibility of the Research & Development department's head.

What better way is available to demonstrate an attitude of positive support than to issue a clear statement of the responsibilities of the new post, the authority vested in the Director to carry out this responsibility and the procedure of accountability? This provides in a usable form the statement of management's intentions of how the program will be set up, how it will function, the interrelationships between departments and, most important, the place of the R & D Director in the management team. If such a statement has been prepared in advance, discussed with the other executives and members of management, agreed to by all concerned, and made a part of the operations by the time of arrival of the new executive, the most difficult part of the task of establishing the new function will be in the past.

Such a statement need not be lengthy, specific, or complex. In fact brevity is to be preferred for no position which encompasses the broad scope necessary in R & D can be described in concrete terms. However, it should define the basic understanding of the scope of Research and Development and contain some policy statement of the limitations placed on the activities of the Director. The executive to whom he will be accountable for all of his activities should be clearly stated

followed by a brief summary of the relationships expected with the other executives and outside the company. If management chooses, it should also include the degree to which his authority may be delegated to his subordinates by him, making it clear, however, that such delegation does not relieve him of the primary responsibility or any of the related accountability placed with him.

Even if the formal statement is ready when the executive comes into the post, he will still have the problem of implementing the assignment. Thus, it is entirely in his hands to develop the personal relationships which he must depend on to discharge his responsibility. The procedure will simply make it that much easier for him to get directly to the task at hand without needless time-consuming and sometimes damaging effort spent discovering for himself just where R & D is supposed to fit into the over-all operations.

3. Evaluation

The Director of Research and Development, like any other member of management, will be subject to constant and thorough evaluation by his associates as well as his superiors. The process will have begun even before he actually arrives to take over his post for his reputation and the impressions he created during the selection process will precede him. Initially, however, most of the

evaluation will be on the basis of personality characteristics and accomplishments elsewhere. It will be many months before his record with the company can be viewed with any degree of accuracy sufficient to judge his success or lack of success with the R & D program.

Yet from the very day of his arrival, his actions, personality and the impressions he creates as he moves on to one task after another will begin to mold the opinions of those associated with him in a virtually irreversible process. The manner in which he conducts himself in meetings, the enthusiasm he exhibits when planning and selling the new program, the business judgment he uses in evaluating ideas presented by his associates, the warmth of his personal relationships both inside and outside the company, all of these and many other facets of the whole man will gradually form the evaluation of his inaugural efforts.

While the total evaluation of the R & D program as a whole and its Director in particular may not be complete for several months, the individual pieces of that total will begin forming on the very day he arrives. Therefore, the usual management alertness to such developments should begin at the same time. Valuable clues to the man's makeup which might go unnoticed later on will undoubtedly be in evidence.

When the subject of evaluation does enter upon the scene, management must keep in mind that Research and Development is not measurable in common terms to which it is accustomed. There are no standard units which can be measured, no standard costs subject to accounting determinations, no goals which can be set down and then achieved. The process of R & D is concerned with too many intangibles to be predictable. This evaluation is more suited to the process of comparison with previously defined goals that were agreeable to all concerned. This will be developed further in the sections to follow. Similarly, comparisons with other programs outside the company in the area or in the industry can prove to be useful as guides in the overall process of evaluating the success of the program. Bear in mind the degree of success (or lack of it) is not entirely attributable to the Director. Top management plays an important part in this through the degree of interest and support it displays at every juncture. In the final analysis, they are the ones that must be satisfied. Thus the aspect of accountability becomes doubly involved and of paramount importance.

4. Compensation

An entire thesis could be developed and would be needed to cover adequately the subject of the R & D Director's compensation. Many surveys have been conducted and much useful information is

available on current practices. The principles involved do not differ widely between this executive and any other member of the management group. However, one notable difference does deserve mention here. That is the apparent degree of importance that the technical profession places on the salary level. Surveys conducted to determine what satisfies the technical man in his employment indicate that income ranks several steps below the top. More important motivations are described variously as status in the organization, opportunities for professional development, freedom from rigid policies and procedures, opportunity for individual expression as well as other intangibles too elusive to include here. It is entirely true that in recent years the technical man has enjoyed a rapid rise in the salary paid to him due to the scarcity of qualified professionals. This may have reduced the importance of salary to him since it is well known that he can command an attractive income for his services on the open personnel market. However, it is safe to assume that the R & D Director will follow the general pattern of others in his profession by viewing other satisfactions in his work ahead of the level of compensation.

5. Professional Development

Out of the list of intangibles mentioned above as being important to the technical man, the subject of professional development of the R & D Director deserves further discussion since it is of vital importance to the company as well. This becomes more apparent when one realizes that science and technology are expanding and developing at a rate never before achieved. Thus if the company is to receive the full benefits of this dynamic progress as evidenced by its act of maintaining an R & D program, it must look to its R & D Director to keep abreast of the rapid changes, new techniques and new knowledge as they occur. In fact it must encourage this development by positive means to assure the Director that one of his tasks is to keep well-informed on every technological front that is of interest to the company operations.

This will be done largely through personal membership in various professional societies by the Director and his staff. Much will be learned from the technical papers and periodicals but this must be supplemented by personal contacts in the field. Regular meetings of the professional societies offer excellent opportunities to discuss technical problems and review first-hand the most recent developments. Similarly, contacts at various academic posts give

valuable insight into what is on the horizons in the fields of fundamental research. Special symposia directed toward specific subjects round out the sources available to the R & D Director.

All of these activities should be encouraged by top management who can rest assured in the knowledge that only through such professional development will its R & D program and, ultimately, the company benefit from the evolution of technology.

C. ESTABLISHING THE R & D DEPARTMENT

The initial steps involved in establishing a Research and Development department can be outlined and discussed relatively easily. The more complex aspects however of creating a smoothly functioning operating unit are infinitely more difficult and will take much longer to accomplish. The more direct actions must be completed as quickly as possible to permit the R & D program to begin.

As will be the case in all matters pertaining to the R & D department, the responsibility for initiating positive action lies directly with the Director. However, active interest and support by top management will greatly simplify his tasks. Particularly desirable would be a general outline of the range of activities and scope of the program that the management expects to sustain. In the final

analysis the order of magnitude budget allocated is the most meaningful data to determine the scope. Conversion of the dollar budget into the number of technical personnel that it can comfortably support will immediately allow the director to plan on the size of staff and particular talents needed. Facilities and equipment needs will become apparent in like fashion. From that point on it is up to the Director to fill these needs.

1. Staffing

By far the most important part of any R & D effort is its people. An effective program is never carried out by a group of highly qualified individuals working as single units, but like any other phase of the company's operations, it is the result of the group working as a team, complementing and supporting each other.* This will never be more necessary than in R & D, for the individuals must depend on each other not only to perform work but to create ideas which are practical and yet novel. Often the key to a problem's solution lies in the ability of someone to look at it from an entirely new side and bring a fresh point of view to bear on it. Close proximity may temporarily blind one person while an associate who is new to the project and has only viewed it from a distance can enter the scene and, with apparent ease, establish criteria for a solution.

* 41, pp. 98-101.

In light of these conditions which will exist, it is of the utmost importance that an over-all look at the whole R & D program be taken to determine the various talents that will be needed. Only after a soul searching appraisal by the Director of his entire operation can he define the individual personnel requirements. True, as actual interviews and selections progress, individual differences in talent and experience will have to be taken into account and the composite picture altered to fit the realities. It is also likely that he will have one or more present employees to consider in the initial staffing process. However, it would be unwise and, in the long run, detrimental to the program's success if the needs were artificially altered to make a place for someone who didn't otherwise meet the prerequisite qualifications.

Just as technical competence is important in selection of the individual staff member, so is personality make-up. Because they will be working very closely together, it is impossible to ignore the ability of each man to work as a member of the group. Getting along with others may sound trite but it is an essential quality if the full potential of the R & D Department is to be realized. Thus close screening and complete references from the prior employer are indicated in order to assess fully the individual's ability and personal

characteristics. The process of staffing fully and completely in light of known end objectives may be difficult and relatively slow. However, the results in the end will more than justify the effort.

2. Facilities And Equipment

Simultaneous with the buildup of a staff, the problems of space and working tools must be faced. Usually the most important question is not how much but what kind. This is true both of facilities and equipment. Certain minimum requirements can be set down in light of known immediate objectives of the R & D effort. Beyond that some longer term study and recommendations must be considered.

On the matter of space, due consideration of basic layout, type (office, laboratory, shop), light, temperature and humidity control, ventilating hoods etc. must be given to provide adequate working facilities for the program. The physical location may be important where proximity to existing facilities in other departments may be sufficient in place of duplicating plant and equipment (machine shop, instrument room, analytical laboratory). On the other hand, isolation may be equally important if noise, vibration, fumes and gases or similar situations merit special consideration.

Dangers lie at the extremes of the considerations. On the one hand, some companies present their R & D laboratory as a

show place with primary regard for producing a favorable impression on visitors. The needs of the technical phases of the operation are only secondary. As a result, the group is handicapped by lack of functional facility as well as facing the interruptions caused by a continuous stream of visitors and onlookers. At the other extreme is that company which maintains only the very minimum facility on the grounds that since this is an overhead activity it deserves least priority on space considerations. This is equally demoralizing since it reflects directly management's attitude of the relative unimportance of the R & D effort.

In between these two extremes lies a wide range of satisfactory solutions to the space problems. The technical man is generally quite reasonable in these respects and given adequate attention with emphasis on functionality, the maximum available within reason is quite satisfactory.

On the matter of equipment, due care and deep thought should be given to this subject, in light of current needs and more important, longer term planning. Initially, the emphasis should be on generally useful equipment which is adaptable to a wide variety of tasks. The various projects which become active will have varying degrees of potential. Thus, it would be unwise to invest heavily

in specialized equipment for a specific project when the chances of future need for a particular item are rather remote. Often the staff's ingenuity will develop a satisfactory substitute through either adapting a standard piece of equipment or making a substitute or model do the job. In general, a bench lathe would be a much wiser investment than would a sine-wave generator in a new laboratory. R & D storerooms are usually filled with new equipment bought hastily and then relegated to inactivity when the need quickly vanished.

3. Development Of Working Relationships

The range of working relationships necessary to the effective functioning of the R & D Department has already been covered in Section III-A. Developing these relationships should occupy the attention the Director and his staff during the formative stages of the department. That is the time when greatest interest in the new activity will be apparent throughout the organization. In addition, assuming that top management has expressed suitable interest to all concerned on the matter of inter-departmental liaison, the early operating period will find the other department heads ready and eager to establish the level of cooperation in a favorable atmosphere.

It will be to the advantage of each person to move on this rapidly but it is most likely that the initial steps will be expected

of the R & D staff itself which is to be preferred. Certainly they should not expect to be able to sit back waiting for others to approach them and offer their services. A positive move will break down any initial reluctances and pave the way for establishing mutually advantageous relationships.

As is true in any inter- departmental cooperation, developing is one thing and maintaining is quite another. It is not enough to reach mutual agreement on what each can offer to the other without a continuous and sincere effort to accomplish this objective with a minimum of confusion and ill-will. Therefore it is important to review periodically where the working relationships with each department stand, where improvement is needed and what should be done to attain the required level of effectiveness. This periodic review should be made regularly and as thoroughly as the initial efforts were conceived and carried out.

4. Top Management Support

It is not difficult to appreciate the need for continued support and active backing from the top management during this critical formative period. Creating the proper atmosphere into which the new staff will be injected is not as simple as it may sound. The resistance to change is a well known human characteristic. It requires positive action to break down the reluctance to accept this new operation.

Having created this function, top management must follow through on its decision to ensure that the program gets on the right course at the beginning with a minimum of delay and confusion.

IV. CONTROL TOOLS FOR TOP MANAGEMENT

A great deal of background information and formative discussion has been presented in preparation for developing the procedures to control Research and Development. Without a basic understanding of the purposes, functioning and inter-company effects of R & D, management would be at a serious disadvantage when it reached the point of asking for controls, limits and related reports on the activities of the group. Secure in this knowledge of how R & D is set up, it can aggressively pursue the more important task of regulation and guidance in relation to the over-all corporate objectives. Otherwise it will simply go through the motions of control without understanding. This could be worse than no control at all.

Turning now directly to the control procedure to be developed, it should be established that any control must be simple, timely, understandable and complete. These four basic qualities of good management control will assure that:

First, because it is simple, it can be accomplished with a minimum of expense and administrative barriers. Being simple, it will be far more acceptable to those who must make the procedure work and require the least possible time to carry out its requirements.

Second, because it is timely, the procedure will produce the needed information in time to take action on it, rather than simply receiving interesting historical data that is too old to be useful.

Third, because it is understandable, those concerned with implementing and using the procedure will be able to do so intelligently with complete confidence in the information presented and assurance that the control is understood by all.

Fourth, because it is complete, all of the necessary information will be available at one point to assure prompt and accurate appraisal of the whole picture.

In spite of all the interesting technical aspects of the Research and Development operation, top management will be most vitally concerned with answering just two questions.

1. What is R & D doing?
2. How much is R & D costing the company?

Controls on these two phases of R & D will be sufficient to assure top management that the program is accomplishing precisely what is intended with respect to the over-all operation and that the total cost is within the limits of what the company can afford to maintain. However, a procedure that simply supplies the answers to the two stated questions, even if the reporting is done immediately after

events occur, is only part of a good control system. The procedure must also establish and clearly state top management objectives in both the technical and the fiscal aspects of the total operation. Thus the need for two control mechanisms is indicated, one technical and the other budgetary.

Breaking the problem down still further, it becomes expedient to divide the Research and Development function into two logical subdivisions. In the discussion of the components of an R & D program it was shown that Research was concerned with investigation and exploratory activities to establish the specific products which would be subsequently developed. Essentially it dealt with ideas and converting these to finite terms. Development on the other hand was concerned with accomplishing a definable task on a known product, namely bringing the new product from a laboratory sample or model to a production item. Even though the two activities are usually treated together organizationally, there is a sufficiently clear line of demarcation and equally clear differences in objectives of the two to separate them for control purposes. Therefore two areas of operation controls are defined, one is Research and the other is Development.

In order to see the relative scope of the R & D activities as a whole before dividing them up, it might be helpful to consider

the following data. Industry as a whole in the United States spends about 10% of its total R & D expenditures on Research and the remaining 90% on Development of the fruits of this research. On the other hand only 5% to 10% of the project subjects considered in the Research phases ever reach the Development stage. Those projects which complete the Developmental process are even a lesser percent of the original total. Thus a small percent of the expenditures are used to vigorously screen the unfeasible projects at an early date, as one might expect, so as to avoid unnecessary expenditures of funds on useless efforts. As a result even a relatively small total R & D budget carefully administered and controlled can consider and evaluate a wide range of potential developmental projects with nominal expenditures. However, once a project gets well into the developmental stages, the company's investment begins to climb rapidly.

A. RESEARCH ACTIVITIES

By way of review, a brief restatement of the scope of Research is in order at this point. Research is concerned with the quest for scientific knowledge and conversion of it into practical product applications. The typical corporate effort in this area will most likely be concentrated on the application phases--Applied Research, leaving the bulk of the search to the University Fundamental

Research program. Turning now to the questions that the management requires answers to, the controls required are divided into two phases, technical and financial. Since the optimum of control requires action before the fact to determine what will be done as well as information after the fact to measure what has been, the program outlined below provides for prior approval on both the technical and the financial plans.

1. Technical Phases

Management would be side-stepping a major responsibility if it did not exercise control over the various projects which the Research program conducted. Corporate policies and long term objectives must be considered at each step. The future operations of the company will depend to a large extent on the Research that is currently underway. The first opportunity to exercise a true management control is at the outset of each Research project. Each proposal for a subject to be studied by the Research program should be presented in written form to the top management for approval. Top management then has an opportunity to review each recommendation in light of over-all company objectives. At the same time, it is reasonable to assume that such a proposal will have been submitted only after a reasonable amount of consideration at the operating level originating it. Depending on the

merits in the proposal, management would then approve the project for a preliminary study by Research. Periodic review of the project would determine the advisability of continuing for additional study. Termination of the project by management would occur at any point where the feasibility and practicality of the project dictated.

Thus, management would retain control of the technical phases of its Research program by retaining the authority to approve and terminate each project. Naturally it would rely heavily on its Director of R & D as well as other members of the management team for advice and recommendations. The Evaluation Committee discussed below provides formally for this advisory function.

a. Sources Of Project Ideas. It is nothing short of amazing to review historical records to discover the source of an idea which later became a marketable item. The source may range from the more natural spawning ground of the R & D department to progressively less likely places as the Sales Department, Production, Maintenance, customer or the janitor. Literally every conceivable facet of the company is a potential source of an idea for a new product. Some may be more practical than others but no company can afford to overlook any possible stroke of genius or just plain common sense.

Any company that has had experience with internal suggestion programs will know that the most fruitful ideas will originate from

the ranks where everyday association with a problem eventually produces a workable improvement or complete solution. While it is not intended that a comparison can be made between a suggestion program and a Research program, the parallel is intended to demonstrate the need for recognizing every potential source of new ideas that is at hand. The cost is small compared to the total R & D Budget and infinitely less than the ultimate gain from production and sale of just one worthwhile idea out of 100 or more submitted.

Periodically it is strongly recommended that a review be made of inactive and rejected projects to determine if some new development which seemed totally unrelated at the time has altered the feasibility of a discarded idea. Within a relatively short time, a sizable number of such inactives will accumulate and only a formal review can be relied upon to uncover an old project which has suddenly developed some promise. This need be done only once every year or so but it should not be neglected.

b. Evaluation Committee. In order that Management can be assured that adequate attention has been given to each proposal submitted to it, some formal procedure is necessary prior to the top management decision. Since all phases of the company are concerned eventually, it is well to provide for early consideration by all concerned. This is most logically done by an Evaluation Committee

which is charged with the responsibility of receiving, reviewing and recommending to top management on each proposal submitted.

The Committee as a minimum should have a representative from Sales, Production and Research & Development. Unless there are strong reasons to the contrary, the head of each of these operations would serve as permanent members of the group. As circumstances dictate, one or a maximum of two additional members would be selected on the basis of their individual abilities. In this way, each proposal would receive a thorough impartial review from each major aspect of the operations and it would be possible to screen out at an early date those ideas which were impractical from one or more points of view. While the Committee's recommendations would carry considerable weight, it is still top management's responsibility to render the final decision.

Periodic review of active projects already approved would be an equally important function of this Committee. Having the same people overlooking the progress of the project would provide an ideal continuity of thought, planning and standards for evaluating results. Thus, the Committee would be responsible for reviewing regularly the progress report of each active project and recommending to top management on its merits for continuation or termination. As before, the final decision on such action rests with top management.

c. The Progress Report. The single most important document connected with a Research project is a regular progress report. In it the technical man in charge of the project reduces to writing the significant events and findings of the preceding period of technical work. Without such a report, no one is aware of what is going on, what has been accomplished, and most significantly, what remains to be done in the coming periods of project work.

While it should remain as brief as possible, consistent with giving a clear picture, a good progress report must contain three basic elements to be useful. First it must state what has been accomplished technically since the last report. Second it must evaluate the significance, technically, of everything that has been accomplished since the beginning of the project. Finally, and most important, it must outline what remains to be done before a final decision on the project can be made. The final decision refers to either going on to a formal Development Project or terminating the project.

The progress report provides a permanent record of the entire project. As such, it is an invaluable tool to top management who is constantly viewing, through its Evaluation Committee, several projects simultaneously. Therefore it must decide not only on the merits of each project but also on the relative merits of the entire group of active projects comprising the Research Program as well as the new

ideas flowing in continuously. Yes, as one may deduce from this, priorities for projects are inevitable for as will be shown later, there is never sufficient funds available to activate all of the projects which appear attractive. Thus the progress report's content counts heavily in the ultimate decision.

2. Budgeting

The purpose of budgeting is to plan in advance for a reasonable framework within which a particular operation is expected to perform. Budgeting in the usual sense stresses the financial aspects but literally speaking it may be concerned with any or all of the phases of an operation such as manpower, time, space, machine utilization, etc. In the case of Research & Development both time and dollar expenditures are key factors to be dealt with in the Budgeting operation. *

At this juncture, it is well to think of the entire R. & D operation before settling on to the Research program. In the over-all budgeting for a given calendar period, say one year, it is vital to think first in terms of the total R & D effort for each component is

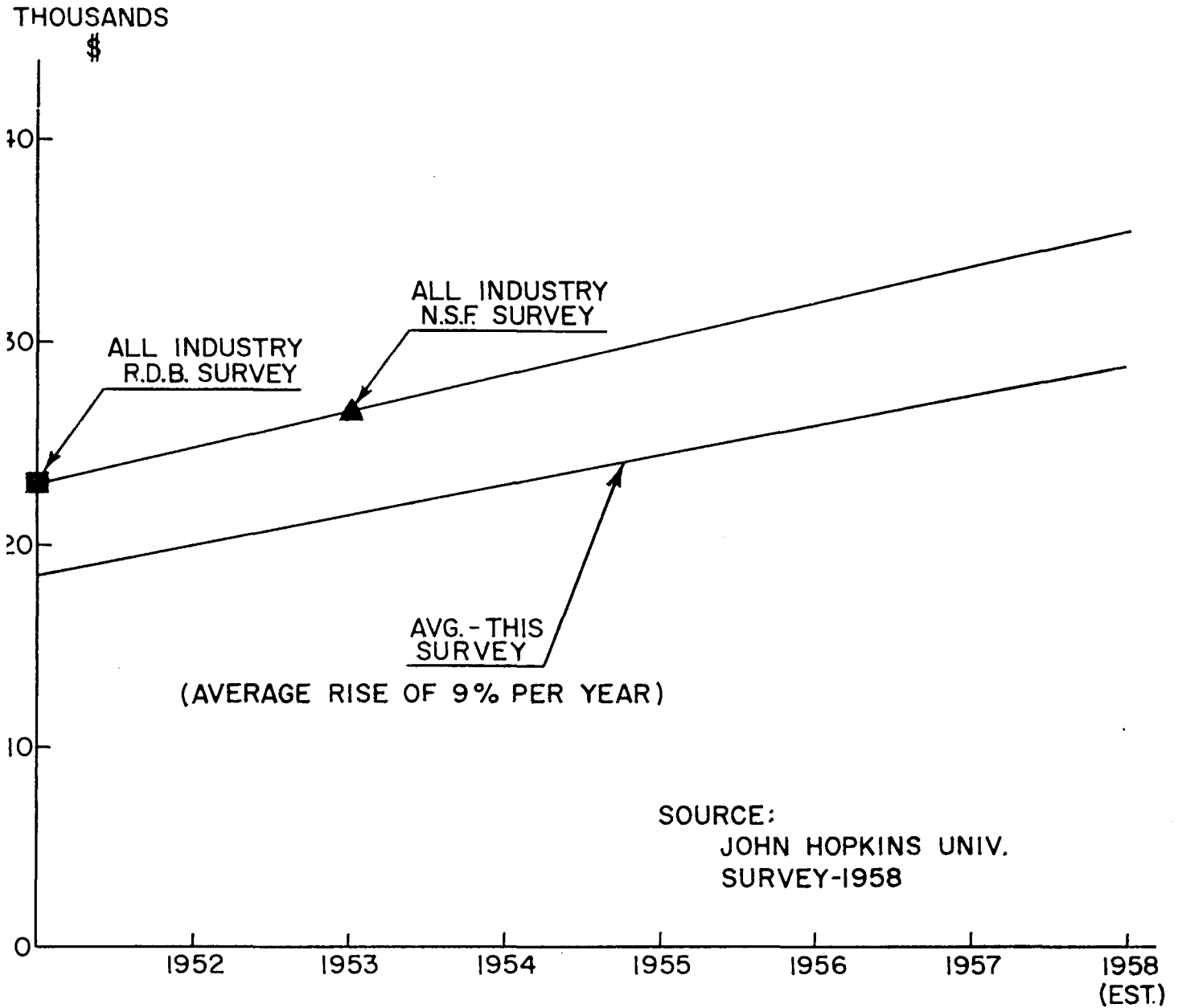
* 28.

dependent directly on the total funds available. To provide over-all cognizance of the R & D Program, management should expect to approve a total budget for the coming budget period in line with the company's over-all abilities to support this expenditure.

The determination of how much should be set aside cannot be approached with any predetermined rule of thumb. The proportion of total revenue spent for R & D varies quite widely from industry to industry and there is equal latitude in the range between companies within the same industry. The earlier reference to Tables I and II is recalled for further emphasis upon this point. Unfortunately, too many companies arrive by some devious line of reasoning to a figure of x % of Gross Sales and then hang on to that limitation through all fluctuations when prudent planning would call for a more flexible line of reasoning.

Actually the more logical approach to the determination of a total R & D budget would be to establish a finite dollar level and, allowing for normal increases, consider that as a continuing rate of expenditure. There is a sound reason behind this approach. A 1958 survey of R & D costs shows that expenditures vary in direct proportion to the number of technical personnel engaged in R & D (see Figure IV). While each company varied slightly, any one company was

FIGURE IV
COST PER TECHNICAL MAN - YEAR
(AVERAGE OF NINE TYPICAL RESEARCH
ORGANIZATIONS SURVEYED)



shown to have a direct proportionality between annual costs and number of technical man-years. An approximate rate of 9% increase per year over the period 1952 to 1958 was observed. This is attributable to rising salaries and costs of materials.

Thus, given a fixed dollar budget, it becomes a simple arithmetic exercise to translate this into a number of technical men that the budget will support. It also suggests that control of additions to the R & D staff will provide excellent first round control at the source of the expense.* Therefore, top management may wish to consider the following control mechanism on R & D total costs. Approve a dollar and equivalent number of technical men budget. Then require prior approval on net additions (not replacement hiring) to the R & D technical staff. Related expenses for nontechnical salaries and materials will not vary within reasonable limits.

From this point on, the budgeting discussion can resume the pattern of separating Research from Development.

a. Planning The Basic Program. Two factors should be considered in planning the Research Program. The first is to be

* 24, pp. 82-84.

certain that a reasonable balance is maintained between the share of total available effort going into Research and into Development. The second is to assure that no individual Research project is absorbing a disproportionate share of the Research effort while another project is lacking.

The first consideration is best handled by establishing a fixed share of the total R & D effort as available to Research projects. This share is normally 10%-15% of total R & D funds with some flexibility permissible in unusual situations. *

The second and more difficult to control factor is approached through periodic planning (preferably quarterly and at least semi-annually) by the Director. This phase of the planning is handled simultaneously with the technical planning of the Evaluation Committee. Each Research project is identified by a project number (R-1, R-2, etc.) and the funds needed to accomplish the stated objectives during the next period is estimated. The total sums of all active projects is then compared with the total Research budget for the period. Regular monthly cost reports for each project would reveal any project progressing at a rate greater than budgeted as well as any project being neglected. Any project not at the planned rate of activity would require supplementary explanation.

* 20, pp. 637-638.

Such a planning function would accomplish both of the stated objectives. The first is to establish the over-all Research budget and the second is to plan the individual projects so as to stay within the total funds available.

b. Establishing Control Reports. Control reports must be developed to measure each of the two factors considered above in the Research planning. While it is optimum to review each project as soon after the close of the reporting period (usually the calendar month) as possible, it is invariably the case that total figures can be produced more quickly than supporting detail documents since fewer individual items must be collected, transcribed and reproduced for distribution. Assuming this to be the case, the first control report would be a total of actual Research expenditures compared with the budget. Such a report should contain as a minimum, the data indicated in Figure V.

This would be followed by a project summary tabulation showing the status of each project and comparing actual expenditures with the project budget. For a sample of this type of report, see Figure VI. It is important to note here that the details of allocating costs, interdepartmental charges, General and Administrative overhead rates and the like are an important part of developing costs.

FIGURE V

TOTAL REPORT OF RESEARCH EXPENDITURES

ABC COMPANY
 TOTAL RESEARCH EXPENDITURES vs BUDGET
 PERIOD ENDING JULY 31, 1958

	THIS MONTH		YEAR TO DATE	
	<u>ACTUAL</u>	<u>BUDGET DIFFERENCE</u>	<u>ACTUAL</u>	<u>BUDGET DIFFERENCE</u>
TOTAL SALARIES	\$482	+\$118	\$3907	+\$293
TOTAL EXPENSES	241	+ 59	1953	+ 147
TOTAL	<u>\$723</u>	<u>+\$177</u>	<u>\$5860</u>	<u>+\$440</u>
TOTAL BUDGET BY QUARTERS	<u>\$2700</u>	<u>\$2700</u>	<u>\$3000</u>	
	1ST	2ND	3RD	4TH

ABC COMPANY
 SUMMARY OF RESEARCH PROJECTS EXPENDITURES vs. BUDGET
 PERIOD ENDING JULY 31, 1958

PROJECT NO.	NAME	THIS QUARTER			TOTAL SINCE OPENED	
		ACTUAL	BUDGET	BALANCE REMAINING	ACTUAL	BUDGET
R1	PRELIMINARY STUDIES	\$72	\$200	\$128	2472	2600
R3	COPPER INSULATOR	212	600	388	812	1200
R6	WIDGET	414	900	486	2254	2740
R9	VACUUM PUMP	25	100	75	125	200
R11	OIL BATH HEATER	0	900	900	300	1200
TOTALS		\$723	\$2700	\$1977	\$5963	\$7940

NOTES: 1. PROJECTS CLOSED PRIOR TO CURRENT QUARTER OMITTED.
 2. AT END OF QUARTER BUDGET IS SET EQUAL TO ACTUAL IF
 PROJECT CONTINUES. THUS "BUDGET" LESS "ACTUAL" ALWAYS
 EQUALS APPROPRIATION BALANCE REMAINING FOR CURRENT QUARTER.

SUMMARY REPORT OF RESEARCH PROJECTS EXPENDITURES

FIGURE VI

However, good accounting practice will dictate these procedures and the details are not pertinent to this discussion just as long as the budget and actual charges are expressed in the same terms.

The final control document necessary to the over-all system, but of secondary interest to top management except that it must be provided, is the detail project report of expenditures. This is an itemized report of all charges to the project and is primarily for the use of the man directly running the project. It is of importance to him to keep him informed of who is working on the project and how much costs of nonlabor items and total appropriation remaining. This permits analysis of the status of the project and provides the data necessary for planning the remaining work yet to be done. Figure VII suggests the essential data to be provided.

c. Maintaining Range Of Limits. As is the case with any planning procedure, the budget is only as reliable as the accuracy of the person making it in predicting unexpected developments and providing for the contingencies where necessary. However, it is reasonable to expect that actual costs will usually vary by at least 5% to 10% of the Budget and a 20% variation on individual projects is not uncommon. However, in the aggregate, these wide fluctuations will tend to average themselves out, if the budgeting is consistent. Experience does show that overexpenditures are more likely to occur

FIGURE VII

DETAIL REPORT OF RESEARCH PROJECT EXPENDITURES

ABC COMPANY RESEARCH PROJECT EXPENDITURES REPORT PERIOD ENDING JULY 31, 1958	
PROJECT NO: <u>R6</u>	NAME: <u>WIDGET</u> LEADER: <u>DR. SMITH</u>
DATE OPENED: OCT. 16, 1956	
PREVIOUS EXPENDITURES: <u>\$375</u>	<u>\$250</u> <u>\$1215</u>
1ST PREVIOUS 2ND PREVIOUS PRIOR QUARTER Q'ARTER QUARTERS	
CURRENT MONTH EXPENDITURES:	
SALARIES: <u>NAME</u>	<u>DOLLARS</u>
BROWN	27
JONES	17
SMITH	52
WILLIAMS	142
TOTAL SALARIES	<u>\$238</u>
EXPENSES: <u>ITEM OR VENDOR</u>	
MISC. CHEMICALS	6
120' - 1/2" COPPER TUBE	10
BLACK CO. - TEST STAND	160
TOTAL EXPENSES	<u>\$176</u>
TOTAL EXPENDITURES This Month	<u>\$414</u>
TOTAL EXPENDITURES This Quarter	414
BUDGET This Quarter	<u>900</u>
BALANCE REMAINING This Quarter	<u>\$486</u>

than underexpenditures however. For that reason it is advisable to establish a range of limits to review situations automatically that appear to be out of line.

This review should take place as soon as expenditures vary from the budget by more than a reasonable amount, say 10% of the total appropriation in the quarter. This should be done on projects that are under budget in order to determine if a project is being neglected as well as those projects which are over budget. The individual review procedure should be tailored to the company's needs but normally a brief communication from the R & D Director is sufficient for the usual events. However, more formal review may be required if a project continues a pattern for several consecutive periods. Finally, the regular Evaluation Committee review should provide for special attention to those projects where costs are out of line at the time of revaluation.

3. Expected Results

As with any operation within the company involving a management decision, it is reasonable to expect a clear statement of the eventual results to be gained from a Research project. This is important not only in considering the initiation of the project but also in determining the priority and rate of activity it

should have. Recalling that Research is carried on at a stage where it is too early to set down positive statements of profitability to the company, and also remembering that only a small fraction of the Research projects ever get to the Development and finally, production phases, there are other ways of stating the results to be expected. The four most frequent end results will be reviewed briefly to provide a framework in which to categorize potential Research projects.

a. Advancement Of The Science. The majority of Research projects will begin as an exploration to gain further knowledge. The knowledge so acquired will then be used to determine whether further effort is justified beyond the point of the initial search. Such projects inevitably lead into one of three possible channels that are described below. Hence it is important to appreciate that the addition of this knowledge to the general storehouse of science is an expected and unilateral outcome to any other motivation or expectation.

It is customary to allocate a small portion of the Research budget for just such exploratory work without going through the formality of individual projects for each new task. The scope of the use of this is then administered by the R & D Director on the basis of discussions with his associates inside as well as outside of the department.

This may appear contradictory to budgeting discussion above. However, the finite description of much of this early exploratory work is so vague that the mechanics of securing approvals is difficult to justify in view of the small expenditure of the technical staff time involved.

Even negative results of Research projects add to the general knowledge. The unsuccessful attempts of Research to follow a particular line of exploration will be extremely significant to the next person who, independently, receives a similar inspiration to follow the path previously taken. He will be alerted to avoiding the same pitfall. For this reason, it is imperative that the negative results of research be recorded just as accurately and completely as the more fruitful results.

b. Projects For Further Development. It is obvious that the primary objective of a Research program is to pursue successfully the quest for a new product that will be suitable for further Development work and, ultimately, that will become a production item. The actual proportion of such successful projects is small considering the total number of projects involved. The statistics on this point are vague but the consensus is that only 10% to 15% of all Research projects are suitable for the transition to Development. Similarly

perhaps only one in 100 becomes a revolutionary development, the majority being typical of the gradual transition occurring continuously in the industrial field.

This rate of productive Research projects has a very real significance to the management when evaluating the over-all results. It should be observed that if this rate varies significantly from the accepted yardsticks, it can be a symptom of poor selection of Research projects. For instance if the rate becomes very small, say two to three percent, then it should be reviewed to see if too many ill-considered proposals are reaching the project stage. On the other hand, if the rate climbs to 30%, then it is possible that the screening of proposals is too severe and, as a result, potentially fertile ideas are being rejected before sufficient study by a project effort. Either extreme therefore should be a warning signal to management that an over-all review of the Research program is in order.

c. Marketable Knowledge. Every Research program occasionally finds itself at the end of a Research project with a product or patentable knowledge that lies outside the scope of over-all company operations. For one reason or another, be it lack of capital to undertake a new venture, incompatibility of marketing methods or similar operational consideration, the company finds it cannot

use the results of the Research effort. Yet it has a very real value to other companies, be they noncompetitors or operating in different market areas. The problem becomes one of diverting the project results into useful channels outside the company, normally in exchange for financial consideration to cover the costs already incurred.

Two practical methods of accomplishing this are widely used. The first is outright sale of the project results at a price consistent with the value of the knowledge to the purchaser. Ideally the price would cover the research costs plus a reasonable profit but this is not a necessary factor. If the sale is consummated at any price, the income is more than would otherwise be realized on the project. Negotiations will be influenced more by the profit on production the purchaser expects and its value to him.

Where the project is of such a nature that several companies can use it simultaneously to their own advantage, the licensing agreement is usually employed. Under this arrangement, the project remains the property of the owner and he in effect sells permission to use it in return for a payment to the owner. This income may be based on number of units produced or on the basis of fixed amounts at regular intervals. In this way, a regular income is derived from the project with no further cost to the company, except possibly to police the licensees for compliance.

Other more complicated methods of putting marketable knowledge to profitable use are used but the mechanics are basically the same, sale or lease of the rights in return for income.

d. Apparent Failure. The complementary result of a Research project to the three outlined above is of course apparent failure. Here, for clarity, it is best to think of failure as being unsuccessful in achieving the predicted goal.

Statistically, this is the result that will be experienced most often. That knowledge, in itself, does not lessen the disappointment experienced each time it happens. Naturally, careful analysis and review is needed each time in order to benefit from the lessons learned so that knowledge may be applied to future endeavor. From that point of view, no project can be a complete failure for there is always something to be learned from each experience. Likewise it is difficult to imagine a research effort, no matter how small, that does not add some technical knowledge or skill that may be useful at some time in the future on another effort. This, too, falls in the category of learning from experience.

Aside from the corollary points made in Section b above on the significance of major changes in the rate of apparent failure, one other significant control is of value to management. That is the

rate of expenditure of funds on such unsuccessful projects. With the relatively small amount of funds available for the total research program, it is imperative that as little as possible be expended on those projects which do not culminate in useable knowledge. This requires frequent review of each project and the sound business approach to the decision of continuing a project. The early exploratory phases if properly conducted and soundly evaluated, will indicate quite quickly if a project is unpromising. At the moment that this occurs, positive action must be taken to assure that no further effort is devoted to it. There are always many other projects waiting to get under way. It is an unnecessary waste to spend further time on a project that is known to lead nowhere.

Management will do well to review all closed projects regularly with a keen eye to the proportion of the total research effort which has been expended on them. If that total in a given period of time approaches one-third of the Research budget, an over-all evaluation is in order not only on the economic justification but also on the technical direction. A very minimum of two-thirds of the Research effort is needed to accomplish the work necessary to complete the other 10-15% of the projects which are successful.

B. DEVELOPMENT ACTIVITIES

A great deal of similarity exists between Development activities' controls and those already discussed under Research. One fundamental difference in the approach to the control is in evidence, the order of magnitude of funds involved. Recall for instance that of the total expenditures for Research and Development only about 10-15% is normally designated for Research. The balance is the share for Development. Thus the importance of controls is increased substantially from the financial outlay point of view. Similarly, the company's over-all interest has a stake in proper control of Development. At that stage, much careful planning has been done and the decision made to prepare a product for production. The more effectively this is done, the more quickly the company will be able to reap the reward, profit-wise, of its investment in the project and justify the soundness of its decision.

With that preamble, the task of setting up controls for Development should be approached vigorously.

1. Technical Phases

How ever more difficult the task of controlling the technical aspects may be, management will at least find itself dealing with finite objects to which it is more accustomed. This will be a considerable

contrast to its objective in the Research activities where it was necessary to evaluate and make decisions on intangible ideas, influenced by such human traits as self-confidence in and enthusiasm for the end results. Development has a significantly well-defined beginning and end. In between there are discernable check points at which evaluation and control may be applied.

Each project should be treated as a series of dependent tasks, each following the next in logical sequence. Each task then may have a definite allocation of funds and, equally important, a specific time period in which it is to be completed. Thus time as well as fiscal measures against predetermined budgets form the basis for control.

a. Sources Of Projects. As in the case with Research, Development project recommendations will originate from a variety of sources, though not nearly as numerous. Recall that Development does not begin until there is a model or laboratory sample in existence. Therefore, the likelihood of such beginnings coming from more than a few sources is remote.

Quite naturally, the most logical originating point is the results of the Research activities. The successful Research project will usually take precedence. A great deal of effort and soul-searching

decision-making will have gone into the project already. There will be much more familiarity with the over-all aspects of it. Most likely, only the formal transfer of status from Research to Development project and allocation of funds is necessary to continue progress. However, an excellent opportunity exists at this time for a careful re-evaluation based on current circumstances. It is doubly important to review the effects on all phases of company operations before the costly Development process commences. Once begun, the total investment increases rapidly.

This evaluation must be no less critical than that of any other recommended project which may have originated outside of the R & D program. Such recommendation may come from a Research program outside the company which is offering to sell or license its rights to a company prepared to continue with the development. The manufacturing function is usually a prime source, also. Proposals may originate through a salesman from a customer who has done the necessary background work in anticipation of a supplier doing the development for production and sale back to the customer. This is quite common where the customer prefers not to undertake the development investment. Other incidental sources are of no major importance and would deserve attention only as each individual circumstance would dictate. Active solicitation would probably not be justified in the returns.

b. Evaluation Committee. As with the Research program the Evaluation Committee provides an excellent mechanism for considering all projects to assure adequate attention to every phase of the operations. Individual circumstances will vary but, in general, the basic committee would be the same as the Research Evaluation Committee, namely the R & D Director, Sales Manager and Production Manager. In addition, one vital phase needs a voice in the evaluation, specifically, Finance. The Treasurer or Controller will find his operation affected substantially by the work of this group and conversely, the Committee as a whole would benefit by having the first hand knowledge of financial matters as they relate to the Development program. The total capital necessary for the completion of the project as well as the production requirements must be within reasonably attainable limits before initial work begins. Otherwise unnecessary waste of effort and money will result.

As before, the responsibility of the Committee will be to evaluate thoroughly and recommend to top management. Final approval still rests with top management.

c. The Progress Report. The importance of regular Progress Reports which are thorough and complete in the summation of past accomplishments and future plans cannot be overstated. True,

physical evidence of progress will exist in visual form but translation of the project status relative to the end point as well as the pre-determined schedule must be done in writing by the technical man directly responsible.

Accuracy and dependability of the reports will determine the attitude to be adopted and the decisions to be made. As a minimum, estimates of time and expenditures should be included as well as possible changes in over-all planning necessary as a result of previously unavailable knowledge. This data will permit reappraisal of over-all feasibility at any point in the Development project, particularly at the completion of each of the several tasks of the total work.

2. Budgeting

The determination of the total R & D Budget and the division of funds between the two activities has already been discussed. Control of the Development Budget requires a clear understanding of what constitutes Development costs. In general, the Development costs of a particular project will be expended simultaneously with other costs related to the preparation of the new product for production and sale. Careful attention must be paid to the separation of costs of such activities as tool engineering, factory layout, market research and the like. Otherwise, in collecting data for the total

cost of getting the product to the market, management will have no concept of what the actual Development costs are and how experience compares with the original estimates. It behooves management to require separate cost data for the Development phases of a project. Only in this way can it evaluate all of the Development program.

a. Establishing The Total Investment. Approaching the problem of budgeting the Development program, project by project, management cannot avoid careful perusal of the total investment required to bring the project to complete fruition. While this total outlay of funds goes far beyond the scope of the Development work itself, initiation of the project cannot take place without some concept of the total investment needed to give the Development work any significance. Obviously to begin a Development project before realizing that the total capital need is beyond availability would be a total loss of the Development effort. Invariably another promising project which has capital requirements within reach is always available to take its place.

Thus a critical financial analysis must precede the decision to approve a Development project. Such a study must view all aspects of Sales and Production as well as total Development cost estimates in relation to the Financial operations. Only after this has been set down and can be defended, is the management ready to procede with project

approval. Regular review of the over-all financial plan is similarly indicated as the project progresses through its various tasks. It is not uncommon for a technically sound project to become unfeasible due to shifts in the financial fortunes of the company.

b. Establishing The Initial Appropriation. Now the project is ready for approval. A well documented picture of the time and money needs is at hand. All that remains is to decide that Task I of the project will begin. This will have fixed time and money requirements. Only that portion necessary to carry the project to the next evaluation point in the sequence, prior to Task II, is approved initially. This provides automatic stoppage of the project at the desired point in order to carry out the necessary re-evaluations of the technical, financial, and over-all feasibility aspects. Management is thereby assured of sufficient controls to keep the project within bounds. Such assurances are particularly necessary at the outset of the project because at that stage, estimates are necessarily preliminary and subject to change. Without periodic review, all control of total costs would be lost as the project moved along, accelerating its pace as it progressed.

c. Extending Subsequent Appropriations. As each control point is reached, the succeeding Task is subject to specific approval in

much the same fashion. Over-all review of the program is carried out, the necessary re-evaluations made and if appropriate, the next block of funds are budgeted and work continues. As long as the project proceeds according to the original pattern within reasonable limits and as long as outside circumstances are unchanged, no apparent reason exists to change the original decision.

Note however, that a change in any of the related factors may necessitate a fresh appraisal of the total picture with special emphasis on the effect of change of any of the parameters associated with it. Maintaining these controls will provide a positive mechanism to permit reconsideration at the earliest opportunity rather than after it is too late to remedy the situation.

The sum total of all of the project appropriations must naturally fall within the total Development funds available. This procedure is similar to the Research program. Establishment of a priorities system will usually follow the natural sequence of events.

d. Establishing Control Reports. The control reports for Development, like their counter parts in the Research program will fall into three general types, two of them going to top management. The first reports on the total Development effort and the second concerns the status of each project. Since time is a vital element due to

the effect of Development of parallel activities throughout the company, the schedule is reported in comparison to the original estimate just as expenditures are compared to the budget. The third report, a detailed expense listing is for the use of the R & D department only. Samples of each of these are shown in Figures VIII, IX, and X respectively.

The prominence of the "TARGET DATE" or similar description of the final ending date emphasizes the need for keeping every person affected by the project informed of the date on which the project will be turned over to Production. Each department in the organization must gear its planning to this key date. Periodically, perhaps quarterly, the summary tabulation, excluding the budget and cost data, would be distributed to each department head in the company. This provides him with up-to-date estimates with which to coordinate the planning necessary in his particular function.

3. Expected Results

In direct contrast to the Research project which is conducted as an exploratory activity, each Development project has a well defined end objective which has reasonable expectations of being achieved. Given sound evaluation at the outset and a continuing review during the life of the project, only major changes in outside influencing factors should shift the end result. Inevitably,

ABC COMPANY
 TOTAL DEVELOPMENT EXPENDITURES vs BUDGET
 PERIOD ENDING JULY 31, 1958

	THIS MONTH			YEAR TO DATE		
	<u>ACTUAL</u>	<u>BUDGET</u>	<u>DIFFERENCE</u>	<u>ACTUAL</u>	<u>BUDGET</u>	<u>DIFFERENCE</u>
TOTAL SALARIES	\$2345	\$2200	-\$145	\$15,973	\$15,400	-\$573
TOTAL EXPENSES	3767	3600	-167	25,784	\$25,200	-584
TOTAL	<u>\$6112</u>	<u>\$5800</u>	<u>-\$312</u>	<u>\$41,757</u>	<u>\$40,600</u>	<u>-\$1157</u>
TOTAL BUDGET BY QUARTERS	<u>\$ 17,400</u>	<u>\$ 17,400</u>	<u>\$ 17,400</u>	<u>\$ 19,200</u>		
	1ST	2ND	3RD	4TH		

FIGURE VIII
TOTAL REPORT OF DEVELOPMENT EXPENDITURES

ABC COMPANY
SUMMARY OF DEVELOPMENT PROJECTS EXPENDITURES vs. BUDGET
PERIOD ENDING JULY 31, 1958

PROJECT NO.	NAME	TARGET DATE O=THIS QUARTER	THIS QUARTER			TOTAL SINCE OPENED	
			ACTUAL	BUDGET	BALANCE REMAINING	ACTUAL	BUDGET
D2	WISKET	9/1/58	\$ 3 327	\$ 5400	\$ 2073	\$ 51,927	\$ 54,000
D4	HOT COILS	7/1/59	1 873	7600	5727	39,873	45,600
D5	OIL PUMP	1/1/60	912	4400	3488	5312	8 800
TOTALS			\$ 6,112	\$ 17,400	\$ 11,288	\$ 97,112	\$ 108,400

NOTES: 1. PROJECTS CLOSED PRIOR TO CURRENT QUARTER OMITTED.
2. AT END OF QUARTER BUDGET IS SET EQUAL TO ACTUAL IF PROJECT CONTINUES. THIS "BUDGET" LESS "ACTUAL" ALWAYS EQUALS APPROPRIATION BALANCE REMAINING FOR CURRENT QUARTER.

FIGURE X

DETAIL REPORT OF DEVELOPMENT PROJECT EXPENDITURES

ABC COMPANY			
DEVELOPMENT PROJECT EXPENDITURES REPORT			
PERIOD ENDING JULY 31, 1958			
PROJECT NO: <u>D4</u>	NAME: <u>HOT COILS</u>	LEADER: <u>DR. JONES</u>	
DATE OPENED: JANUARY 12, 1957	TARGET DATE: JULY 1, 1959		
PREVIOUS EXPENDITURES: <u>\$7,421</u>	<u>\$7,616</u>	<u>\$22,963</u>	
	1ST PREVIOUS QUARTER	2ND PREVIOUS QUARTER	PRIOR QUARTERS
CURRENT MONTH EXPENDITURES:			
SALARIES:	<u>NAME</u>	<u>DOLLARS</u>	
	BROWN	39	
	SMITH	194	
	JONES	388	
	TOTAL SALARIES	<u>\$621</u>	
EXPENSES: <u>ITEM OR VENDOR</u>			
	MISC. SHOP MATERIALS	167	
	30' - 1 1/2 S.S. PIPE	360	
	ALLEN CO. - HEAT EXCHANGER	725	
	TOTAL EXPENSES	<u>\$1,252</u>	
	TOTAL EXPENDITURES This Month	<u>\$1,873</u>	
TOTAL EXPENDITURES This Quarter	1,873		
BUDGET This Quarter	<u>7,600</u>		
BALANCE REMAINING This Quarter	<u>\$5727</u>		

however, technical reverses are possible at any stage of the Development process, even though their anticipation may be impossible. Nevertheless, the contingency element should be considered to be a part of each separate effort.

a. Ready For Production. Successful completion of the Development phases and transfer of the new product to production activity is, naturally, the most frequent result of Development projects. All of the technical aspects of the problem have been solved as expected, the estimates and forecasts have been accurate and the company has a new product.

One major problem occasionally appears at that point in spite of the apparent success of the project in fulfilling the predefined objectives. That problem concerns reluctance by the individuals concerned to formalize the transfer of responsibilities from R & D to Production. Whether this reluctance stems from the unwillingness of R & D to relinquish responsibility on the grounds that the project is not satisfactory technically for production or whether Production does not want to accept the task of tackling an untried item is immaterial. The result is a stalemate.

This eventuality can be anticipated and avoided through proper liaison between the parties involved at all stages of the

Development project. This is particularly vital as the "Target Date" approaches. Any unresolved questions may be taken up and reconciled early enough to assure a smooth transfer of the responsibility at the specified date. Naturally, after the shift, R & D will continue its interest and should be available to assist Production wherever circumstances dictate. However, management has a real duty to perform to assure that responsibility is at the proper place in the over-all picture at the appointed time. Without such positive action, transfer may be delayed unnecessarily with an evitable loss in effort and time advantage.

b. Marketable Process. Like the Research effort, a Development project reaches its planned completion in a form which has great interest to parties outside the company. In the event that Production internally is unfeasible, the interest of the company in the project may be sold outright or licensing for outside production may be extended. In addition a third outlet for the results of development lies in the joint venture where one or more companies set up a subsidiary, jointly owned, to carry out the production activity. This is particularly useful where the capital requirements are beyond reach of any one of the companies. By pooling resources and sharing the risks, each profits proportionately from the combined venture.

Because of the investment costs involved, it is unusual for the entire Development project to be carried out on a speculative basis for this purpose. Usually negotiations will be held early in the Development phases to provide some assurances of an end use for the final results. However, if a disproportionate share of the total Development program is devoted to these external interests, the company as a whole may suffer. The primary purpose of R & D should be to provide new items for internal production to replace those no longer in demand. Failure to channel projects accordingly may spell disaster in the long run.

c. Apparent Failure. The Development project which does not culminate in its original objective or a satisfactory alternate represents a failure in many ways. Substantial amounts of time and company funds will have been invested and there usually is little prospect of recovery of any part of the latter.

Two objectives should be accomplished on an abandoned project. The first step, as soon as the fate is known, is to evaluate everything that has gone before in an effort to determine the real reasons behind the lack of success. Once these are established, some further study is in order to find how the event could have been foreseen. This accomplishes two things, fixing responsibility at the

proper point and conversely relieving others of undue criticism; secondly, learning how to avoid the same errors in the future.

The second step is to periodically, perhaps once or twice a year, review briefly all closed projects. In the event that circumstances have altered a situation, possible reactivation may lead to profitable results. This is particularly true of projects suspended for economic, market or policy reasons. Sale of the results to new outside interests may become feasible at later times.

Management is prepared to expect reasonable rates of lack of success in any program that is as forward looking as Development. However, periodic review of all inactive projects is necessary to assure that no pattern of repeated errors exists. If it does, corrective steps as necessary are in order. Without such review control the financial risks are indeed great.

V. SUMMARY AND CONCLUSIONS

"The function of Research is to supply Production and Sales management with the answers to problems before they are needed."* If this objective is to be realized, effective use of the Research and Development effort requires the positive support of top management and adequate controls to guide it. Before an enthusiastic reception by management is possible, it must understand what R & D is, how it functions, where it fits into the overall organization, who will direct it and when to initiate the program.

The earlier sections developed answers to these basic questions in only the most general terms. Yet some appreciation of the complexity of this relatively new and rapidly growing industrial activity is readily apparent. However, the written description is no substitute for first hand experience and observations of R & D actually at work. To the company seriously considering the beginnings of an R & D effort, discussions with business associates already engaged in this activity successfully would be very enlightening to the top management. Additional experiences wherever found would add to the understanding immeasurably. It is by no means a decision to be considered lightly.

* Professor George W. Howe - Boston University lecture, March 6, 1958.

The more important task of controlling Research and Development takes on added significance with the realization of the potential returns. Costs generally are the first thought where controls are indicated. However, a much broader definition is required for true management control since costs are fundamentally a reflection of some form of human activity in business. No cost can be incurred unless there is a related decision first to consider the expenditure and then to incur the actual expense.

Therefore the R & D control pattern developed here has a two-fold objective, to control the activities which R & D will undertake and to control the results of the program. In the broad sense used here controls are applied to both the technical as well as the financial aspects.

The essential steps developed for assuring this scope of control are restated briefly as follows.

1. An annual rate of total Research and Development funds is determined in line with the company's ability to support this expenditure through all but the most drastic economic stringencies.

2. The total R & D budget is divided between Research Projects and Development Projects, thus establishing over-all limits on the rate of each activity.

3. Proposed Research projects are presented with adequate technical descriptions and estimated costs.

4. A Research Evaluation Committee is established. This committee reviews all proposed as well as active projects for the technical aspects and recommends action to top management.

5. A priority system is set up to control Research Projects activity within the prescribed financial limits.

6. Control reports on rate of expenditures are developed to assure that the rate of activity on each project as well as the total Research effort is at the desired level.

7. Regular technical review of each active project by the Evaluation Committee is provided.

8. Periodic review and evaluation of inactive Research projects is provided.

9. Proposed Development projects are presented with adequate technical descriptions and estimated costs. Related financial investments and expense are also included.

10. A Development Evaluation Committee is established. This committee reviews all proposed as well as active projects for the technical aspects and recommends action to top management.

11. A priority system is set up to control Development Projects activity within the prescribed financial limits.

12. Control reports on rate of expenditures are developed to assure that the rate of activity on each project as well as the total Development effort is at the desired level.

13. The target date or planned point of transfer of the project from Development to Production is reported to all persons concerned.

14. Regular technical review of each project by the Evaluation Committee is provided.

15. Periodic review and evaluation of all inactive Development projects is provided.

As is the case with any procedure in business, it need only be as explicit as circumstances dictate. Modification or elaboration is possible provided that management is able to use the system to accomplish its fundamental purpose, control of Research and Development to achieve maximum effectiveness in over-all company operations.

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