

News and views

Physics in Engineering Education

THE major points in the article by E. L. Woodside ("Physics Curriculum for Engineers", *Physics Today*, November 1954, p. 4) are well made. First, given the premise that a fundamental knowledge of physical laws is desirable for engineering students, specialists do tend to emphasize the importance of their subject matter domain. Second, there is a need and a value in learning to think formally. Third, time is an important consideration in the development of the best curriculum possible for engineers. The issue is of real significance to the welfare of the nation and I would like to expand some of the points and take issue with another.

In the Natural Science course at Michigan State College, we find the engineering majors and pre-medical majors among the better students. With due respect for the dangers of generalizations, however, these students might be described as "little men in a big hurry". They are impatient with what we call fundamental courses, and are exceedingly anxious to get on with what they consider to be the real meat of their training. The word "training" is used here to indicate clearly the type of knowledge desired by these students. In general, pre-medical and engineering students "believe" in a basic education for others; for themselves they consider it an impediment in the attainment of their goal. Time is a critical item in the career of a budding engineer. Under these circumstances one must ask oneself "What is the best preparation for an engineer?" It almost sounds too simple to answer by saying "those subjects which are most fruitful", because the next question is: Most fruitful of what? One can hardly deny that the ability to think logically would be fruitful in any special field in engineering, yet the experience that an entering college freshman has in thinking logically and formally in any area, and especially in the area of science, is pitifully inadequate. This experience should involve those fundamental areas which point up sharply the *process* of science while establishing significant facts and relationships in the area. This becomes fruitful in providing the methods used by scientists in all areas and in providing the subject matter principles which become the deductive keys to a whole host of engineering problems. As I see it from the end zone seats (and this may be the critical weakness of the whole argument), engineering as a field of principles in their own right will not long

stand if the young engineers emerging from colleges and universities do not have a substantial understanding of the principles of physics, mathematics, chemistry, biology, and communications, and, most important, a real understanding of the nature of the scientific process which these subjects embody. Biology is listed here because the line between biological science and physical science is becoming blurred, as indicated by the direction of thinking of an engineer like Kettering, who urges the widest application of physical science to solution of biological problems, and of Harold Urey, the atomic scientist now engaged in problems involving the synthesis of proteins. The development of the biological sciences might be greatly accelerated by an influx of physical scientists.

Theories or conceptual schemes, as broad generalizations arrived at inductively from many or few facts, are explanations of relationships, and are of greatest impact because of the predictive value of the theory. The prediction (deduction) concerns the relationship of objects and/or events. Science moves in the direction of fewer and fewer generalizations to explain more and more facts or events. Most areas in science can be illustrative of the process of science, and particularly in the physical sciences, where one has little or no concern with vitalism, one can find somewhat clearer analytical patterns. Here, as indicated by Woodside and many others, one can find sharp cause and effect relationships. In addition, one can also find, as in heat and motion, cause and effect relationships which are not always clear, and these enigmas constitute a part and parcel of the process of science that must be presented to prospective engineers. One may find heat defined as "a form of energy resident in the random motion of molecules", or that heat "is not a fluid, nor anything material, but that it is a form of motion". On the other hand if a gas is heated, its molecules move faster. Motion produces heat; heat produces motion. The root-mean-square velocity equation for molecules is a simple mathematical expression of the possibility of this cause-effect equivalency. The process of science is not a clear one-way street leading to successful solution of problems. It is essential that the student sees the inadequacy at times of the three-step process described by Krauskopf in his *Fundamentals of Physical Science*. Toward this end, perhaps, the student should be required to digest the contents of Butterfield's *Origins of Modern Science*, Campbell's *What is Science?*, or Conant's book *Science and Common Sense*. Conant expresses his concern over the lack of realism of a point of view expressed in Karl Pearson's analysis of the scientific process as a simple step-wise pattern. A good basic education should place the total scientific process in a more realistic framework.

Although there is no question about the necessity of a solid foundation in mathematics, those students who require more than other students the fruitful application of mathematical principles to less abstract objects will still find a wide range of applications in a course dealing with fundamental physics. Some edu-

cators object to the emphasis on theory as if the theory were taught in a pure vacuum. Good theories lead to deduction and the deductions are very much on the empirical level.

The number of presently known facts is appalling, and no good scientist will argue against the advantage of a solid background of facts. However, he may want to evaluate one fact against another or one process in science against another, and he may decide that in the limited time available it might be wise to choose certain areas and certain processes and eliminate other areas and processes of science. Perhaps after the student's formal schooling, much factual information can be attained more effectively in the process of solving particular practical problems. A good scientist never stops learning nor does a good engineer.

Sarton, Cohen, Butterfield, Conant, Campbell, and others feel that much of that which is essential to understanding science might well emerge from the inclusion of some history of science. This history unless mistakenly presented in an encyclopedic fashion rather than as a dynamic activity could help elucidate the scientific process. Engineering students must understand the fruitfulness of ideas, especially in a country such as ours, where the opportunities are so great. In order to understand the origin, development, and deductive capacity of the significant ideas in physical science, he should, sometime in his learning period, work through the development of those ideas fundamental to the great advances made in physics and engineering today. The development of ideas by men of genius, and the influence of the society of their times on the success or failure of the idea, are a dynamic aspect of science that should not be neglected. The historical development of ideas is well suited to the fundamental courses.

There has been a tendency of late to absorb fundamental courses into specialized curricula so that instead of students taking physical chemistry in the chemistry department they take it in the soils department; instead of taking thermodynamics in the physics department, they take it in mechanical engineering, or in chemical engineering, or in physiology. This tendency results in much duplication and creates new markets for textbooks particularly adapted to the specialty in question. The book turns out to be a third-hand presentation of the fundamental principles for four-fifths of the book, with a first- or second-hand presentation of the applicable field for the remainder of the text. This incorporation expands the engineering school curriculum and restricts the development of the student. A good look at many college catalogues would astonish almost anyone. Two students could graduate from some colleges without having a single course in common. Two engineering students might have such diverse training that a layman talking to them might not recognize both of them as prospective engineers. This is not an argument against specialization. It is an argument for a good solid education before specialization. This may mean an additional year of training to

their present education. If anything has to be reduced, many top notch engineers have said to us, "Give me a graduate in engineering with a good solid basic education and we will take care of the rest of his training in the field". However, with the vast compendium of engineering knowledge today, it is only fair to present a five- or six-year curriculum, and take this additional year or two out of the student's pre-college education or out of his post-college education. Certainly the engineering faculties have toyed with this idea. Competition among different engineering schools remains a factor in determining the time for an engineering curriculum. With the current scarcity of engineers, the normal struggle for existence plays only a small role in weeding out inadequately educated individuals. In the long run, however, our national economy will suffer under the strain of mediocre personnel, as will the patience of administrative officers and chief engineers.

Alfred Novak
Michigan State College

Bakker Succeeds Bloch as CERN Head

EUROPE's nuclear research center (CERN), which has been in formal existence for less than a year, has announced the forthcoming resignation of its director general, Nobel Laureate Felix Bloch of Stanford University. Professor Bloch, who "has found the administrative duties that have fallen to him during the period of construction unexpectedly heavy and too onerous to allow him to devote sufficient time to research", will return to Stanford in September. His successor will be C. J. Bakker, director of the Dutch Institute of Nuclear Physics and professor of physics and head of the University of Amsterdam's Zeeman Laboratory. In the interim Professor Bakker is serving as deputy director general of CERN in place of E. Amaldi, who has found it necessary to devote most of his time to the development of the research school of high-energy physics at the University of Rome. Professor Amaldi will continue to act as consultant to CERN in the field of cosmic-ray research.

The CERN program calls for the construction of a modern high-energy physics research laboratory equipped with two large accelerators: a 600 Mev synchrocyclotron and a 25 billion volt proton synchrotron. Completion of the laboratory and associated apparatus is expected to take at least until 1960. Meanwhile, the organizational structure of CERN has been established and research groups are active at the Geneva headquarters and elsewhere. CERN's governing body, the council of the European Organization for Nuclear Research, consists of 24 members, two appointed by each of the twelve participating nations. Sir Ben Lockspeiser, director of Britain's Department of Scientific and Industrial Research, is president, and Antonio Penzetta, president of the Corte di Cassazione, Rome, and Jacob Nielsen, professor of mathematics at the University of Copenhagen, are vice presidents.