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Research in Industry

By HOWARD G. VESPER

SOME years ago the British magazine **Punch** published an extended analysis of research in business, concluding as follows:

"To sum up, the following are the main advantages and disadvantages of a research department:

"Advantages:

1. It does no harm.
2. Visitors and shareholders are impressed by the sight of so much science and the smell of so much hydrogen sulfide.
3. It provides congenial employment for a number of people who otherwise would invariably be reduced to teaching small boys that $2HCl + Zn = ZnCl_2 + H_2$.
4. One of these days someone may find out something that will make all the difference to your business; the thing is at least statistically possible.
5. Scientists are usually quite nice lads without vice.

"Disadvantages:

1. Cash.

"We cannot visualize any business man, comparing the advantages with this single slight impediment, being in any doubt as to what he should do. Money isn't everything, and you can always get somebody eminent to come down and open the new research building."

EVOLUTION OF MODERN INDUSTRIAL RESEARCH

In contrast to this humorous approach, modern industrial research has a long and interesting background of evolution. While there were a few earlier high spots, science really began about the 16th century gradually to take definite form and supplant the speculations of the alchemists and philosophers on the imaginary properties attributed to matter. This progress took great strides during the 19th century through the activity of scientists in Europe and the United States, substantially increasing man's fundamental knowledge. Notable landmarks included Count Rumford's establishment in 1800 of the first organized science laboratory, The Royal Institution of London, and Liebig's founding in 1825 of the first chemical laboratory for systematic study in that field.

There was a considerable lag between 19th century fundamental developments and their commercial application. This was mainly because industry had abundant resources and was serving a rapidly increasing population and market, with the result that there was small incentive to look for new or better things. The first industrial research laboratory in the United States is claimed to have been established by the Merrimac Manufacturing Company in Lowell, Massachusetts, in 1834. The second such laboratory of any significance was founded about 1860 at Wyandotte, Michigan, for investigating the difficulties of the Bessemer steel process.

Competition did not become sufficiently severe until roughly the last quarter of the 19th century to cause industrialists to turn with increasing frequency to science for assistance. However, when they did, the results were so outstanding that the gap between pure and applied science diminished quite rapidly and trained chemists, physicists, and other technicians found increasingly ready employment in industry. During this period independent investigators also made discoveries leading to the establishment of new industries, thus further demonstrating the practical value of science. Examples are many, including Bell, Edison, Goodyear, Hall, and Baekeland.

Until the 20th century industrial research remained largely a matter of the unorganized effort of individuals. Early in the 1900's a few companies organized separate research departments and began a systematic search for the solution to their immediate problems and for new knowledge. Thus, organized industrial research is less than 50 years old!

Public attention was focused by the first World War on the accomplishments of applied science. This resulted in a greatly stimulated growth of industrial research. Our supply from Germany of chemicals, dyes, medicines, and glass was cut off, thus inspiring American scientists to new and intense efforts, out of which grew a number of important new American industries.

This article is based on a talk presented at the annual Tau Beta Pi dinner at the California Institute, March 14, 1947.

Many companies started organized research activities in the early 20's, either directly or indirectly because of this war impetus, and set up laboratories which have become increasingly important since that time. For example, Standard Oil Company of California initiated an organized research and development program in 1920 as a research division within its Manufacturing Department. Initial efforts were directed toward improvement of refinery processes, particularly distillation, thermal cracking, acid treating, and acid recovery. Very successful results led to the formation of a separate Research and Development Department in 1926, which has since grown into the California Research Corporation with a total personnel today of over 800.

The impetus on research from World War II was similar to that of the earlier war, but much more important because of its greater magnitude. A few examples will be sufficient to illustrate; namely, atomic energy, synthetic rubber, high octane aviation fuel, radar, rockets, penicillin. This is emphasized by a statement made recently by Mr. Robert P. Patterson when he was Secretary of War: "There is a great new voice in the world today, the voice of science and technology. It is a voice heard since ancient times, but never until today has it spoken with such authority, have its words been so filled with promise, has it been listened to with such hope. And in no country in the world does the voice speak as eloquently as in our own."

The following table indicates graphically the amazing growth of industrial research in the United States during the past few years (based on National Research Council data):

Year	No. of Industrial Research Laboratories	Total Personnel	Personnel in Petroleum Research
1920	300	9,300	145
1940	2,200	70,000	6,000
1946	2,500	139,000	10,000

Best available data indicate that the present annual rate of industrial research expenditure is in excess of $700 million.

It is interesting to note that out of 139,000 people now engaged in industrial research work, approximately 41 per cent are technical graduates doing technical work, the remainder being administrative, clerical, maintenance, and similar supporting personnel. Of the scientific group, percentage wise, 39 are chemists, 38 engineers, 5 physicists, 4 metallurgists, with the remainder including a wide variety of special professions.

The distribution in research personnel within individual industrial research laboratories will vary considerably from these average figures. For example, in the California Research Corporation the percentage of scientic to total personnel is considerably higher, approximately 48 per cent. However, the ratio of engineers to total technical personnel checks the national average closely, being about 40 per cent.

CHARACTER AND MOTIVES OF INDUSTRIAL RESEARCH

The kind of research conducted by industry is primarily applied science using and extending the basic facts and principles uncovered through broad fundamental research. Thus, the fundamental findings of nuclear physicists and chemists in the atomic energy field are now being applied to atomic energy power development. The dividing line between fundamental and applied research is not distinct. Its complexion depends on the character of the problem and the nature of the agency conducting the investigations. The study of properties of a hydrocarbon by a manufacturer of electrical equipment might be fundamental research, but if conducted by a petroleum research laboratory, it might be considered largely applied research.

Broadly, industrial research is the endeavor to learn how to apply scientific facts to the service of mankind. In general, the objective of industrial research is the material objective of civilization itself—to prolong life, to improve health and comfort, to enhance happiness, and to enlarge productive ability and usefulness; in other words, to contribute to the common store of technical knowledge and thus improve our standards of living.

By helping to translate fundamental scientific facts into new or better products for a greater number of people, industrial research has become a vital part of our competitive economic system. Obviously, the profit motive is a basic consideration in selecting and carrying out industrial research projects. Nevertheless, the success of industrial research in improving living standards and making life easier and happier for more people is both a justification and an indication of greater things ahead.

Industrial research is essential to the survival of business. All businesses face changed post-war conditions in marketing, competition, customer demand, and other operations, and must be flexible to meet such changing requirements. This applies to large and small business alike. There are many examples of industries that have languished because they have had little or no research protection and support. Industrial research is also important in maintaining employment. Organized labor by 1940 had officially indicated its approval of the encouragement of applied science.

Mr. C. F. Kettering of General Motors has said, "An industrial research project should do one or more of the following:

1. Reduce cost of production
2. Reduce operating cost to the user
3. Increase the utility of the product
4. Increase its sales appeal
5. Produce new business
6. Determine technical information contributory to to some other project."

Industrial research operates in a variety of fields. Projects are often concerned with the finding, growing, creating, and use of raw materials. In the petroleum industry this refers to research in oil exploration, drilling, and producing. Another broad field is research work on "normal" processes and products. Within the petroleum industry this would include, for example, refining work on such indigenous products as gasolines, lubricating oils, and greases. An increasing field is research on synthetic processes and products. Examples in the petroleum field would be the increasing emphasis on synthetic fuels made from various non-petroleum sources such as coal and shale. Also included would be chemical syntheses from hydrocarbon raw materials. Another important phase of industrial research is the engineering related to the foregoing, including particularly the preliminary and final process designs for new plants.

An important field closely related to industrial research and frequently carried out by the same organization is that of technical service to operating groups on processes and products. This is in effect technical consultation by the research group for the purpose of increasing the efficiency of existing plants or bringing about better use of existing products.

Another closely related subject is that of patents and licensing. Generally the results of modern industrial research work are protected by patents, the degree of activity in this field being dependent on how aggressive the company concerned decides to be in exploiting its developments.

In the modern approach to industrial research, the coordination of motive, men, and money has replaced the scattered efforts of individuals and the poorly directed, planned and supported research of earlier days. The time has passed when a Daniel Boone with rifle and packhorse could add greatly to our store of geographical knowledge. To make significant industrial research addition today requires a wealth of scientific equipment and observers.

Careful organization planning is necessary to achieve maximum effectiveness of technical manpower. Too often in the past the time of highly trained technical men has been so restricted and hampered by other demands that technical efficiency was seriously reduced. Much of this was the result of the very rapid growth of industrial research organizations, furthered by the thought that technical activities do not lend themselves well to the same kind of organization planning as do other phases of modern business. Experience has indicated, however, that this is not true and that there is just as much — or more — need for the application of sound organizational principles in industrial research work as in other phases of business activities.

Research ideas may originate from any one or more of a number of sources, including individuals, groups, other departments, consumers. However, the modern industrial research laboratory handles the development of these ideas as projects assigned to teams or groups. There was wide adoption of this practice on war projects where its effectiveness was proved beyond doubt. These projects must be carefully planned, directed, and budgeted to accomplish specific objectives, yet with enough provision for flexibility to permit necessary changes as the work progresses.

RELATIONSHIP BETWEEN ACADEMIC AND INDUSTRIAL RESEARCH

From the foregoing discussion, there is an obvious close relationship between academic and industrial research. Any former lack of understanding and mutual confidence between industrialists and scientists has practically disappeared. Full cooperation between such groups is essential in the future if we are to continue our modern industrial progress. Industrial research is dependent to a very large degree on universities and colleges for fundamental research work. While industrial laboratories can and do carry out a moderate amount of such fundamental work, this type of activity is inherently a minor part of the job such laboratories are set up to do. In fact, a grave danger today lies in the possibility that industrial research and development may go forward so rapidly that they will outstrip the fundamental research on which future industrial projects must be based.

Not only is industrial research dependent on universities for fundamental work, but it also looks to these institutions for its technical personnel. This further increases the close bond between universities and industry. In this connection, many farseeing industrial firms are today maintaining fellowships at a variety of institutions of higher learning, partly to support their program of basic research and partly to assist students to become better trained for their ultimate work as either research or industrial scientists. Such support is increasingly important in view of the decreasing endowments available to many institutions. The following table illustrates the growth of this type of industrial aid for universities:

Year	No. of Companies	No. of Scholarships and Fellowships
1929	56	95
1941	210	721
1944	201	956

The number today is doubtless much larger.

The importance of academic and commercial institutions working hand in hand in the research field is well expressed in Dr. J. B. Conant's words, "In the last analysis the future of science in this country will be determined by our basic educational policy." However, the question of whether such institutions can do the necessary basic research job raises the possibility of Government support. Government interest in research has increased greatly as a result of World War II, and various federal agencies are now contracting or otherwise supporting extensive research projects. There is an obvious requirement for better coordination of such activities. What is needed is a national science foundation that will coordinate Government support for fundamental research through existing university and other laboratories — not compete on the basis of a separate Government research foundation. It is to be hoped sincerely that the present Congress will enact suitable legislation on this subject.

Another facet of the increasing cooperation between academic and industrial institutions is the growth of research in specific fields or on specific projects carried out in such institutions for an industrial concern. This is accomplished in part through institutions designed specifically for this purpose, such as the Mellon Institute, the Armour Research Foundation, and the new Stanford Research Institute. However, in addition, many universities will undertake specific projects on the basis of grants by the industry. Of 800 colleges and universities canvassed by the National Research Council in late 1945 and early 1946, 292 indicated that they were offering such research service to industry. Another important phase of academic-industry contact and correlation lies in the increasing number of faculty members who are retained as consultants by industrial firms.

PERSONNEL IN INDUSTRIAL RESEARCH

In his report to the President, of July 1945, Dr. Vannevar Bush stated, "The most important single factor in scientific and technical work is the quality of the personnel employed." We are in the midst of a serious war-induced deficit of science and technology students and graduates. The Bush report estimated this deficit in Bachelor degree graduates at 150,000, and in advanced degree men at about 17,000 by 1955. In spite of the remarkable registration being handled by universities today, it may be many years before the demand for qualified technical graduates can be fully satisfied.

Requirements for employees in a modern industrial research laboratory are high. They must, of course, have adequate educational training and background, and this may or may not include an advanced degree. There are as many opportunities for B.S. graduates as there are for those holding Master's and Doctor's degrees. Of comparable importance are such other factors as research attitude, positive approach to technical problems, a personality which will promote good relationships with fellow workers, ability to cooperate, physical fitness, training in oral and written self-expression,

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and some understanding of the economic and social problems of modern business.

For the right men there exists today a great field of opportunity in industrial research. It is in itself a rapidly growing "business" in which high reward may be found both professionally and financially. In fact, a noticeable trend today is to provide for ample salary advancement in straight non-administrative technical work for suitably qualified men. There are, of course, many other avenues of advancement as well, including administrative work within the industrial research group, or transfer to other types of business activity such as manufacturing and marketing.

FUTURE OF INDUSTRIAL RESEARCH

Industrial research is now a large industry in itself and is at the threshold of its greatest expansion. Immediate major problems include the training of more research personnel, the provision of adequate physical facilities, the promoting of public understanding of research and its importance, and the developing of a permanent mechanism for applying effectively the results of industrial research to national security. As potential participants in industrial research, men trained in science and engineering can look forward to the future with confidence. "Science has its cathedrals built by the efforts of a few architects and of many workers."* Industry will look to science and engineering graduates as architects of its future cathedrals of applied scientific knowledge.

*From the preface of Lewis & Randall's "Thermodynamics."

Letters to the Editor

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if I had been busy I would not have read the magazine.

So much for destructive criticism, now for the constructive part. . . . Why not articles on what is new at the Institute? Set some of the graduate students to write them up; it would be good practice for them. An article like this if advertised on the front cover would cause most of us to at least open the magazine. . . . How about the Placement Service? It certainly deserves a place in the magazine giving an account of the new openings available and also in more normal times the men available.

E. D. Alcock '33
Dallas, Texas

What do others think? Thanks for your ideas, we are working on them. Some of our difficulties are mentioned in "With the Editor," November 1947. —Ed.

THE article on Registration of Engineers in California by Martin H. Webster in the October issue has been read with great interest. It has been of particular interest to me because of my long residence in California and the fact that I am now an active participant in the campaign for registration of engineers in Texas.

We have found one of our greatest problems to be that of interesting the young engineering graduate in the value of future professional status during those years when he is gaining the experience necessay to qualify for professional rating. Since the Texas law itself makes no provision for this we attempt to handle it through the Texas Society of Professional Engineers, affiliated with the National Society of Professional Engineers, membership in which is limited to registered professional engineers.

As a member of the fees and salaries committee of the Texas Society of Professional Engineers and a director of its Fort Worth Chapter, I should be very interested in receiving or furnishing any additional data along these lines which may be available or desired and which might in any way promote the acceptance of engineering as a recognized profession.

F. C .Clayton '25
Fort Worth, Texas

E&S will be glad to serve as a clearing house for questions or information. —Ed.