

EXPLORERS AND CREATORS

A consideration of the true role of the
scientist and engineer in the world today

by L. A. DuBRIDGE

A NUMBER of years ago Dr. A. A. Noyes, in formulating the educational policies for the newly reorganized California Institute of Technology, enunciated the following proposition:

"The undergraduate course in engineering shall be of a general fundamental character with a minimum of specialization in the separate branches of engineering. It shall include an unusually thorough training in the fundamental sciences of physics, chemistry, and mathematics and a large proportion of cultural studies; the time for this being secured by eliminating some of the more specialized subjects commonly included in the undergraduate engineering courses. . . . It is hoped in this way to provide a combination of fundamental scientific training with a broad human outlook—avoiding narrowness on the one hand and, on the other, superficiality and lack of purpose. . . ."

Needless to say I subscribe heartily to this statement which has been the "credo" of Caltech for the past 32 years. On the basis of this policy the California Institute has turned out some fairly creditable scientists and engineers! It has also turned out men who have risen to positions of responsibility, influence, and leadership in science, engineering, and industry, as well as in community and national life. In an individual, in a univer-

sity, in a company, in a community, and in a nation we need knowledge and competence of many types; we need breadth of vision, we need not only intelligence but wisdom, not only intellectual but also moral leadership.

That is my philosophy and I want to lay it on the table at the outset, for I do not want to be misunderstood in the things I am about to say. I don't want anyone to dismiss the remarks which follow by saying "Oh, he is just a scientist; he doesn't understand the finer things of life."

That very statement, in fact, is as good a place to take off as any. Who is it that thinks he has a monopoly on the "finer things of life"? Who says that the poems of Omar Khayyam are any "finer" than Newton's Laws of Motion? I'll take my "loaf of bread" and "jug of wine" along with the next fellow. But I'll deny they are any "finer" than the elliptical orbit of the planet Mercury, and far less grand than Einstein's Theory of Relativity. I am quite willing to use the terms beautiful, noble, majestic in speaking of the plays of Shakespeare, the paintings of Rubens, the music of Brahms. But I claim the right to use the same terms in describing the great scientific achievements of Newton, of Darwin, of Einstein, and of Bohr.

But my friends the humanists say "no." Art, music,

"Explorers and Creators" has been adapted from an address delivered at the semi-annual meeting of the American Society of Mechanical Engineers in Los Angeles, June 30, 1953

and literature are beautiful; science and engineering are crass, materialistic, earthy, practical. And besides they are too technical! Then comes the punch line. It goes like this: "Furthermore," they say, "science is the cause of all the world's troubles. If we only had less science and more literature, or art, or music, or religion, or something, the world's troubles would all be cured."

I believe firmly that statements of this sort, even though widely repeated and believed, are sheer nonsense. And it is time that scientists and engineers pointed out the nonsense in no uncertain terms.

In designating the nonsense it is not necessary to make any derogatory remarks about any nonscientific area of human endeavor. It is no reflection on Brahms' music to see beauty in other things too. It should not offend those who receive inspiration from art and literature to suggest that others receive just as true and fine an inspirational experience from astronomy or physics.

I happen to believe that knowledge, truth, and beauty are to be found by traveling down many avenues. Most people cannot travel more than one avenue at a time (though a few do). We should, however, neither envy nor disdain those who have chosen other approaches from the one we prefer.

Physicists and poets

Nor do I think it is possible to say that one avenue is better or finer or more useful or more valuable than another. Any particular human mind and spirit must seek to fulfill its dreams in its own way. Civilization as a whole needs the knowledge, the inspiration, the material products of all lines of effort, of all kinds of people. Physicist and poet, engineer and artist, astronomer and historian, biologist and economist—all men who seek knowledge, truth, beauty, understanding are adding in equal measure to the welfare of men.

Nor do these men work independently. The social scientist cannot hope to see his ideals of a more effective and peaceful social structure come to pass without the tools provided by medicine, public health, science, and industry. Nor is the engineer very effective or useful in a social organization which is unable to provide rudimentary civic orderliness, to say nothing of economic resources. Nor do men live happily, even with physical comfort and social and political stability, if they do not have also access to beauty, inspiration, love.

In short, men, individually and collectively, need intellectual *and* spiritual advancement. We should all encourage all paths which lead to this end.

In this total picture the scientist and engineer have a vital part to play. They can play that part effectively only if the true nature of their role is understood—first by scientists and engineers themselves—and secondly by the public at large.

What is the role of the scientist and the engineer? To make radios, automobiles, bathtubs, deep freezers, jet airplanes, and atomic bombs? Well, I regret to say, to hear many scientists and engineers talk you would think that's

all they are good for. We have bragged so much about the gadgets we have produced that people are getting a little tired of hearing about them. Even our fellow Americans in other pursuits have caught the fever and brag to the world about American gadgets—implying a rather noticeable disdain for other nations that have fewer gadgets to display.

But do we ever stop to raise the question as to whether the inhabitants of other countries even want the gadgets of which we are so proud? The Hindus of India, I understand, do not want bathtubs. They believe it is unclean to sit in water that has already been soiled. (Personally I agree with them!) They are understandably rather mystified therefore when we brag about how many bathtubs we have.

Again there are many people whose standards of *values* differ from ours. They may want certain things but not at the price they would have to pay. I mean not only the price in dollars but in the way of living. A Chinese peasant on his farm might not care to work in a factory even at a very handsome monetary wage. I have even heard residents of southern California wonder whether the smog is not too high a price to pay for the industrial community we have created. I know many people who wish that no one else would drive a car! I am quite convinced that many a resident of Europe is glad that his highways are not as choked as ours. Is not each group of people entitled to its own wants and tastes?—its own collection of things it does not want?

And so, what is the scientist and engineer for? To turn out endless supplies of things, no matter how much they clutter up the place or how much smoke and dirt they produce or cause, or how much they cost?

I claim it is time to call a halt to our continuing oratory about our wonderful gadgets. We need to ask what these gadgets are for and how they came into being. Most of all we should shed our egotistical assumption that, because we like certain gadgets, people on other continents are deprived if they do not long for them also.

What are they for?

So now I can give my version of what scientists and engineers are for.

Let us start with a scientist.

I begin by asserting that curiosity is one of the most sublime of human attributes. I shall always have a grudge against the man who invented the assertion that "curiosity killed the cat." That phrase has been a menace to the advancement of learning for generations. I personally don't believe it is true. I'll bet the cat was killed either looking for food or for another cat. Most likely the phrase was invented as an outright lie by an impatient parent seeking to terminate a torrent of questions from an alert 10-year-old boy. What a tragedy it is that such boys have been so treated by parents and teachers that by the time they are 18 the natural tendency to ask questions has been thoroughly drilled out of them!

Yet I insist that man as an intelligent human being moves forward intellectually and spiritually solely because some men keep on asking questions all their lives. Some men have a divine curiosity which no one can destroy—and the sum total of human knowledge consists of the answers those men have found to the questions they have asked. Down through the ages scholars have asked many questions about many things. They have found many answers; some were right, others turned out to be wrong. But in the process man's knowledge and understanding grew.

Asking questions of nature

Those scholars who ask questions of *nature*, questions about the physical world, and who then seek nature's answers, are called scientists. Some ask questions about the sun, moon, and stars, others about the structure of the earth. Some inquire about the behavior of living things, others about the nature of matter. All are seeking knowledge, seeking to understand.

One man climbs to the top of Mt. Everest—because Everest is there and he wishes to conquer it. A scientist performs experiments with atoms, because atoms are there and he wishes to understand them. Both men are impelled by a basic human urge. The urge to explore, to conquer, is closely akin to the urge to know, to understand.

That is what scientists are for—to enlarge man's understanding of the physical world.

Why enlarge it? Simply because men are so built that they will never rest until they do understand, until they do conquer their ignorance and satisfy their sublime curiosity.

Yes, I am familiar with the argument that knowledge has practical value too—it enables men to keep warm, to prevent hunger, to make money. But tonight it is my thesis that the conquest of ignorance is good for its own sake, good because it satisfies man's intellectual and spiritual desires. And all men everywhere, as they learn to appreciate art and music and literature, should learn also to appreciate, to understand, and to promote the work of the scholar and the scientist as they continue their quest for knowledge.

And how about the engineer? What is he good for? Is he the one whose job it is make things, to desire gadgets, to build structures? Is it true that while the scientist seeks truth the engineer seeks cash?

Sadly enough many people, including many engineers, think of it in just that way. Naturally we are all proud of the things our engineers have created. It is not unnatural that we brag about them. But just what do we brag about? As I have already said, bragging to a Hindu about a bathtub leaves him wholly mystified. And this leads me to state a rule we too often forget: A gadget is not something that is good (or bad) for its own sake; it is something that is good (or bad) only to the extent that it satisfies an important human want, an important human need, an important human desire.

For example, men need a certain minimum amount of food each day. Therefore devices or techniques which enable them to produce more food, to produce it more economically and to transport it to where it is most needed, quickly and economically, are things to brag about. But they are worth bragging about not because they are cute or ingenious, or because they make the inventor a lot of money, but because they save human lives, reduce human suffering, enable human beings to devote energy to things other than the sheer satisfaction of hunger. Similarly with things that keep men warm when the weather is cold, or cool when the weather is warm, dry when it rains, and so on; these things satisfy basic human needs.

Down through the ages the job of the technologist, the engineer, the applied scientist, has been to develop methods of satisfying human needs.

Now, when a device is invented which does satisfy such a need, the people who have the need will work to acquire the device. They will pay for it. Hence somebody makes some money. And there is nothing wrong about that either. But it is wrong to put the importance of the medium of exchange through which a need is met above the importance of the need itself. We will be doing a favor to everyone if in our own thinking and in our public statements we express the engineers' contributions to society in terms of human needs rather than solely in terms of American dollars. This will have also the advantage that we will examine the real needs of people in this and other countries and the price they would have to pay to fulfill them before we criticize them for not using the things that we invent.

Agents of destruction?

Now, as all of us are only too-well aware, there may arise periods in the history of any country when it must resort to force of arms to defend its independence or to preserve its very existence. Patriotic citizens of that country will use their talents and energies to assist their country to carry on the fight successfully. And so it will come about that scientists and engineers of the country will abandon their normal peacetime pursuits and turn their attention to devising weapons and techniques of warfare. No one disputes the great success these endeavors have achieved in recent years.

This is fine, and scientists and engineers can be proud of the results of their work. But it has all added another difficulty to our problem of public relations and public understanding. For now the scientist and engineer are often looked upon not as patriotic citizens who helped preserve their country's freedom but as diabolical inventors of weapons of death. Again the existence of the thing has overshadowed the purpose for which the thing was developed, the human need which it was designed to meet. The scientist and engineer (I must continue now to use both terms because, in times of crisis, scientists become engineers, temporarily, in order to help get a job done), instead of being regarded as the protectors

of human freedom, are looked upon as the agents of destruction. "Science has outrun human relations," it is said. What does that mean? Actually, science and engineering are our best instruments to promote human understanding. They are instruments to protect human freedom. They are instruments to satisfy man's wants and needs, to advance his welfare. The major objective of scientists and engineers is to make the world a better place in which to live. I somehow wish those words could be engraved in a place where all men could see them—especially those fearful men who, seeing the products of science and engineering, hysterically call for a stop to further invention lest evil men use these products for unintended purposes. Evil men there will always be. But they will not be curbed by asking good men to stop thinking!

Science and technology have become so important a part of the structure of modern American civilization that, like air and water, we have come to take them for granted and even ignore their intrinsic value. In the old days the public could ignore science and technology, for these activities were independent of public attention. The scientist would continue his work in the laboratory no matter what the taxpayer thought. The engineer also went about his business, unconcerned about government activities and policies.

Science and government

A depression and World War II have changed that. All citizens are daily more affected by government than they used to be. This is especially true of scientists and engineers. This is true in the first place because a large share of the nation's scientists and engineers turned their attention to war work during the war, thus bringing about a profound change in direction of the nation's technology. A large fraction of them are still at work on problems connected with war technology. Many others work in areas which were opened up or given a new turn through war developments. These developments created new demands—new needs for scientific and engineering effort. All of these things together greatly increased the need for scientists and engineers. The supply has also increased, though never as fast as the need. Thus there are far more scientists and engineers than ever before, spending far more money than ever before. A far larger fraction of them are working directly on government activities. Those still in private business are more dependent on government orders, or at least on government tax policies. The support of research in pure and applied science has been to a substantial extent assumed by government.

Now I am not trying to argue whether the present situation is right or wrong, sound or unsound. All I say is that it exists. And since it is also manifestly true that our nation needs science and engineering more than ever before, it is desperately important that taxpayers and voters understand more than ever the true role of the technical man.

If the taxpayer thinks of the scientist solely as a maker of weapons of war, he will expect him miraculously to appear when weapons are called for and conveniently to disappear from the tax bills when new weapons seem slightly less urgent. The taxpayer will not be happy, however if he finds that technologists in other nations have invented cleverer weapons than ours. And he will be impatient with any excuses such as "our funds were inadequate," "our equipment was obsolete," "not enough trained scientists could be found." The taxpayer wants things delivered on demand.

A healthy science and technology

So far the taxpayer has nothing to complain about. He has received high dividends on a modest investment. But the temptation to kill the goose is still strong. He forgets that golden eggs came, not because they were ordered, but because there was a goose. The task of our nation today is not solely to order science and technology to deliver certain weapons. It is to maintain a healthy science and technology. Weapons will then come when needed—and all the other things men will want and need will come besides.

The maintenance of a healthy science and technology is largely a matter for the private citizens and private companies, universities, and foundations to provide. But the government stake is so great that the government cannot shirk its responsibility. There is grave danger right now, for example, that a substantial fraction of the scientific research and development going on in nongovernment laboratories will be stopped within a year. When budgets are being cut it is only human nature that urgent, obvious, short-range activities will be cut the least. Scientific research—whatever its ultimate value—does not usually pay off within the fiscal year. Thus certain government agencies, such as the Office of Naval Research, which have carried a large share of the load of supporting research activities are being faced with the possible necessity of 30 or 40 percent cuts. A disruption in research projects would thus take place which years of future effort could not restore. Even from a very practical standpoint this is bad economics. From the standpoint of the long-term welfare and security of the nation it is disastrous.

In this particular emergency it may be necessary for all of us once more to call public attention to the dollar value of science and engineering. But if we confine our attention to this issue we shall only be meeting a series of future similar emergencies. For it is a paradoxical fact that in the long run people will not continue to spend money for things whose sole value is a dollar value. We don't very long spend dollars to buy dollars—we spend dollars to satisfy needs, to fulfill desires, to make dreams come true. The explorers and creators of the laboratory are doing more than creating material wealth; they are bringing the stars to earth, and lifting men to the stars.