Sir Harrie Massey (United Kingdom). For 1965 A. Hocker (Germany) is president, and H. C. van de Hulst (Holland) and M. Golay (Switzerland) are the vice presidents. The work of the council is prepared by two committees, the Scientific and Technical Committee (chairman for 1965, R. Lüst, Germany) and the Administrative and Finance Committee (chairman for 1965, E. Ferrier, Holland).

An essential part of establishing the scientific and technical program is carried out by the four-man Launching Programme Advisory Committee (R. Lüst, chairman), which advises the Scientific and Technical Committee, especially on proposals for payloads. The Launching Programme Advisory Committee prepares these payloads with the help of a number of *ad hoc* working groups. At present there are six working groups: (i) Structure of the atmosphere (chairman, R. Frith, U.K.); (ii) Ionosphere and aurora (B. Hultquist, Sweden); (iii) Solar physics (C. de Jager, Holland); (iv) Planets, moon, comets, and interplanetary medium (L. Biermann, Germany); (v) Astronomy (P. Swings, Belgium); and (vi) Cosmic rays and trapped radiation (B. Occhialini, Italy). All proposals for investigations to be carried out by sounding rockets or satellites will be first discussed by the appropriate working groups.

Summary

The European Space Research Organization, which was established in 1964 for the purpose of promoting collaboration in space research among European nations, has made plans for its initial program. The projects already agreed upon include the launching of sounding rockets for investigations of a variety of phenomena, two small satellites for studies of ionospheric and auroral phenomena, a medium-sized, stabilized satellite and a large satellite for astronomical investigations, and a satellite with a highly eccentric orbit for studies of the interplanetary plasma and magnetic fields.

Although most of the scientific activities connected with its projects will be carried out by research groups in the member nations, ESRO will have, in addition to its headquarters in Paris, establishments in Holland, Sweden, Germany, and Italy.

It is to be hoped that this new European Space Research Organization will make important contributions to space science and space technology. The work has started, and the first sounding rockets have been launched. The outlined program is certainly not a final one, but must be kept flexible. It will open new possibilities for the scientists in Europe and certainly will enable the member states to build up space research in their countries. The success of the organization will depend on its scientific work and on good cooperation among its members.

What Are We Doing to Engineering?

By government support we are inadvertently alienating engineering education from the civilian economy.

J. R. Pierce

It is a commonplace that the federal government provides the major support of research and development in the United States. In terms of total dollars, this is true. In 1963 federal support of research and development in all sectors was 65 percent of a total of about $17.4 billion. But this percentage is by itself very misleading, as we can see from Table 1. Here industries are ranked from top to bottom in terms of net sales. Most large industries have a substantial company-supported research and development effort, aimed at improving old products and devising new ones. Government-supported research and development are concentrated in a few fields (for example, see Table 2) and are larger than company-supported research and development only in the fields of electrical communications and equipment and aircraft and missiles. Further, it appears that such government-supported research and development have not displaced a reasonable company-supported research and development, even in these industries.

This huge government expenditure for research and development in a few particular industries has been dictated by overriding and highly specialized needs or goals of extreme urgency, in space and in defense. Thus federal support of research has caused us to reach ahead, at great cost, in certain urgent directions, rather than affecting industry as a whole. This has led to achievements in nuclear submarines, supersonic aircraft, in radar and guidance, in ballistic missiles and atomic warheads, which are as astonishing as they are necessary, and to magnificent achievements in space.

The Civilian Economy

However, defense and space are only special aspects of our technology. Our synthetic fibers, our excellent and varied food products, our life-saving drugs, our automobiles and the freeways on which they travel, airlines and air terminals, the electric power and the appliances in our homes, the ease with which we can talk with people thousands of miles away, the television, newspapers, magazines, and books which keep us in touch with the world, all give us advantages over earlier generations.

When we trace the history of these technological achievements, we find their origin in science—in the discovery and understanding of the laws of nature. But essential as the understanding of

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nature is, it has taken far more to bring our world into being. Part of what has been necessary is industrial initiative and enterprise. But one essential factor has been engineering, which links man's needs and capabilities with the control of nature that is implicit in the discoveries of science.

Engineers perform many functions. Some of these functions are much like those of scientists, for some engineers through their research add to and particularize the basic discoveries of scientists in a way that is essential to their application. Other engineers invent, understand, and improve devices or components out of which complicated things such as electronic computers, communication systems, machines, factories, and spaceships can be built. Other engineers design these complicated systems. And engineers have an important part in manufacturing and even in marketing.

In all of these activities, the engineer must exploit our understanding of science in such a way as to make its fruits economically available to man. Sometimes, as in defense or space, economic considerations become secondary to a pressing and overriding national need or objective. But, generally, and always in the civilian field, a primary consideration of the engineer is to make any manufacture, either of industrial equipment or of consumer products, cheap enough to insure use. And generally, an economically viable product is achieved through purposeful research and development, rather than as "spinoff" from defense or space technology. Insofar as there is "spinoff," it is clear that defense and space technology have benefited more from civilian technology than civilian technology has benefited from defense and space technology.

Because of the importance of engineering to our welfare, it behooves us to ask what our engineering schools are training men to do. Are they training them to contribute to that 65 percent of all research and development which provides us chiefly with weapons and space shots, or to that other, smaller part which provides us with the good things of life?

We can answer this question by examining graduate engineering education, which today dominates all of engineering education. Undergraduate engineering education is a reflection of the ideas and attitudes of leaders in engineering education. These are men who have been leaders in university engineering research and teaching. Their attitudes reflect the research they have done. In turn, the research and attitudes of the graduate student reflect the research and attitudes of his professor. And the graduate students supply the universities with a new generation of professors, as well as supplying industry with some of its best-trained and intellectually most capable engineers.

Engineering research in universities is a source of new ideas and skills for government and industry. Research in universities is an apprenticeship and challenge essential in training and sharpening the minds of the best students. Research is what keeps university engineering departments intellectually alive and responsive to what science may afford society. Whatever influences university engineering research inevitably and irresistibly influences all of engineering education and all engineering students.

Table 1. Net sales and expenditures on research and development in industries and segments of industries (1958)*.

Industry	Net sales (billions)	R&D expenditures (% of net sales)	
		Company	Noncompany
Food and related products	$61.6	0.1	0
Petroleum refining and extraction	33.5	.7	0
Machinery	23.2	1.9	1.5
Primary metals	23.2	0.4	0.1
Motor vehicles and other transportation equipment	22.8	2.3	1.3
Chemicals and allied industry	21.8	3.1	0.5
Industrial chemicals	(11.2)	(4.0)	(0.9)
Other chemicals	(7.9)	(1.2)	(.2)
Drugs and medicines	(2.8)	(4.5)	(.1)
Electrical and communication equipment	21.7	2.9	6.1
Fabricated metals	18.1	0.4	0.3
Aircraft and missiles	15.4	2.5	14.8
Lumber, wood products, etc.	11.9	0.1	0.1
Paper and allied products	10.7	.6	0
Rubber products	6.7	1.0	0.3
Professional and scientific instruments	4.8	3.3	2.8
Optical, surgical, and photographic instruments	(2.9)	(3.2)	(1.5)
Scientific and mechanical instruments	(1.9)	(3.4)	(5.0)
Other manufacturing	61.6	.3	0.1

* Latest complete figures obtainable.

Money and Consequences

We can see what these influences are by considering who supports the vitally influential university engineering departmental research in engineering. We see from Table 2 that only 6 percent of the support comes from industry. The federal government supplies 79 percent. The National Science Foundation, which has broad objectives, provides about 5 percent of the total support from all sources. But by far the greatest fraction of the total support comes from mission-oriented federal defense and space sources. Further, there is rightly an increasing insistence that such government agencies support only research which has long-term or short-term relevance to their particular missions.

Under these circumstances, it is no wonder that thesis subjects of Ph.D. candidates in engineering are strongly associated with the few sectors of industry relevant to defense and space. It is no wonder that, of those Ph.D. candidates who go to work in industry, a large proportion go to aerospace and defense industry, and that another large fraction who go to universities teach what they have learned in doing defense-supported and space-supported research.

The present state of graduate engineering education has led to unease and complaints on the part of leaders in civilian engineering. They complain that engineering graduates do not want to work in nondefense, nonspace industry and that engineering graduates regard the economic challenge of making a product marketable and available to the consumer as a challenge to be avoided rather than met.

This is not a criticism of the quality of engineering education, which is increasingly high. But the concentration of research support in mission-oriented agencies of defense and space necessarily tends to alienate engineering education both from other national needs (health, education, transportation, and problems of pollution) and from most of American industry. It is to the credit of American engineering educators that they are aware of this problem, but they have been subjected to inexorable financial forces, and these forces have established a pattern which makes it difficult for the educators to follow the dictates of their own wisdom.

The situation is then this: The federal government supports a majority of 65 percent of all research and development. This support is concentrated in two industries, electrical and communication equipment, and aircraft and missiles, and only in these industries does federal support dominate company support. It is through engineers that new technology is created. Federal support of research in engineering at educational institutions is 79 percent of all support received by these institutions, and 82 percent of the government support comes from the Department of Defense and the National Aeronautics and Space Administration. This support has had an overpowering influence in turning a great deal of engineering education away from the productive civilian economy to fields with very different requirements and problems—defense and space. (This has not been true of chemical engineering, which is associated with industries in which the major support of research and development does not come from the government.)

Table 2. Support of research in engineering at educational institutions.

Source	Agency support (% of government total)*		Share of total 1962–63 (%)†
	1960	1970 forecast	
Federal government			79
Department of Defense	68	38	
National Aeronautics and Space Administration	14	33	
Atomic Energy Commission	3	4	
Department of Health, Education, and Welfare	7	8	
National Science Foundation	6	9	
Department of Agriculture	1	4	
Department of the Interior	< 1	1	
Department of Commerce	< 1	1	
Agency for International Development	< 1	1	
Total millions	$157.4	$337.0	
State and local government			6
Industry			6
Other			9

* Figures supplied by the National Science Foundation. † Figures from Information Document No. 4a, Goals of Engineering Education Project, Purdue University (Sept. 1964).

What We Can Do

In the face of this emphasis on space and defense technology, how is the productive civilian economy to advance and prosper? Clearly, among its many needs are engineers who are interested in meeting human needs in a practical and economically feasible way. Can the atmosphere of engineering education be so modified as to produce engineers who will push our productive economy forward?

Should industry support more university research and the government less? Even if industry does increase its support of graduate education and research, it is unlikely that industry will ever supplant the federal government as the main source of support. Wittingly or unwittingly, the nation has committed itself to the federal support of graduate engineering education. Thus, we must hope that the federal government will, in providing support, act in a way conducive to filling the needs of the civilian economy.

The National Science Foundation has been particularly responsive to this need, through putting industrial as well as university engineers on its Divisional Engineering Committee, through using industrial engineers as reviewers for engineering research proposals, and through adopting, as a pertinent criterion for support of engineering research oriented toward public or industrial needs, relevant industrial experience on the part of those associated with the research projects. However, the National Science Foundation provides only a small, though an increasing, part of government support of engineering research.

Whatever the federal government may do, and even though industrial support of university engineering research may remain small compared with government support, industry and engineers themselves must do what they can to see that engineering education is drawn closer to the civilian economy. In doing this, industry could find powerful support in such organizations as the Engineers Joint Council and the new National Academy of Engineering.

It should be quite feasible for industry to increase its support of engineering research in universities. To bring this about, industry must be enlightened enough to support research which is not made unattractive by proprietary considerations. Industrial support must not be much more difficult to obtain than government support, as it now is. At present a faculty member has a familiar, easy, and well-oiled mechanism for applying to a number of government agencies for support. No such mechanism exists for seeking industrial support. Perhaps industry, working through engineering organizations, could supply such a mechanism.

There is another way in which industry could establish a closer relation with universities. The most valuable way in which industries can give engineering students an insight into industrial problems is to employ them in design and development departments during the summer. To the student, this gives financial support as well as invaluable experience. Further, it is the general experience that if a company acts thoughtfully in providing a student employee with a challenging problem, it generally gets full value for his salary and often the inspiration of a fresh young mind. Such summer employment has been widely regarded as a recruiting device. It is far more than that, and whatever recruiting benefits it may have are exceeded by the benefits cited above.

It is quite possible that industry could work with engineering organizations toward establishing a procedure for finding suitable industrial summer jobs for individual students or for selected groups of students.

Whatever the solution or solutions may be, the problem is real and urgent. Government support is alienating engineering education from the civilian economy. If we are to remain strong and prosperous, we must take thought and action to draw engineering education and civilian industry closer together.