Engineering Research and the Colleges

By F. C. LINDVALL

ENGINEERING research is a term which is loosely applied to a wide variety of projects, ranging from mere acceptance testing of a manufactured gadget to very fundamental studies leading to new data, indistinguishable from work normally called "science". By definition, engineering consists of the application of known principles of science to specific problems or devices, with the result that engineering research frequently tends toward development work which is in a sense engineering design. In this type of development the function of engineering research is to eliminate, as far as possible, the "factors of ignorance" in the design.

The demands of modern industry and transportation have required machine designers to "sharpen their pencils". Higher operating speeds, greater pressures, economy of weight and cost, improved efficiencies, all have forced designers into intensive study of stresses, new materials, analyses of vibration and dynamic loading, and new manufacturing techniques. These more difficult specifications require of the designer a better comprehension of fundamental principles, particularly in the field of Applied Mechanics. New data must be found, and refined instrumentation must be developed, both for obtaining the necessary design information and for analyses of performance of test equipment.

OPPORTUNITIES

Industrial research is generally undertaken with the purpose of attaining specific objectives and particular developments, whereas the engineering colleges have many opportunities for fundamental research directed toward improvements adaptable by industry in general.

The gas turbine is an instructive example of engineering research and development. In principle and practical use the gas turbine is old. Its development as a complete working unit is a major industrial project that is not suitable for a college to undertake. However, the improvements which are needed for extensive acceptance of the turbine by industry today lie in the fields of combustion, heat transfer, materials, machine design, and fluid mechanics. An engineering college could make substantial contributions in any or all of these basic fields: through a better understanding of the combustion process with a variety of possible fuels, through heat transfer studies and modifications of the basic thermodynamic cycle, by metallurgical improvement in the materials of the turbine, by aerodynamic studies of the flow problems involved, and by mechanical design directed toward higher performance and reduced cost. Results useful not only to the turbine design, but to other applications as well, should accrue.

SCOPE OF ACTIVITIES

Research in the engineering colleges, however, is not confined to the advancement of scientific knowledge. It has a number of other important functions. In the training of college students for work in modern engineering, it is most desirable to maintain a creative environment: research work is a stimulus to the students as well as to the staff members, and for worthwhile graduate work it is a necessity. A good research program requires collaboration with other research groups, both academic and industrial, with a resultant influx of new ideas and inspiration. Moreover, on a particular campus research engineers will be in much closer touch with their faculty colleagues who are doing investigations in related fields of chemistry, physics, and mathematics, with the result that some of the unfortunate departmental isolation which has existed in the past will tend to disappear. As demonstrated by war project work, the line between physics and engineering is indefinite, if not non-existent. As future applications of nuclear energy are studied, the engineers working in this field will require more knowledge of atomic and nuclear physics, and the physicist in turn will need more engineering assistance in apparatus design and development.

In such applications as servo-control systems, the combination of electrical, mechanical, and hydraulic elements involves engineering in a broad sense, and the analysis of servo-systems, with the associated feedback amplifier theory, is precisely the type of advanced work in engineering study and research that colleges should provide.

LIMITATIONS OF RESEARCH

Colleges will advisedly restrict research to that best suited to their particular facilities in personnel and equipment, and the work to a large extent should be fundamental. Too often college laboratories become loaded with testing work of routine character which provides little in the way of new information or inspiration for the better students.

Whenever a college has laboratory equipment which is unique, such facilities should be made available to the community and to industry, as a service. In return, outside sponsorship should be encouraged for related basic engineering studies which may have no immediate application. For example, at the California Institute of Technology unusual facilities exist for the study of physical properties of materials under rapid loading. The directors of this laboratory were asked to undertake an extensive series of tests on specimens of a particular steel which had been subjected to various kinds of heat treatment. The proposal as presented involved only test work of routine nature; but as modified at the request of the Institute, the program was broadened into a research activity which should give not only the specific information on how the material behaves, but also on why.

SUPPORT

The lack of adequate support for engineering research in colleges has always been a serious limitation. Unfortunately, a good deal of the desirable work to be done requires test equipment and facilities which are expensive, as relative to apparatus necessary for good work in some of the basic sciences. Most college budgets can support only a limited amount of engineering research, so that outside support must be sought from industrial and governmental groups. This type of support automatically brings the collaboration with outside laboratories and application engineers which, as mentioned above, is one of the objectives of engineering research in colleges.

The impetus given to research by the war will be maintained to a considerable degree in both governmental and industrial activities. Not only will new problems arise in which the colleges can be effective as research

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velt appear to have been incorrectly advised at Casablanca that the morale of the German people could be broken by bombing their cities, and that the ability of the German Army to resist could be materially reduced by bombing munitions plants. The two air forces did a remarkable job; the physical destruction wreaked was terrific. Nazi propaganda, however, was able to maintain the German will to resist in spite of great personal discomfort, and the Allies had not reckoned on the recuperative capacity of German industry.

Secondary criticisms of the Combined Bombing Offensive can be made, though they are mentioned with full appreciation of the fact that hindsight affords an unfair advantage: 1) Allied Intelligence failed at many points, especially as to industrial matters. 2) The types of bombs dropped and their fuses were not such as to cause maximum damage to the targets; the percentage of duds was high. 3) Undue emphasis was put upon tons dropped, regardless of their effectiveness.

Too much cannot be said in praise of the crews of the bombers and the pilots of their fighter escorts, and for the way in which they carried out their parts in the Combined Bombing Offensive. The airplanes themselves were highly satisfactory. Division Commanders worked out brilliant devices such as formation flying, to insure the return of as many as possible of the aircraft and their crews.

If strategic bombing was not as successful as expected in reducing the will and ability of Germany to resist, what did beat her? The answer appears to be this: As a by-product of strategic bombing the Allies secured air superiority; with air superiority it was possible to mount, execute, and carry through a successful invasion. The ground forces moved into Germany with air cover. The Luftwaffe had been beaten, and Germany's ground forces, acordingly, were at a great disadvantage. Germany was not beaten until Allied soldiers physically took over the occupation of Germany. The question that remains to be answered is: Could the Allies have secured air superiority over Germany in a more direct way than through the use of thousands of four-motored bombers, tens of thousands of lives, and billions of dollars?

NEW PRESIDENT

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dollars. In directing the work of the laboratory, Dr. DuBridge won the wholehearted cooperation and confidence of the scientists, the industrialists, and the armed forces. To the thousands engaged in the effort, his name is synonymous with intelligence, integrity, and modesty; and they bear witness that his attitude made this important war work a model of fellowship in effort.

Internationally known for his research work in nuclear physics, Dr. DuBridge supervised the construction and installation of an atom-smashing cyclotron at the University of Rochester in 1938. This seven-million volt apparatus produced in 1938 the highest energy proton beam which had been used up to that time.

Among the academic, professional, and scientific organizations of which Dr. DuBridge is a member are, the National Academy of Sciences, the American Physical Society (of which he is now vice-president), Sigma Xi, Phi Beta Kappa, the American Association for the Advancement of Science, the American Optical Society, the Institute of Radio Engineers, the American Association of Physics Teachers, and the American Association of University Professors. He is representative of the American Physical Society on the Physical Science Division of the National Research Council, and a member of the executive committee of the American Institute of Physics.

He has been a member of the editorial boards of the American Physics Teacher, the Physical Review, the Review of Scientific Instruments, and is consulting editor of the International Series in Physics. He has published many articles in scientific journals, and also two books, "Photoelectric Phenomena" (1932) and "New Theories of the Photoelectric Effect" (1935).

In 1925 Dr. DuBridge was married to Doris May Koht of Reinbeck, Iowa. They have two children, Barbara, 15, and Richard, 12.

It is expected that Dr. DuBridge will assume his new duties as president of the California Institute of Technology at the beginning of the next academic year, in September, 1946.

ENGINEERING

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laboratories, but also much work can be done in the "fine structure" of engineering, to borrow a term from spectroscopy—in details of analysis and performance which are no longer unimportant in modern, more refined engineering design. The colleges are in a favorable position in engineering research, since all phases of science are represented and may be made available for contribution to specific problems. With a proper balance between such research and teaching, the colleges can be even more effective in their primary responsibility—the training of engineers.

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