era, most recent graduates of the French-Canadian universities are believed to have been absorbed by the long-neglected "Quebec system." It is in this system, embracing French-Canadian business and industry as well as public agencies and institutions, that the *Québecois* is most comfortable. There he can advance professionally without having to adapt to English-Canadian culture.

Many French-Canadians hope that foreign-owned and English-Canadian-owned enterprises in Quebec will come to use French as the principal language of business. This hope may be illusory, inasmuch as some of the most important firms have a continental market and many of their employees come and go between Quebec and English Canada or the United States. The surest way, it seems, to provide promising and compatible job opportunities for the *Québecois* is to redouble efforts to build up his own establishments.

If the development of the Quebec system should ever lag behind the growth of the Quebec middle class, increasing numbers of young university-trained men and women are likely to become profoundly dissatisfied with their lot. The predictable consequence would be a release of political energy certain to prove destructive.

The University of Montreal's actual and potential role in fostering the development required for a prosperous and politically stable Quebec is obvious. Furthermore, this dynamic new university and its sister institutions (Laval and the new University of Sherbrooke) can, by insisting on the intellectual rigor and objectivity which scholarship requires, encourage the examination of the problems of confederation in the most realistic possible light.

—LUTHER J. CARTER

"Hindsight": DOD Study Examines Return on Investment in Research

In recent years, the Defense Department has been spending $6 billion to $7 billion a year on what is categorized as research, development, testing, and evaluation. Most of this money, $5.5 billion out of the current $6.9 billion, is for development, testing, and evaluation—activities that generally result in equipment whose military value can be measured in one way or another. Furthermore, the equipment is tangible evidence of value received when the politicians who appropriate the money inquire about the Department's vast expenditures in this area. The research category, however, presents an altogether different problem, technically and politically.

Over the past two decades, the Defense Department estimates that it has spent about $10 billion on research, with a large chunk of this sum going for undirected basic research. In the current fiscal year, Defense is spending about $1.5 billion for "research and exploratory development"; of this amount, nearly $400 million, mostly spent in universities, is for the support of basic research, and perhaps as much as $100 million in this category is for undirected research. Thus the Defense Department, which is ostensibly supposed to confine itself to the business of defense, is in fact one of the principal supporters of basic research in this country; its expenditures in this area even exceed those of the National Science Foundation, which was especially established for the purpose of supporting basic research.

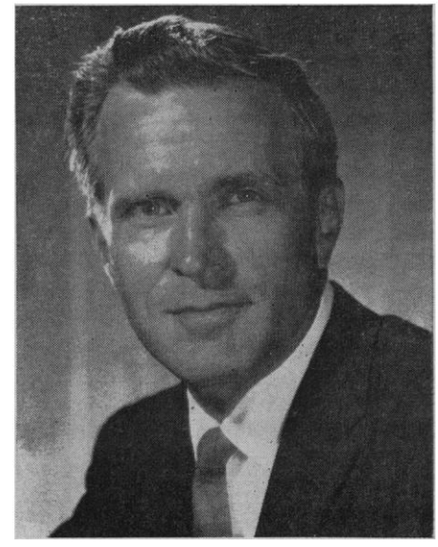
The Defense Department's large presence in basic research can be traced to two facts: (i) it has always been politically easier to get money for defense than for science, and (ii) there has been faith, though little systematic evidence, that basic research ultimately pays off in military value. Over the past few years, however, the large expenditures inspired by this faith have aroused a good deal of skepticism, and, as a consequence, there has been a growing interest in studies aimed at identifying the utilitarian consequences of nondevelopmental research.

In August 1963, at the suggestion of Chalmers W. Sherwin, deputy director for research and technology, the Defense Department undertook a massive retrospective study for this purpose, with the specific object of identifying the origins of science and technology embodied in 20 major weapons systems that, in large part, comprise the backbone of this country's military defenses. Two weeks ago, the first interim report on this study, entitled Project Hindsight,* was quietly released. (Earlier this year, Sherwin was appointed Deputy Assistant Secretary of Commerce for science and technology. The director of the study is Colonel Raymond S. Isenson, an engineer with long experience in technological planning for the Army, who joined Sherwin's staff at Defense in May 1965.)

What must first be observed is that Project Hindsight is not likely to sit well with those statesmen of science who have long propounded the ideology that science pays off best when it is left free to follow its own curiosity. For the major theme that emerges from this first report on Hindsight is that the Defense Department's huge investment in basic research has had little direct consequence for advanced weaponry. A hundred arguments can be thrown at this conclusion, but the fact is that Hindsight arrives at the finding that the "contribution from recent [essentially, post-1945] undirected science to the systems we have studied appears to have been small." The report acknowledges that "The sequence of contributions in atomic and nuclear physics culminating in the discovery of fission in 1939 has had a revolutionary impact on military arms and strategy." And it points out that contemporary weaponry is almost wholly dependent on the "organized body of physical science extant in 1930—classical mechanics, quantum mechanics, relativity, thermodynamics, optics, electromagnetic theory and mathematics. . . ." But, in terms of providing a rationale for the Defense Department's huge financial support of undirected basic research, Hindsight has little to offer.

* Available from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151.

Colonel Raymond S. Isenson



Chalmers W. Sherwin

On the other hand, the report states that applied research—defined as research directed toward the timely gaining of knowledge in areas of specific interest to the sponsor—has paid off well for new weaponry, leading to the conclusion that "the length of time to utilization of scientific findings is decreased when the scientist is working in areas related to the problems of his sponsor."

The methodology employed by Hindsight was as follows: Teams of 5 to 10 scientists and engineers were appointed to study each of the 20 weapons systems, which included nuclear warheads, radar, an assortment of missiles of various ranges, torpedoes, mines, the 105-mm howitzer, the C-141 air transport, and a navigation satellite.

The assignment of these groups was to "dissect" the systems and identify "each contribution from recent [post-1945] science and technology which . . . is clearly important either to increased system performance or to reduced cost. . . ." Each contribution was termed an "event" and efforts were then made to identify the contributors, cost, source of funds, motivation, and pathway to eventual incorporation into the weapons system.

An analysis of 15 of the 20 systems under study turned up 638 events, 39 percent from Defense in-house laboratories, 49 percent from industry, 9 percent from universities (including research contract centers), 2 percent from non-DOD federal laboratories, and less than 1 percent from foreign laboratories—which conforms fairly well to the actual distribution of Defense research funds. (In a note of support for the productivity of the in-house laboratories, which, over the past 20 years, have fallen behind industry as objects of Defense support, the report observes that on the basis of events per dollar, these facilities compare very well with industry.)

The principal conclusion that emerges from the study—which Defense says took 40 man-years of effort—is that, whether or not necessity is the best mother of invention, it has tended to play that role in weapons technology.

"A clear understanding of a DOD need," the report states, "motivated 95 percent of all events." Noting that "37 percent of the events which occurred after engineering design was initiated were necessary to the ultimate performance of the system," the study states that "these late appearing events were largely not predictable in advance. . . . Whatever the reason it appears that an effort to actually build and operate a complete, working system (not just produce a paper design) generates a burst of innovative activity."

As far as the proportions of science and technology incorporated in the weapons system are concerned, the Hindsight study offers little direct justification for Defense support of nondirected basic research. "Of the Science Events," it reports, "the great majority (6.2 percent of all Events) were applied research, clearly oriented toward a DOD need. Most of the balance (1.5 percent of all Events) was applied research with a commercial objective (there were 8 Events in the transistor field at the Bell Telephone Laboratories). Only two Science Events (.3 percent of all Events) were identified that appeared to have a minimum relation to any applied objective. They were the early development of the shock tube at Cornell University and a project in statistical sampling at Wayne State University." The study adds that both of these were funded by the Office of Naval Research in the early 1940's.

At a time when basic research is under skeptical scrutiny, the implications that might be read into the Hindsight report are rather fearsome for those who must plead the case for federal support in this area. When the report, prior to release, was making the rounds of federal agencies, NSF and the Office of Science and Technology—the main bastions of basic research proponents in the federal hierarchy—expressed some concern about the return ascribed to the Defense Department's investment in basic research. That particular section was subsequently rewritten. In the original version, it opened with, "we conclude, in the systems which we studied, the contributions from recent undirected research in science was very small." The final version was amended to state that the "contributions from recent [post-1945] research in science were greatest when the effort was oriented." As far as can be ascertained, no effort was made to have the report acknowledge that the practitioners of technology get a good deal of their training from the practitioners of basic research: nor, apparently, was any effort made to present the argument that, if it frequently takes 30 years for basic research to show up in new technology, it might be useful to examine the process that seems to live so comfortably with this lag.

In any case, when the statesmen of science ascend Capitol Hill next year to defend their requests for ever-growing support of basic research, they might profitably have something better to offer than expressions of faith that basic research pays for itself.

The Hindsight study concludes that the $10 billion that Defense has spent on science and technology since 1945 has been "paid back many times over" in more effective weaponry. But little, if any, rationale is offered for that very sizeable amount of money which the Department has been providing for basic research.—D. S. GREENBERG