ATOMIC ENGINEERING?

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IT has happened now for the third time in our lifetime ("our" referring to the elders of the engineering profession) that new avenues of engineering activities of tremendous importance have been opened by physicists and the engineering profession has found itself unprepared to challenge the task.

In 1887 the physicist Heinrich Hertz discovered "wireless telegraphy." In fact, he experimentally confirmed the existence of electromagnetic waves which anybody may easily read in Maxwell's equations of the electromagnetic field, i.e., anybody who can read equations at all. It took several decades for radio engineering to become a branch of the engineering profession and for adequate measures to be taken to incorporate the fundamentals of field theory into the engineering curriculum.

The discovery of electromagnetic waves of long wave length was followed very soon by the discovery of X rays, i.e., electromagnetic waves of very short length of a frequency far beyond the spectrum of visible light. It has to be said to the credit of the engineering profession that it took advantage of X-ray techniques in various industrial fields and the design and construction of X-ray apparatus was recognized as an important branch of engineering.

Similarly, the infrared technique, i.e., the technique of waves longer than those of visible light but very much shorter than radio waves, was justly considered as an engineering problem.

However, in the period between the two world wars, physicists made great efforts to narrow the gap between radio and infrared waves. They succeeded in producing microwaves which made possible the marvelous technique now commonly designated as the art of radar. The physical facts were known a long time before the beginning of the recent war. However, during the war, physicists, by their superior knowledge of electronics, i.e., the mechanics of electric particles, were able to solve the engineering problems of producing and directing microwaves. I will not contest the fact that a great many American engineers were sufficiently familiar with electronics; many made important discoveries and contributions to electronic devices. But somehow our engineering education does not encourage the idea of the unlimited horizon, when fundamental thinking in novel fields is required.

And now it seems we are at the threshold of the new atomic age. I do not know whether or not this is true, but certainly we shall have "atomic engineering" in the fields of power and transportation. Are we prepared for the problems involved?

The first application of atomic engineering was directed by military engineers; plants and many gadgets were probably designed and constructed by engineers. However, not only the discovery of the fundamental facts but also the methods of application were suggested, worked out, and tested by physicists. I concede that security regulations and personal relations in the "nuclear clan" played a great part in the choice of collaborators. However, I raise the question, do we give today to the future engineer enough fundamental knowledge in basic questions of the structure of matter, the nature of energy, the relation between matter and energy, so that he will be able to think intelligently in the new field, to have good engineering judgment on possibilities and methods? Is he better equipped than anybody else who reads a few popular articles in the *New York Times* or in the *Saturday Evening Post*? Is there something wrong in our engineering education? I am afraid there is.

First, I believe we have a tendency to restrict our teaching to scientific knowledge which has immediate applications. We often forget that almost every new physical or chemical discovery *might* have engineering application. After all, engineering is the conquest of nature, i.e., matter and energy, for human comfort, and therefore an engineer cannot know too much about the inner structure of the matter against whose whimsical moods he struggles and the laws of energy which he wants to exploit and harness.

Second, we underestimate the interest of our students in "natural philosophy." We are reluctant to present the fundamentals of physics and chemistry as a living science full of question marks and changing concepts. We believe we ought to introduce the findings of research only after the unshakable truth has been established. We tend to stick to classical concepts. I found while teaching mechanics of continuous media, elasticity and fluid dynamics, my students listened eagerly as I told them something about atomic structure of the materials and kinetic theory of gases. I wonder how many engineering students obtain a picture of entropy, chemical reaction, and the like, from a modern point of view. And why should ordinary combustion be an engineering topic, and nuclear reaction a mystery of modern alchemy?

Third, we overestimate the importance of transfer of experience to coming engineering generations in comparison with a training aimed at true understanding of the happenings of nature. We try to train engineers so that the employer can use them almost immediately after graduation from school. One of my former students was employed as an instructor in a well-known engineering school. He suggested some changes in the hydraulics curriculum in the direction of modern fluid dynamics. His superior asked him the use of teaching the findings of research men who, he conceded, found interesting results in hydrodynamics. None of these men, he said, would be able to design a sewage pipe system. No doubt he was right in this statement of fact, but he was wrong in his conclusion. Fortunately, the more intelligent employers are beginning to realize that immediate usefulness is not the most important criterion of a novice engineer. They appreciate sound fundamental understanding and do not want the school to train for them the type of practical engineer, who—according to the *bon mot* of a prominent Englishman, himself an engineer—perpetuates the errors of his predecessors.

Fourth, I certainly do not wish to make of every engineer a scientist, or, God forbid, a nuclear physicist. However, we shall try to give him an education which shall enable him to follow the progress of science, as, I believe, every medical doctor should have sufficient education to follow the development of biology which has produced in our time almost as spectacular discoveries as physical science. At the institution at which I have been teaching in the last fifteen years, science and engineering students have essentially common curricula the first two years. The physics student continues after that to move on a relatively high intellectual level of understanding natural phenomena from a scientific point of view. I have often wondered why the engineering student has to make a steep dive into an atmosphere in which the beam on three supports is considered a most difficult problem and the exact clear principles of mechanics and thermodynamics are replaced by semiscientific, semipopular "ersatz" truths.

I am convinced that the knowledge of the deepest origins and also the limitations of the principles does not handicap a

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General Electric jet engines is that the former utilizes an axial-flow compressor instead of a centrifugal compressor. The German plane is powered by two jet engines, one mounted in each wing, while our jet fighters have the power plant in the fuselage. The German jet engine is a Jumo 004.

From the Society of British Aircraft Constructors, Ltd., comes some newly released details of the Gloster *Meteor*, Britain's first operational jet-propelled fighter, a twin-engined, low-wing all-metal monoplane with a nose wheel undercarriage. A high-set split tail plane is necessary to give ample clearance for the jets from the gas-turbine engines. The gas-turbine propulsion units are built by Rolls-Royce in collaboration with Power Jets Ltd., British Thomson Houston, and the Rover Company. It is said that at least two other gas-turbine engines are being developed in Great Britain, one by de Havilland (the *Goblin*) and the other, as yet unnamed, by the Bristol company.

Youth

In concluding his remarks to the press at a luncheon at The Waldorf-Astoria in New York when the General Electric jet engine was "unveiled," R. G. Standerwick, engineer, Aircraft Gas-Turbine-Engineering Division, General Electric Company, paid a tribute to youth that is worth recording. Said he:

"To those of us who have spent most of our lives in the engineering profession, it is extremely gratifying to see the interest and productivity of the new generation of engineers in this work. It has been said that 'flying is a young people's sport.' Not so exclusively, please; aviation engineering is decidedly a young engineer's avocation. Youth, in the eyes of age, may be reckless, but youth is really agnostic and this shows up in engineering as well as in other activities. However, do not misunderstand me. Engineering youth is also trained to use sound judgment. Often, though lacking (and I say this facetiously) years of experience, they can accomplish in this day and age things which in our day were termed impossible. Upon this combination of a new art and well-trained youth I base my belief that progress at a high rate is inevitable."

Creative Engineering and Patents

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The Commission has recommended that there should be a central body, in the Executive Office of the President, to supervise and approve departmental patent policies regarding employee inventions and the disposal of patent rights, and to instruct and advise departments and agencies regarding their patent problems.

MORE INVENTORS AND A SOUND PATENT SYSTEM NECESSARY

Science and engineering have demonstrated their value in supplying the type of knowledge needed to wage a modern war. To maintain our place in a warlike world we must keep our scientific and our engineering knowledge at a high level as a basis of national defense. We must continue research in war equipment and we must maintain an active armament industry as insurance for the future. At the same time we must have more men and women who have the ability to invent and develop new machines and processes useful in providing full employment and high standards of living for our people. For our country to grow and prosper we must have more epoch-making inventions fully protected by a sound patent system. For our war industries to be utilized most effectively in providing full employment we must have more new knowledge. For new wealth to replace the material losses the world has suffered in this war we must create new wealth through research and invention.

Evaluating Ball- and Roller-Bearing Greases in Electric Motors

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sistency and a flow point of 332 F. This was put in the test motor and run for 18 days, during 4 of which the temperature on the bearing on the coupling end of the motor was 175 F and on the opposite end was 158 F. At the end of this time, the grease became so thin that most of it leaked out of the housing along the shaft and into the windings. That which was left was very soft and plastered around the balls. This grease was unsuitable as it would leave the bearing almost empty of grease after a few days.

Grease B. A ball-bearing grease of about 318 worked consistency and a flow point of 275 F. This grease was run at room temperature in the motor, then the temperature was raised to 175 F and held there for a few hours. The bearing temperature suddenly shot up to 284 F and stayed there for 2 hr when the motor was shut down. The test was repeated when the same thing happened, and it was decided that this grease would not stand 175 F without breaking down. The grease became very soft but did not leak out, remaining in the bearings.

Grease C. A ball-bearing grease of about 274 worked consistency and a flow point of 444 F. This grease was run for 3 weeks in the motor, 2 weeks at 90 C, and 1 week at 100 C. At the end of that time, its condition was perfect in appearance and it seemed to be operating very satisfactorily. Although it was quite stiff in consistency when cold, after this run, the consistency at operating temperature was very good and the bearing surfaces had a thin film of grease. In the author's opinion this grease showed good promise for further field trial.

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person in their practical application; as a matter of fact, real knowledge makes the application easier and safer. And after all, physics students are not any more intelligent than engineering students.

I have digressed from the subject indicated by the title. From the little I know and the little I have read on the subject, I really believe that the problems involved in the development of atomic power for stationary and transportation purposes are primarily of the nature of engineering and especially applied mechanics. In other words, the picture of the nuclear processes obtained by the physicists contains so much of the truth, if such thing as truth exists, that from now on systematic observation and computation must lead to practical solutions. Certainly intriguing engineering problems, like the development of materials resistant to extreme temperatures and extreme corrosion, and difficult applications of our knowledge in diffusion and heat transfer, will be involved. However, it may sound paradoxical, but it seems to me that the processes involved in atomic engineering are less complex than, for example, the processes of combustion of conventional solid and liquid fuels; less complex in the sense that simple considerations and theoretical computations may give closer approximations to reality than in the case of molecular reactions. What can appeal more to a scientific engineer?