BASIC RESEARCH in INDUSTRY

Status Symbol or Necessity?

By S. W. Herwald

AT the Westinghouse Research Laboratories we have recently re-examined four questions which scientists have asked many times: (1) What does a corporation expect of a central research and development activity?; (2) Why carry out basic research in industry?; (3) Are scientific objectives and the profit motive compatible?; (4) What support should management provide the research scientist? The answers to these questions are important to us because they are important to our scientists. We have sought, therefore, to ask ourselves these and similar questions as directly as the scientists themselves would put them and then to seek answers in language just as understandable.

The stimulus for our study has been the planning for the consolidation of the Westinghouse Central Laboratories on a campus-like surburban site. With the completion of the construction now underway, separate buildings will house our Research Laboratories, Materials Laboratories, and New Product Laboratories. The scientific and engineering activities encompassed will range from "nonproduct-oriented" basic research through applied research to development. This variety of activities has permitted us to assess more accurately, I believe, the true importance of research to a large corporation. I hope these considerations will lend some general validity to the remarks that follow.

I appreciate this opportunity to discuss these matters, for, with nearly one-half of the physicists in this country working in industry, it is essential that industrial laboratory managers appreciate the feelings of the physicists about themselves and their profession. Conversely, scientists should make an effort to understand and contribute to the philosophy of industrial research. My remarks certainly will not provide complete answers; they represent a portion of that continuing discussion needed between scientists and research management.

What the Corporation Expects

LET us examine the question of what the corporation expects of a central research and development activity and, in addition, how these activities are affected by corporate considerations. The corporation's future virility and profit-making ability depend upon major laboratory contributions that far exceed current laboratory expenses. These contributions are to be obtained by the development of new technology and its skillful application either to the improvement of existing products and techniques or to the establishment of new products. It is axiomatic that the economic health of any organization ultimately determines the things it can or cannot do. This is true whether the organization is a market-oriented business, a university, or an industrial laboratory. Consequently, laboratory management must try to realize the corporate expectation as efficiently as possible in order to obtain maximum benefit from the advancement of science and technology. Furthermore, management must operate within constraints that determine how an industrial laboratory functions and how individual research succeeds in this environment. The boundary conditions most likely to affect the objectives of any industrial laboratory are (1) the skills of the individual staff members, (2) the size of the budget, and (3) laboratory facilities.

Although short-term research programs can be augmented by consultants and in some cases by contract research, generally what would be called current research is limited by the skills of present staff members. Of course, for long-term research, existing skills can be supplemented. Within rather narrow limits the size of a particular corporation, as well as its type of business, determines the amount it can spend on research. It is important that the proper balance between current profit structure and expenditures for the future be attained, because only a sound company is able to attract continuing investor support. Experimental capital equipment as well as new buildings usually require several years to become operationally useful. Research involving such new facilities or equipment must be planned with this delay in mind.

To meet the expectations of the corporation, we have chosen, consistent with our constraints, what we consider to be a balanced program. We have come to the conclusion that, to assure a continuing, successful influence of science and technology upon our corporation, we need simultaneous effort in basic research, applied research, and development. This leads us directly to the second question.

Why Should Industry do Basic Research?

PARENTHETICALLY, I might remark that it is generally not the answer to this question which raises doubts in the mind of the basic research scientist. It is rather the related question of "How does one who is motivated by an urge to acquire new

S. W. Herwald, vice president for research of the Westinghouse Electric Corporation in Pittsburgh, received his doctorate in mathematics at the University of Pittsburgh. He has been associated with Westinghouse as an engineer and as an administrator for more than twenty years.

scientific knowledge fit into this picture?" The answer here is really contained in how a particular industrial laboratory is organized and what method it uses to pursue the long-term profit objectives of the parent corporation. In our laboratories we are fortunate that the size and nature of our business require a broad spectrum of scientific and technical effort, all parts of which are equally essential to our continuing success. While (hopefully) the results of development efforts can be seen soon, and the results of applied research in the not too distant future, the new knowledge gained in basic research is the ray of illumination needed to form judgments of what might occur in the more distant future. Contrary to the statements of some that basic research has no place in industry, we believe that basic research is absolutely essential to us even though, on the surface, there is no direct link between our basic program and the profit of the corporation in the near future.

Let us explore this point a bit further. Scientists in basic research can, through free exchange of their ideas and results with colleagues in other laboratories, provide us with a window that is open to the knowledge of the world. This knowledge will often aid us in solving problems encountered in developmental areas. Even more important is the fact that from this knowledge we can expect occasionally to come up with a better understanding of physical phenomena that may lead to radically new engineering concepts. Such concepts are as unpredictable and illuminating as a stroke of lightning, but, when they are uncovered, we sometimes derive from them entire families of new products. Basic research thus makes an essential contribution to the needs of the corporation for profitable new products.

However, it is not enough for an industrial laboratory just to be *engaged* in basic research. It can freely participate as a member of the basic research community if, and only if, the quality of its research has the respect of this community.

Considering the matter from the standpoint of the health of the sciences, I believe that basic research should not be done only in universities. As Dr. Clarence Zener, Director of the Westinghouse Research Laboratories, has pointed out, an industrial laboratory can provide an enrichment of the kinds of problems that prick the interest of the research scientist. The industrial laboratory is apt to offer problems in areas that are not the current fashion or which fall between the disciplines or specialties. Basic research benefits from the flavor and points of view gained from different environments.

Our new research center will purposely expose the complete spectrum of our research and development activities to the view of our entire professional staff. We have chosen to erect separate buildings for the different types of effort so that there will be stimulation without domination. To assure this, budgets are separated and current problems in applied research and development financing are dealt with independently of basic research. It is both possible and useful, I believe, to do good basic research with applied research going on nearby if the participating groups have a clear understanding of their differences in purpose and motivation. Within this framework new questions or new facets to old questions are expected to arise which should suggest intriguing areas for new basic research.

For those doing basic research there must be freedom to choose the problems and to carry them on within their capabilities; there should be no restriction of field except in the most general terms. For example, we do not plan to do work in archaeology, but other fields equally unrelated might be chosen for study if our research men believed that these would yield important scientific knowledge or understanding for the sciences.

To put the matter another way, management cannot know beforehand where the important scientific discoveries of our time will be made. Within broad scientific areas we must therefore rely on the talents of the able scientist who is making the investigation. Consequently the basic-research physicist should meet essentially the same set of standards that the scientific community applies to other men in research. Research management should not judge him by the number of useful products developed from his ideas, but rather by the scientific value of his work. He must, however, communicate sufficiently with his colleagues (whether in basic or applied research) so that they can profit from his work or from his judgment of other work in his field.

Occasionally ideas will result from our basic research which we will wish to capitalize on in some way. The freedom of choice at this point, i.e., as we start to develop and apply a new principle, begins to narrow as we approach the manufacturing process. This is selection rather than restriction, in the sense that the choice of assignments must become more and more definite and must be determined more by considerations of time, cost, feasibility, and potential worth to the company. In other words, to operate most effectively within the financial sources available, management must at some stage select those ideas which are to be exploited and then see them through to fruition quickly and efficiently.

As most research managers know only too well, many men come from school with the idea that the

only fitting occupation for the newly graduated scientist is basic research. Of course we eagerly seek such research talent among new graduate students. However, to us basic research is so important that it must be entrusted only to those scientists who, in our judgment, meet the special qualifications demanded by such work. These men may be young or well-seasoned, new graduates or mature scientists. It is not our practice, therefore, to assign the newly hired scientist to basic research with the intention of shifting him to other work later. In the applied research and development areas, we try just as hard to get the very best match between individual skills and position requirements.

It is a common experience that qualified recent graduates in the sciences have little knowledge of the exciting range and depth of scientific problems suggested by industrial requirements. After they begin to work in an industrial laboratory, they frequently find unexpected challenges and gradually develop a desire to follow some of these problems into other fields. Sometimes a competent man in basic research will get an idea suitable for practical application and follow it through from inception to the production of the final apparatus. On the other hand, the man who does competent basic research should be provided, if he desires, the opportunity for a lifetime career in his field. Means should also be provided for a flow of people from development into research, depending upon abilities and interests. All of these people are needed in a well-balanced industrial research laboratory.

The Basic Research Committee

IT is probably undesirable to organize a laboratory so that all basic research is done in one discrete unit, and indeed most laboratories are organized by disciplines or functions in which both basic and applied research are carried out in many different departments. In order to help cultivate a climate in which basic research can grow and flourish, we have recently formed the Basic Research Committee consisting of senior scientists representing laboratory departments in which basic research is conducted. Their viewpoint on scientific questions and matters affecting the research climate is regularly sought by laboratory management. For example, the committee has been asked to recommend appropriate standards for judging the work of scientists engaged in basic research. The committee has also been asked to suggest areas in which research may or may not be desirable. Their recommendations have been generally followed. Based upon what we have seen to date, this group also offers a means for greatly improved horizontal communications and a consequent beneficial effect on the operation of our laboratories.

I should like to make one more remark about basic research—this time about theoretical research. Although the role of the experimental scientist is well recognized, the need for the theoretical man in industrial research is perhaps not so widely appreciated. It is entirely natural that the range of interests and techniques in our company not only facilitates the work of the experimentalist but also offers him a direct outlet for useful ideas. The theorist is similarly important in an industrial laboratory because he is in a position to promote the understanding of natural phenomena, and through his insight he is able to give direction to research and indicate future possibilities. Surely it is important to give the research program any added means that will assist in making correct early selection of fruitful research pathways and in delineating fundamental possibilities in proposed work.

Scientific Objectives and the Profit Motive

LET us now turn to the third question: "Are scientific objectives and the profit motive compatible?" This sometimes takes the form of, "What does an industrial research laboratory do to advance the welfare of society and to promote the objectives of the scientific community?"

Most corporations seek their profits through contributions toward a social need—the improvement of our standard of living and our security. It is true that occasionally some product is questioned regarding its contribution. If, in fact, the product makes no contribution, society will usually reject it, thus making it unprofitable. The small number of products in the questioned category is greatly offset by a continuing flow of products that unquestionably increase man's health, ease his toil, and increase his knowledge. Since industrial research scientists are asked to contribute new scientific knowledge which may enable a corporation to continue the flow of new products of this type, it is hard to see any fundamental incompatibility between scientific objectives and the profit motive.

Unfortunately, some scientists think of profit only in terms of rapid turnover of funds, cost reduction, and a rigid control of operating expenses. These individuals then arbitrarily exclude the pursuit of scientific knowledge as a profit contributor and therefore conclude that it conflicts with the interest of the corporation. I believe these people do not fully understand that current profits really do provide the funds to assure future profits. Properly used management tools such as those mentioned above directly increase the corporation's opportunity for present profits, which in turn finances the balanced research program required for future profits. Perhaps these scientists do not share our faith that a balanced research program, including a vital portion devoted to the basic search for new knowledge, truly is best for the long-term profit structure of a corporation.

The only real conflicts that I see between the pressures for current profit and the desire to search for new scientific knowledge involve (1) the distribution of funds derived from current profits among wage increases, dividend increases, capital expenditures, and investment in research, and (2) the degree of fluctua-

tion of these factors under varying profit conditions. Such conflicts are best resolved by a skillful management that endeavors to provide continuity to meritorious research, as well as increased dividends to stockholders and better wages for employees, all of which are derived from the increased profits that past research has helped obtain.

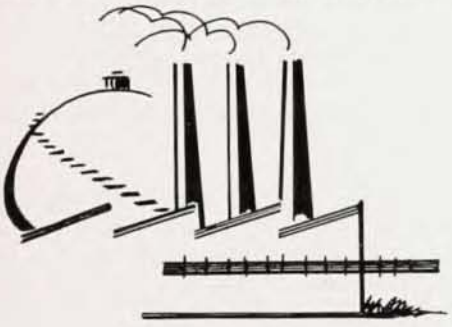
A small but recognizable group of questioners insist on the freedom to pursue scientific work of their own choice and yet refuse to communicate with their colleagues. These people have little place in industry, for it is important not only that a scientist be given the freedom to communicate but also that he recognize his responsibility to do so. At the same time, he must be made aware that proper communication is as important for his own professional development as it is for the attainment of management's objectives. Interestingly, university presidents have remarked to me on the similar problem of research men in their institutions who wish to have no teaching responsibilities.

Management Support for the Scientist

IF one now accepts, as many scientists have, that industrial research objectives as stated above offer the possibility of a favorable environment for the pursuit of scientific knowledge, this leads to the posing of the last question: "How does a scientist in the corporation work to reach these objectives?" Sometimes this is put as "In addition to freedom to pursue research of my choice, what financial support will I have and what colleagues will I be working with?"

I believe that industrial research management would be behaving most foolishly if after making the important decision to carry on a balanced research program, including basic research as an important element, they did not make available continuous funds, trained technicians, and laboratory equipment. I believe it fair to state that in the judgment of our scientists they get the support needed to accomplish their work.

We should perhaps examine the question of colleagues in the light of the type of laboratory environment I have described. First, as I have stated, we are fortunate that the size and type of our business allows us to pursue a broad spectrum of science and technology. This opens up many facets of scientific progress, with competent individuals available to discuss almost any aspect of a given question. Second, the fraction of our effort that we devote to basic research is sufficiently large to give the "critical mass" required for the adequate exchange of views among our basic research people.



On the other hand, we recognize that internal communication with the most competent colleagues is not enough. We want to stimulate the interchange of basic scientific information between this laboratory and the scientific community. Obviously, our scientists must be in a position to exchange basic research information freely. They must attend technical meetings, present papers, and talk to other scientists so that contributions to new knowledge can be properly exchanged and evaluated within the scientific community.

Since new knowledge on a broad basis is being sought in this way, our belief is strengthened that all basic research should not be pursued in just one environment, but rather in universities and in industrial and government laboratories. It is desirable to encourage exchange of people between these institutions because it is mutually stimulating.

Finally, because of the unpredictable and lengthy time scale generally associated with the acquisition of new knowledge, we believe it is important for the basic research scientist to have confidence in the continuity of his support. Our intention is that no basic research program is to be terminated without first asking for the recommendation of the Basic Research Committee. We are hopeful that this committee, because of its composition, will represent the views of the scientific community at large and will be able to evaluate the potential importance of individual basic research projects on the basis of their contribution to the scientific world.

Conclusion

IN summary, my thesis is that the answer to whether a scientist searching for new knowledge has an important place in an industrial research laboratory really depends on how that particular laboratory operates. In our own laboratory we earnestly feel that basic research is a vital part of our balanced program. Consequently, we try to evaluate this work and to provide an environment for it which recognizes scientific knowledge as the objective. On the other hand, we judge our equally important programs for the exploitation of research on the basis of their corporate significance and secondarily on their contribution to scientific knowledge. There is no reason to think that these points of view restrict the scientist in pursuit of new knowledge. Rather, it is possible for scientists of all inclinations to find work that offers unusual challenge to them and full opportunity for personal development.

My understanding of the questions discussed has benefited materially from numerous exchanges with my colleagues about their ideas and philosophies. It is hoped that the views presented here will contribute to the rapport between the scientist and industrial laboratory management that is essential to meet the challenge of our society in the years ahead.