# THE CHALLENGE OF INDUSTRIAL PHYSICS

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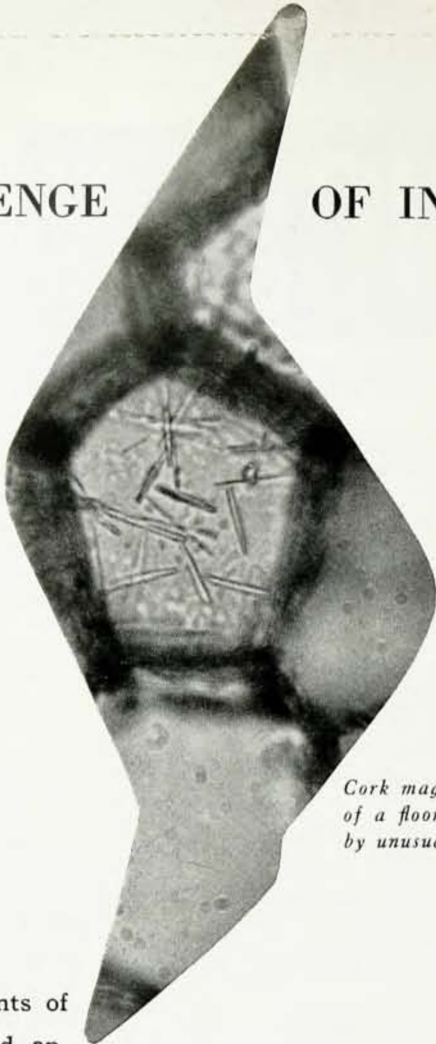

*Cork magnified. How do you measure the comfort of a floor? Unusual properties must be measured by unusual methods.*

**The differing viewpoints of physicists in pure and applied research are discussed by an industrial physicist.**

In physics, as in every other branch of human endeavor, there comes a time when each individual must consider for himself the future of his personal relationship with the science he is attempting to master. At the present moment, with the war years over, large numbers of students propose to join the ranks of the 10,000 or 12,000 of us in this country who have been educated in physics. While it is true that the colleges of the country, because of their increased enrollments, will be in a position to absorb an increased number of these younger people, many more of them will go into the industrial and government laboratories of the country.

In many cases a student has had little or no experience to show him whether his interests lie in an academic or industrial sphere. In both lines of endeavor there are fields of challenge and in both lines of endeavor there are certain necessary evils which must also be understood. But many erroneous conceptions of industrial problems have arisen and are likely to arise. There are misunderstandings of the aims of the industrial physicist and in the minds of some men a nervousness about these aims, which comes from contact with the unknown. Often there is an underestimation of the industrial physicist's abilities and importance. Like superstitious fear of any sort, many of these problems are conjured up by misunderstanding, and efforts to exorcise them must be made.

### What IS an Industrial Physicist?

Arthur D. Little, in his memorable address to the Franklin Institute in September 1924, defined what he called a "Fifth Estate." According to Dr. Little the fifth estate includes those having the simplicity to wonder, the ability to question, the power to generalize, and the capacity to apply. If one adds to this definition the phrase "willingness to expound" he will obtain a pretty good idea of a successful industrial physicist. It is not at all strange that this is the same definition which would apply to a successful physicist of any description, or indeed to any successful worker in any of the natural sciences. The raw material must therefore be the same and, since in America no distinction is made in educational circles between those who eventually go into industry and those who do not, the only thing which remains to differentiate the two is a difference in viewpoint.

The academic physicist is properly concerned with reducing phenomena of nature to terms of basic concepts; it has been generally believed in the past that the fewer these concepts are in number, the more powerful they are in action. This line of thought has resulted in the great simplifications inherent in such basic physical laws as the conservation of energy and the equivalence of energy and matter, as well as in the methods of mathematical physics.

An industrial physicist is in an unusual position for, like the lawyer, he must be prepared to answer on a moment's notice a wide variety of specific questions in an almost unlimited number of fields. He must therefore be a person of exceptionally broad training and more than unusual abilities, for often the problems which come to him are not couched in physical terms. Industrial physics is complicated by constraints of a nonmathematical nature and one is forced to add intuition to training and knowledge of the successful methods of the past. Thus industrial physics in some ways covers a much broader field than does basic or academic physics, and often the industrial physicist finds himself measuring (after all, the science of physics is basically the science of measurement) many very unusual things, sometimes in very unusual places, and sometimes by nontraditional methods.

In addition, in industrial work, one is often struck by the necessity of cooperating with others trained in other scientific disciplines. Industrial physicists are constantly being exhorted to know more chemistry or to know more mechanical or electrical engineering. The specific discipline will vary from industry to industry but it is true that industrial work requires a breadth of viewpoint and a necessity for cooperation which is sometimes considered unnecessary in a university.

### Physics Problems in Industry

How can one measure the comfort of a floor? In years gone by this would not have been a proper question to ask a physicist, but in the past decade those physicists concerned with the measurement of color or with the measurement of acoustical properties have discovered, somewhat to their amazement, that these border-line problems in which an individual is part of the measuring system can sometimes be solved. Thus the broadening of physics to include physiological manifestations is now well established.

How can one measure abrasion resistance of a material and yet have such measurements reproducible and from them derive a standard scale of abrasion resistance? How can one, from these measurements of abrasion resistance, construct the future with any confidence to show that one given material may be expected to outlast a number of others? Is one justified in using a type of dimensional analysis in which time plays the same role as length or volume in an ordinary scale model? How can one hope, by the standard methods of chemical physical research, to find an industrial process for oxidizing linseed oil, a natural product of variable composition, when purification to a single ester may destroy the oil's original, very desirable properties? What are the forces involved in holding a crown on a soft-drink bottle and what excess of force is necessary to prevent such a gasketed assembly from leaking?

These are problems which, in the academic sense, are not basic, and yet for the industry, which is built upon their successful solution, the problems are very basic indeed. In fact, the whole success of the industry, the financial well-being and happiness of the several thousand families thereby employed, as well as the health or physical welfare of the people who will use the product, all depend upon a satisfactory solution. The incorporation of these problems into the body of physics will go a long way toward satisfying the criticism of those who feel that physicists do not pay enough attention to the social results of their work.

## The Two Approaches

One is constantly struck, in industrial research, by the necessity of proceeding along two main lines. One group of scientists, even in a small laboratory, is properly concerned with extending the basic simplifications of physics into untapped fields, but if the greatest use and good are to come from these generalizations, another and often larger group of physicists or chemists must be in a position to apply these or other ideas to problems of current interest. Often, in research on product development, teams using both approaches are necessary. Strangely enough the team using the quick approximate methods usually succeeds first, and in many cases the fundamental approach must be reserved for the few problems of great complexity which are obviously not going to be solved immediately.

Physics itself has historically proceeded along these same two lines. We have had the great pioneers who established the structure of the atom, who discovered radioactivity, or who are engaged in understanding the nucleus. Almost without exception the minds able to make these great simplifications, and discover these underlying facts, have had to wait for masses of experimental data (or have had to develop such data themselves) before building a valid theory. In mathematics there is no such forced dependence on experimental data, and many physicists of late years have tended to misunderstand the teaching of history and have believed it possible to progress in physical knowledge by constructs of the mind only. While it is of course true that this type of reasoning does and can lead to valuable results, it is extremely doubtful that it is the only type of reasoning applicable to the needs of a pragmatic civilization. In many cases, constructs of this type actually hamper further knowledge and under certain conditions this viewpoint can lead to sterility. The industrial physicist tends to minimize the value of many of these theoretical methods usually because they very often do not suffice to settle his problems.

The difference between physicists in general and doctors of medicine is most striking. Few doctors consider it other than part of their duty to cure a patient, even though the disease may not be recognized in medical textbooks; yet many physicists seem to resent the fact that they are called upon to use their intelligence in fields for which the textbooks have not been written. The industrial physicist cannot allow himself this luxury, and if he is given a problem of finding out why one material is slippery and another is not, he must be prepared to utilize his intellect and training to solve the problem.

Thus academic freedom, superficially, constrains individual action less than does industrial physics, and in the sense that an academic physicist is free to pursue an isolated trend of thought, this may be the case. But in the larger universities, the last few years show many cases where individuals group together in a mass attack on some given problem. The chances are that this trend may continue, particularly if the world remains too unsettled. Thus the division between the individual and a mass worker is tending to disappear even in those places where one would not expect it to.

As we have seen, though there may be a broader field of individual action for the academic physicist, the questions asked of the industrial physicist are apt to be broader in scope as well as being more varied in nature than those asked in college laboratories because they often cover unusual aspects of human endeavor. For this reason it is often much more difficult to solve such problems and, in many cases, it may be impossible at the present time with present resources. This impossibility can arise because of mathematical difficulties, but often one is not even allowed to consider these problems without the added complication of the nonphysical constraints mentioned above.

## Generalization or Utilization?

We are thus led back to the problem of viewpoint. One has to decide whether his greatest contribution can be made in the traditional field of generalization or, in the manner of most physicians, in the field of utilization. The traditional field leads to analysis and the industrial field to synthesis. Clearly one can never be wholly in one or wholly in the other, and the successful attack on a complicated problem usually requires elements of both types of thinking. At this time in our society, the greater monetary awards usually follow the line of synthesis.

Science has tended to make a virtue of its isolation, but in the present political complexion of the world it is unfortunately more than possible that this virtue will be legislated out of existence. It is important that the legislator understand that our traditional viewpoints have value, and one of the great tasks of the industrial physicist will be to insist that the freedom of his academic brother be adequately protected. It is for this reason that we have added the "willingness to expound" to A. D. Little's definition of the "Fifth Estate."

Thus it appears that work in physics can be classified into two main groups. In the first lies work along traditional lines. Early physicists were interested in discovering the properties of matter *en masse*. As time went on they became more interested in the atom in an attempt to explain these mass properties. This led in its turn to that study of the nucleus which is now proceeding so vigorously. It is, of course, imperative that problems in this category be pursued with full vigor and with the help and aid of as many people as possible. The results of this work are important to both pure and applied physics. Consider, for example, the discovery of radioactivity by Madame Curie. This work has led not only to a great broadening in our understanding of the structure of the nucleus, but also to important industrial and medical applications.

In the second group lies work in physics utilizing present or past discoveries for future economies. This is the field in which the work of a majority of industrial physicists, particularly those in the smaller laboratories, will lie. The results of this work are also important to both pure and applied physics. Edison's development of the carbon-filament incandescent lamp led to the invention at the General Electric Company of the tungsten lamp and the development of other types of lighting. But a byproduct of Edison's research (the Edison effect) was the first of several pieces of evidence which eventually led to the discovery and understanding of the properties of the electron. Often it has not been sufficiently recognized that either category of physical problem can stimulate and aid the other.

Many physicists are clearly confused on the relative importance of the two approaches but it has been shown that the impetus toward basic knowledge can come from an economic demand as well as from an intellectual approach. Further, it must be borne in mind that neither aspect can be considered more important than the other. No less an authority than Sir James Jeans, in a presidential address before the British Association for the Advancement of Science, has remarked that the economic value of the work of one scientist alone (that is, Edison) has been estimated at three thousand million pounds. While one, of course, cannot hope or wish to assess the monetary value of the theory of relativity, it would seem, in view of the enormous amount of potential benefit involved in industrial work, that one can obtain real satisfaction at being part of a group which clearly is able to add so much to the happiness and welfare of the peoples of the world.

It is perhaps unfortunate that the impetus for work on the nucleus, which occurred during the war, came from the desire for developing such a destructive weapon as an atom bomb. The fact that such use was made of the work of nuclear physicists has led many of them into philosophical difficulties, and attempts are being made to rationalize their efforts by pointing out to the public the vast amount of potential knowledge which lies in store for the science of medicine or even for industrial application in the field of atomic power. It would be very unfortunate if younger physicists should gain the idea that all types of applied research lead to such horrible results. It must be realized, in the larger scheme of things, that the value of knowledge comes with the application of that knowledge to new and useful properties for the benefit of society. The evil byproducts of such research unfortunately have to come along with the beneficial byproducts, and whichever aspect gains the most use is a matter of education among peoples coupled with their inner energy and their accepted ethics.

Because physicists are a small group, they often suffer in many ways from psychoses similar to those found in political minorities. In an effort to keep their own individuality they feel it necessary to resist pressure from the outside and the result is, as has been pointed out by Langmuir, that a group of physicists tends to behave like an amoeba. In this animal a cautious arm goes out to find something of interest and pulls in the entire body behind it. As physicists increase in number this tendency of the whole body to follow the leader must become less marked and simultaneous exploration into several unknown or hitherto unallowed fields must become more prominent. It is the task of the industrial physicist of today to assist in and demand this broadening of our concepts.