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Scientific investigation is now so costly, the little fellow with a big problem often cannot solve it by himself. But he can get packaged research from the increasingly active industrial research foundations whose mobile structure is geared to handle all kinds of applied research.

INDUSTRIAL RESEARCH FOUNDATIONS

Photos Battelle Memorial Institute. From top to bottom: measuring thermal conductivity of refractory brick, the electron diffraction camera, a Schlieren system.

PHYSICS TODAY

The development of industrial research foundations as an important force in the advance of applied science is unquestionably one of the major contributions of this century in the field of technological progress. Their appearance on the scene—in the United States at least—ended an era of hit-or-miss invention and unorganized technical development characterized by the free lance investigator in his attic or backyard workshop.

Not that the free lance era was unproductive! This was the period that produced the telephone, the electric light, the can opener, the airplane, the submarine, the automobile, the mechanical harvester, and hundreds of other things that we like to mention as symbols of a new standard of living. It was the period during which countless individuals began to recognize the opportunities provided by the Patent Office for those who had the ability and initiative to apply science to everyday needs. But it was also a time when so little applied research had been done that the individual investigator could plunge in almost anywhere and come up with something significant. Even the safety pin was enough to cause comment.

Then industries began to realize that, instead of waiting for blind chance to bring them a purchasable new development, they could save time by deciding what they wanted and hiring scientists to invent or develop to order. The industrial concerns themselves began to operate laboratories. Not long after the end of World War I there were at least 500 of these laboratories in the United States, and by 1932 the National Research Council listed 1600.

Other industries, meanwhile, had been taking some of their research problems to universities. There were doubts, however, of the compatibility of motives in the university laboratory and the industrial research laboratory. Sponsorship of applied research in the hope of better products and ultimate commercial profit involved the necessity of trade secrets, and that did not square with the university's primary duties of fundamental research and education.

Robert Kennedy Duncan, industrial chemist and world traveler, was a pioneer in the successful adjustment of scientific and commercial motives. In 1906 he conceived a system of industrial research fellowships which he put into practice first at the University of Kansas and later at the University of Pittsburgh. In 1913, with the financial assistance

of Andrew and Richard Mellon, the system was given a broader scope by the founding of Mellon Institute of Industrial Research at the University of Pittsburgh. Finally, in 1927, the organization was incorporated independently as Mellon Institute of Industrial Research, with its affairs managed by its own board of trustees.

There are now three large institutions of this general type in the United States; in chronological order of their birth they are Mellon Institute of Industrial Research, Battelle Memorial Institute, and Armour Research Foundation of Illinois Institute of Technology, the last named having been established in 1936. Newer and smaller are several of importance such as Midwest Research Institute, Southern Research Institute, Southwest Research Institute, and Stanford Research Institute.

There is also a large group of research institutes or foundations of a somewhat different character, each of which is in reality an integral part of some college or university and, strictly speaking, not properly classed with the others because of differences in structure and function. If we include them all, however, there are perhaps more than 130 so-called industrial research institutes or foundations in this country. Trade association laboratories, private profit enterprises, and organizations with similar names created for advertising or promotion are not included in this total.

As a basic pattern, the industrial research foundation of today is an independent, nonprofit corporation founded to serve industry and the general public in the development of useful knowledge, especially in the practical application of science to better living. Its work consists mainly of laboratory and field studies for the development of new or improved products, better or more abundant raw materials, improved manufacturing processes, production short-cuts and economies, new uses for ma-

Haldon A. Leedy, director of Armour Research Foundation of Illinois Institute of Technology, received his PhD in physics from the University of Illinois in 1938 and immediately joined the Foundation staff. A research physicist specializing in acoustics and vibrations, he became chairman of the physics department in 1944 and was named director of the Foundation in 1948. He is president of the Physics Club of Chicago and has spent a great deal of time and effort during the last eight years in acoustical research and in promoting noise abatement for the city of Chicago.

Francis W. Godwin, director of the International Division for Armour Research Foundation of Illinois Institute of Technology, has been a staff member since 1937 when he came from the State University of Iowa where he had just received his PhD. After directing research in chemical engineering at the Foundation, he took charge of a technological survey of Argentina in 1942 and has specialized in international research since that time. He has been director of the International Division since it was organized in 1947. He lives in Mexico City where the Foundation has its International Division headquarters.



Main buildings of Battelle Memorial Institute, Columbus, Ohio

terials, and the elimination of various types of production troubles.

The essence of the research foundation idea is in meeting a definite need. Industry and government agencies find that they need applied research at a reasonable cost. Scientists in universities discover a conflict between education, with its implication of the advancement of pure knowledge, and industrial research, with its built-in need for confidential, full time services. Industrial research people, even those employed by the largest companies, see good reason for centralized technical organizations which can supplement their own knowledge or facilities. Smaller companies with applied research problems desire effective solutions on a financial basis which they can afford.

Research projects at all these foundations or institutes have similar life stories. The sponsor—an industrial executive, for example—discusses his research problem with the organization. If the subject does not conflict with programs in progress, is of a nature that the foundation can handle effectively, and is judged to be in the public interest, the foundation prepares a proposal embodying an estimate of the time and cost necessary to perform the project.

The sponsor and the research organization then enter into a contract which, as a rule, provides for confidential handling of findings and the automatic assignment to the sponsor of all patent and publication rights resulting from the project. Thus, industrial concerns can take their private problems to these full time problem solvers, and receive the same benefits and protection as they would have if

they did the work themselves plus the advantages of specialized help. The contract also specifies the limits of costs, method of charging for expenses, and similar details. A common formula for covering the basic costs is to charge direct staff salaries plus a like amount for overhead, supervision, and other general costs.

The research foundation then assigns appropriate staff members to the project and sets up its system of guidance and reporting of results. The sponsor participates in guiding the project, often as a member of a steering committee. Perhaps members of the foundation may visit a sponsor's plant to study problems at first hand or to consult further with the concern's own research people. Periodic reports go to the sponsor in accordance with the contract.

Internal organization of the foundations and institutes differs somewhat in accordance with their respective beliefs and philosophies regarding research itself. The method of attacking a problem by a research organization may involve the term assignment of fellowships, either individual or group, for a general program; the use of semi-autonomous teams who follow several projects from inception to final report while using the entire facilities of the establishment; or the coordinated efforts of various departments each specializing in one type of applied science, such as electrical engineering or ceramics. Whatever the organizational method, the objective is to synthesize the diverse talents of a large technical staff into the best possible team.

Two other aspects of internal organization are the administrative and servicing functions. The director and his staff, of course, handle matters of

administration and policy for the organization. The various services—such as carpenter shop, machine shop, and photographic laboratory—are maintained in order to release laboratory workers from routine work better performed by craftsmen.

The foundations are independent in technical, financial, and legal affairs. Occasionally, however, they may be more or less closely associated with a university, sometimes to the extent of a common board of trustees. They may or may not be endowed, and their special interests differ. Certain fields of science may be stressed, or there may be a particular effort to develop a regional area. These differences, however, are minor in comparison to the similarities.

Viewers-with-alarm have continually told us that fundamental research is being slighted for applied research. Yet it seems that an industry, or anyone else who plays the game of research for its material rewards, finally learns the whole story: that we must continually nourish the wellspring of science, where the search is for pure information alone, if we are to have the facts and principles that we will need someday for "practical" developments. Learning this principle requires first hand experience, usually beginning with applied research, and the research foundations can point to many cases where they have helped their sponsors to realize the importance of basic studies. Industry is today contributing more scholarships, fellowships, and other appropriations for general investigations than it has in the past. The business executives call it "patient money".

Research foundations support basic programs with their own funds. Since they have first class professional staffs, the institutions recognize the desire for personal scientific development. The foundations are designed primarily, however, to perform wide-range, long-term projects of an applied nature. Because they can do that job well, sponsors come to them; and a flourishing establishment of its kind specializing in technological development therefore makes a good neighbor to an educational institution. Here is common ground for schoolmen and businessmen where both can benefit.

If a young scientist is to become an expert in industrial research, he must work on real industrial problems. By means of fellowships, internships, and the acquisition of outstanding graduates, the foundations have helped dozens of research men make suc-

cessful transitions from graduate school to applied research projects and on to excellent positions in industry. Trained scientists are always in short supply, and the independent research institutions have proved a valuable source of technical manpower with practical know-how.

Research foundations are public service institutions and do not endorse products or buy advertising space. They participate in scientific professional meetings or conferences and in the general dissemination of technical information. They encourage talks, papers, and articles by their staffs and co-operate with sponsors in publication of as much information as possible on research done in the foundations' laboratories.

None of the research foundations compete with privately operated testing laboratories. Sometimes they have unique facilities, or are asked to serve as referee, but they are not designed to perform routine tests. They must specialize in longer, more difficult projects if their rather elaborate structure is to be most economically and efficiently used.

Some of the background of Mellon Institute of Industrial Research has already been mentioned. Housed in a handsome building of more than four hundred rooms, Mellon is the oldest of the foundations. Under its fellowship plan, a donor contracts with the Institute to pay a set fee for a given period of time. Qualified research men are assigned to the project for a year or more. Research expenditure for



Mellon Institute, Pittsburgh, Pennsylvania

*Metals Research Building
at Armour
Research Foundation of
Illinois Institute
of Technology*



the year ending March 1, 1949 was \$3,300,000 and the total staff was 763.

Largest of the endowed foundations is the Battelle Memorial Institute in Columbus, Ohio. A staff of 1250 in a physical plant, which includes about half a million square feet of floor space, handled a volume of \$6,380,000 of sponsored research in 1949. Almost one-third of this research is in the form of cooperative ventures wherein a group of companies with the same research objectives pool their investments for one program. Founded by Gordon Battelle, who died in 1923, the Institute has served industry for twenty years. Best known of this organization's many developments have been metallurgical in nature, but Battelle has also done significant research in such fields as the graphic arts, ceramics, agriculture, and fuels. Ohio State University and Battelle are mutually helpful neighbors.

Armour Research Foundation of Illinois Institute of Technology, operating without endowment, has grown steadily since its beginning in 1936. Last year the Foundation staff of 650 persons handled a volume of \$4,100,000 of sponsored research. Centrally located on Chicago's near south side, Armour Research Foundation has introduced many important developments, including the magnetic recorder; but

a major contribution to applied research has been the "Armour Plan". This practical method for solving problems has become a model for later organizations similar to the Foundation. The "Plan" is a unified, cooperative system of solving a research problem in which the combined knowledge of scientists in many different fields is focussed upon the problem to yield the earliest possible solution. Although the Foundation operates through a number of departments which specialize in different fields of science, projects are not compartmentalized; ideas are customarily cross-fertilized among the specialists. Armour Research Foundation is unique in its large-scale foreign research, having served in five other countries since 1942; its International Division currently operates offices in Mexico and El Salvador and a modern research laboratory in Mexico City.

A group of industrial executives interested in the technological development of their region founded the Midwest Research Institute in Kansas City, Missouri in 1944. With a research volume exceeding half a million dollars annually, Midwest has two functions: private research for sponsors and "improvement of regional economy through fundamental programs in area resources". Southern Re-

search Institute in Birmingham, Alabama also serves a regional need. It is a "nonprofit corporation which provides scientific personnel and equipment for use by industry in the expanding Southern economy" and has a capital fund of \$1,800,000.

Formed in 1946 to furnish technical services to industrialists in the Pacific States, Stanford Research Institute is now operating at an annual volume of about two million dollars. A staff of some 250 persons has worked on more than eighty projects. An interesting regional project has been a study of land subsidence in the Long Beach-Wilmington area.

Southwest Research Institute, with projects of both agricultural and industrial types, has facilities in both San Antonio and Houston, Texas. Petroleum technology and ova transplantation in cattle are two examples of this endowed institution's work.

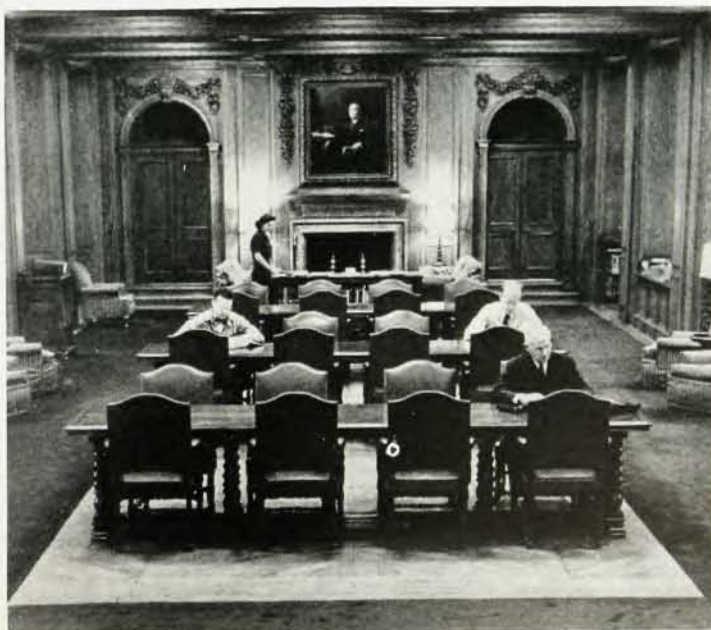
Similar organizations are Augustana Research Foundation, Washington University Research Foundation, and Wyoming Natural Resources Research Institute. To name them all and describe the activities of each one would require hundreds of pages. The idea of an independent research organization which operates confidentially and on a fee basis even emigrated to England in 1947. The Fulmer Research Institute is in the British Mellon-Battelle-Armour image. Located near London and mainly concerned with metallurgical problems, the Institute serves industrial sponsors in approximately the same manner as its American counterparts.

To sum up, the independent research foundations are useful both to industrial concerns and to universities through the functions which they perform. They offer to industry and other sponsoring agencies

a wide variety of well qualified personnel assembled in one place where problems can be approached without interruption. They make available intricate and expensive equipment which it is uneconomical to acquire for limited short-range use. Trained investigators can be hired for limited periods of time and given specific objectives and exact budgets under strict contractual control. The businessman need not put all his research eggs in one basket.

And to the universities, the foundations offer an efficient agency to which applied research problems of service to outside sponsors can be referred. This helps resolve the conflict between the unrestricted educational and scholarly purposes of universities and applied research of a more or less commercial nature. The foundations offer to select graduates the opportunity to begin full-time research work upon leaving the university; they offer an avenue of industrial research training as separate and organized agencies which add to the supply of experienced research workers. Lastly, the attraction of financial support and more widespread interest in the subject of research in general is a way in which the foundations serve the cause of science. The healthy independent growth of independent research foundations has added to the strength of many colleges and universities.

The value of applied research, properly directed with its results wisely used, is recognized in today's industrialized and increasingly scientific society. One of the most practical answers to the question "How can we get more benefit from modern knowledge?" is to be found in the nonprofit, industrial research foundations. They have earned for themselves a significant place in our economy and in the fraternity of science.



*Reading room
in Mellon
Institute Library*