encompass HUD, OEO, and ATD, in a kind of Department for Domestic Affairs or Human Resources Agency (Washington *Post*, 8 December 1968; *Time*, 13 December 1968, p. 17).
2. None of the proposals cited in (*1*) advocate the concentration of all scientific activities in one department. President Nixon, in a preelection statement, promised that there "would be no federal scientific czar," but this does not preclude the concentration of some scientific or technological efforts, especially new ones.
3. On the same point, see C. L. Schultze, "Budget alternatives after Vietnam," in *Agenda for the Nation*, K. Gordon, Ed. (Brookings Institution, Washington, D.C., 1968), pp. 48–63.
4. J. A. Clauson, *Contemporary Social Problems*, R. K. Merton and R. A. Nisbet, Eds. (Harcourt, Brace & World, New York, ed. 2, 1966), p. 47.
5. A. M. Weinberg, *Reflections on Big Science* (M.I.T. Press, Cambridge, Mass., 1967), p. 141.
6. *Accident Facts* (National Safety Council, Chicago, 1968), p. 40.
7. For two recent discussions of the promise in this area as well as references to other discussions, see H. J. Brudner, *Science* **162**, 970 (1968) and P. H. Abelson, *ibid.*, p. 855.
8. CBS is reportedly working on such a development; see New York *Times*, 11 December 1968.
9. *Task Force Report: Science and Technology* (Government Printing Office, Washington, D.C., 1967), p. 1.
10. In Britain, recently, a special nonprofit institute was set up to bring engineering closer to surgery. The organization is called the Bath Institute of Medical Engineering.
11. For a fine discussion of the technical, administrative, and political difficulties encountered in one area, see R. Starr and J. Carlson, "Pollution and poverty; the strategy of cross-commitment," *The Public Interest* **1968**, No. 10, 104 (1968).
12. *Federal Funds for Research, Development and Other Scientific Activities Fiscal Year 1965, 1966, 1967* (Government Printing Office, Washington, D.C.).
13. The relations between government and universities were examined recently from a large variety of relevant viewpoints in essays included in *Science, Policy and University*, H. Orlans, Ed. (Brookings Institution, Washington, D.C., 1968).
14. J. Schmookler, *Invention and Economic Growth* (Harvard Univ. Press, Cambridge, Mass., 1966). See also R. Nelson, *J. Business* **32**, 101 (1959).
15. "First Report on Project Hindsight" (Department of Defense publication) (Government Printing Office, Washington, D.C., 1966).
16. See D. S. Greenberg, *The Politics of Pure Science* (New American Library, New York, 1967), pp. 32–33.
17. The Illinois Institute of Technology is reported to be completing a study with more "depth" reporting and heavier emphasis on nontechnical elements (private communication).
18. *Chemistry: Opportunities and Needs* (National Academy of Sciences–National Research Council, Washington, D.C., 1965); related findings are being reported from a study now being completed under the auspices of the Illinois Institute of Technology, supported by the National Science Foundation (private communication).
19. On this point see "University units of urban study hit as failures," *Chron. Higher Educ.* **3**, No. 6, 1 (1968).
20. D. Wolfle, *Science* **162**, 753 (1968).
21. J. S. Coleman, E. Q. Campell, C. J. Hobson, J. McPartland, A. M. Mood, F. D. Weinfeld, R. L. York, *Equality of Educational Opportunity* (Government Printing Office, Washington, D.C., 1966).
22. D. P. Moynihan, *Commentary* **1968**, 19 (Aug. 1968).
23. For a fine background analysis of the relevant domestic programs, see J. L. Sunquist, *Politics and Policy: The Eisenhower, Kennedy and Johnson Years* (Brookings Institution, Washington, D.C., 1968).
24. On the position of the Nixon administration, see J. Spivak, *Wall Street Journal*, 11 December 1968.
25. The technological adaptations required to make jeeps into fire-fighting jeeps for use in urban areas are not great but are sufficient to be classified as a technological, and not only an administrative (or "logistic"), innovation.
26. The work on which this article is based was supported in part by a grant from the Russell Sage Foundation. I am indebted for comments on an earlier version to Walter G. Farr, Harold Orlans, William Rosen, Bernard Russell, Mary Helen Shortridge, Herbert Stein, and others.

NEWS AND COMMENT

The Eisenhower Era: Transition Years for Science

In his years of service in his country's highest military and political posts Dwight D. Eisenhower was at the center of world events influenced more profoundly than ever before by science and technology.

During the two terms of his presidency, the United States developed the capacity to deliver thermonuclear weapons by ballistic missiles, took the first steps into space, and made crucial advances in the peaceful uses of atomic energy. During this period also relations between science and government were fixed in forms which still prevail.

As a West-Point trained professional, Eisenhower never lost an interest in technical matters. But his career was spent largely in staff work and planning, particularly in the decade of high command when he was concerned primarily with grand strategy and military diplomacy. When he became President, the habits of a lifetime caused him to expect his science advisers to operate in the rather formal "general staff" structure he created in the White House. Those who knew him well observe that he came to place increasing confidence in his civilian scientific advisers as his administration progressed.

Eisenhower declared his attitude toward basic research in a memorandum he issued in 1946 as Army chief of staff. He emphasized that the importance of science to the military had been demonstrated during World War II and urged that scientists be given the greatest possible freedom to carry out research. In effect, he was giving his blessing to the efforts of Vannevar Bush and his associates in the wartime Office of Scientific Research and Development to insure the conversion of the wartime alliance between government and science to a system of government support of university research on a scale undreamed of before the war.

Eisenhower's presidency at Columbia University after his retirement from the Army proved to be an interlude, rather than a new career. Establishment of the Institute of War and Peace Studies at Columbia and founding of the American Assembly during that period are identified with Eisenhower, but he was increasingly involved in the moves to create a North Atlantic Alliance. This led to his return to military life as Supreme Allied Commander in Europe, the creation of NATO, and ultimately to his nomination to the presidency and election in 1952.

He took office pledged to end the Korean War and committed to a policy of "fiscal responsibility" and the reduction of federal expenditures. His party's policies and his own personal views made him uneasy about increasing spending on activities not traditionally supported by government, such as research and education.

At the beginning of Eisenhower's first term, when the domestic political scene was dominated by Senator Joseph McCarthy, relations between the academic and scientific community and the Administration were strained by loyalty battles in the universities and particularly by the withdrawal of Robert Oppenheimer's security clearance. Eisenhower was not personally implicated, but there is no question that many scientists at the time were reluctant to serve in advisory roles to the government. During this period the scientist closest to the President was probably the physicist I. I. Rabi. The two had become personal friends while Eisenhower was at Columbia and Rabi played a prominent part in establishing a NATO science program. Major credit for healing the breach between scientists and the Administration, however, is accorded by insiders at the time to

Lee A. DuBridge, the Caltech president, who was active in the science advisory committee of The Office of Defense Mobilization in the Executive office staff structure. DuBridge was concerned about a drift in decision-making on military technology. It was apparently due largely to DuBridge that a Technical Capabilities Panel of the ODM science advisory committee was formed under the chairmanship of James R. Killian, president of M.I.T. The panel members were mostly distinguished civilian scientists, drawn from industry and the universities. Their report was never made public, but it is known that their survey of technological possibilities was influential in starting such key programs as those that produced the U-2 reconnaissance plane and the Polaris submarine. A similar study chaired by John von Neumann on missile capabilities had a direct effect on U.S. official attitudes toward missile development.

The Gaither Report

The same formula was used after Sputnik I, when a committee of independent citizens, regarded as military experts, headed by Rowan Gaither conducted a study of the potential consequences of a Soviet preemptive nuclear first strike, and made recommendations in the still-secret Gaither Report for the protection of U.S. retaliatory forces. Probably no series of reports by private citizens on defense questions has ever been so influential except for the famous scientists' instigation of development of the atom bomb.

In scientific affairs, the Eisenhower years fall into two distinct phases—pre-Sputnik and post-Sputnik. After Sputnik I, new science advisory machinery was constructed to serve the President. The post of special assistant for science and technology in the White House staff was created and the ODM science committee was upgraded into a President's Science Advisory Committee (PSAC). It was Killian, chairman of the Technical Capabilities Panel, who was named first Presidential Science Advisor, and DuBridge apparently had a strong hand in the appointment.

In the early days, the science adviser and his small staff were relied on heavily for advice on the selection of weapons systems and on arms control matters. At that time there was no Directorate of Defense Research and Engineering (DDR&E) or Advanced Research Projects Agency (ARPA) in the Pentagon and no Arms Control and Disarmament Agency (ACDA). Killian and his successor George B. Kistiakowsky and PSAC were influential in providing the Secretary of Defense with alternative sources of advice on technical matters within the Pentagon, most notably DDR&E and ARPA which were organizations directed and partly staffed by technically trained civilians.

Creation of a space agency after the Sputnik scare raised the question of whether the program should be placed under civil or military control. And the controversy that preceded the formation of the National Aeronautics and Space Administration was in many respects reminiscent of the fight over establishment of the Atomic Energy Commission a decade earlier. Eisenhower's science advisers strongly urged that the space effort be a civil enterprise and the President seems never to have wavered in support of this principle.

By those who worked in the arms control field, Eisenhower is remembered as being cautious but hopeful throughout his Administration that progress in arms control could be made. He put forward the Atoms for Peace Plan, under which the International Atomic Energy Agency could receive and distribute nuclear material for peaceful international projects and was author of the "Open Skies" proposal which would have provided reciprocal overflight rights to guard against surprise attacks.

In 1955 he appointed Harold E. Stassen special Presidential assistant for disarmament, a first step in the process which led to the creation of ACDA in the Kennedy Administration.

The idea of a nuclear test ban treaty was first seriously discussed publicly by Adlai E. Stevenson in the 1956 presidential campaign. Eisenhower, however, evinced a strong desire to see progress made toward a test ban and took considerable personal interest in the discussions which started with the so-called conference of experts called in Geneva in 1958 to discuss the state of technology relevant to inspection and verification of a test ban treaty. The U-2 crisis and arguments that underground testing could not be satisfactorily detected interrupted progress toward a comprehensive test ban. The subsequent agreement to ban nuclear tests in the atmosphere, however, owes much to negotiations and technical work carried out during the latter years of the Eisenhower Administration.

The Eisenhower legislative record on science is somewhat hard to decipher because for 6 of his 8 years in the White House, Republicans were a minority party in Congress. Under Senate Majority Leader Lyndon Johnson and House Speaker Sam Rayburn the Democrats tended to be more expansionary in support of science and education than the Administration or congressional Republicans. The difference was most notable in medical research. Under the solicitous care of Congressman John Fogarty and Senator Lister Hill, medical research expenditures rose from about $81 million in 1955 to nearly $700 million in the year Eisenhower left office. While Eisenhower was a proponent of medical research, the spectacle of Fogarty and Hill seeing the Administration budget proposals for medical research and then raising the ante like big bettors in a poker game is said to have been an annual source of irritation to the President.

Eisenhower's Accelerator

The Joint Committee on Atomic Energy also pursued a rather independent science policy, particularly in such areas as expanding university training and research. The Joint Committee also followed a headstrong course in pushing development of a nuclear-powered aircraft. Eisenhower resisted the project, which was canceled after President Kennedy took office. A project in high-energy physics, which attracted Eisenhower's interest and support—building of a really big linear accelerator at Stanford—on the other hand came to be known as "the Republican accelerator" and was not approved until after he left office.

In general, however, as a minority-party President, Eisenhower achieved a remarkably good modus vivendi with Democratic congressional leaders in dealing with science affairs as with most other important matters. The annual budget of the National Science Foundation rose to about $82 million during his terms in office. Defense R&D went from about $2.8 billion in 1953 to $7.7 billion in 1961. Nondefense R&D climbed from about $269 million to $1.1 billion in those years.

On principle, Eisenhower opposed attempts to pass legislation to give general aid to education. In 1958, however, the National Defense Education Act was passed in the name of national security providing a spectrum of

NEWS IN BRIEF

• **SENTINEL POSSIBLE FOR WASHINGTON**: Although the Administration has rejected the Pentagon's original plan for an anti-ballistic missile (ABM) system to be deployed in the nation's cities, President Nixon has recommended that at least one city —Washington, D.C.—be in line to receive a Sentinel site. In a press conference, Defense Department Deputy Secretary David S. Packard said that the President is not recommending the Washington site as an initial step. He said this would preserve the option for the President to curtail or reorient the system if arms control agreements are reached. Packard said an ABM site was proposed for the Washington area because the Capital is considered an important command and control center.

• **CANCER LABORATORY NEAR COMPLETION**: The National Cancer Institute has announced that a new $3.5-million maximum-security virus laboratory, designed to study viruses that may cause cancer, will be open soon in Bethesda, Md. The laboratory, which Cancer Institute officials say is the only one of its kind in the world, provides security conditions similar to those used in handling radioactive materials to insure that the viruses, which might possibly be contagious, do not escape into the atmosphere. The Institute has also built a $200,000 mobile laboratory, which can be moved to any research center in the nation that needs specialized virus-containment facilities.

• **SCIENTISTS PROMOTE POLITICAL ROLE**: A group of about 100 scientists, mostly physicists, have banded together to take a more active role on political and environmental questions which affect them. Scientists for Social and Political Action, organized by Charles Schwartz at the University of California and Martin Perl of Stanford University, held its first official meeting at the American Physical Society meeting in New York. A move last July to encourage the American Physical Society to take a more active role in politics failed and now scientists who had encouraged political involvement have formed the new group as individuals. A main concern of the group is that scientists have become more and more dependent on the government, particularly the Defense Department, for research funds. Members plan to stress a sharp division between scientific and military interests; they will offer their services as science advisers to local citizens and the government.

• **KENNEDY OVERSEES NSF AUTHORIZATION BILL**: Although it has not been announced officially, it is understood that Senator Edward Kennedy (D–Mass.) will be chairman of a special subcommittee, which will handle the National Science Foundation authorization bill this year. Kennedy's special subcommittee on science handled the NSF reorganization bill last session.

• **PSYCHOLOGISTS FOR SOCIAL ACTION**: The American Psychologists For Social Action (APSA) has been formed to enable psychologists to take action on problems relating to "militarism, racism, and poverty." APSA, which claims about 1000 participants in its activities, was formed at the annual meeting of the American Psychological Association in September 1968. APSA membership consists of individuals and local groups throughout the country.

• **FREE TO FEE**: The Smithsonian's Science Information Exchange (SIE), which receives about 90,000 requests for information on ongoing basic and applied research from scientists each year, plans to charge all users to cover the costs of expanding services. SIE has previously offered subject searches in current research fields without cost to private users. Because of high costs, it limited certain other services to federal users only. Under the new system, the Smithsonian will make available to nongovernment scientists certain previously limited services, such as computer listings, compilations, and catalogs of ongoing research.

• **ANTI-ABM**: A telegram-letter urging President Nixon not to approve deployment of the anti-ballistic missile (ABM) system, which was circulated among National Academy of Sciences (NAS) members by NAS members George Wald and Bruno Rossi, was sent to the President before he announced his decision on the ABM 2 weeks ago. The letter now has the signatures of about 270 of the Academy's 845 members.

programs which set precedents for later federal aid measures at both school and university levels.

As President, Eisenhower maintained attitudes shaped essentially by his Mennonite background, a boyhood in a turn-of-the-century Kansas small town, and a military career, most of which was spent in an Army which knew neither global responsibilities nor astronomical defense budgets. The prewar U.S. Army in which Eisenhower served for 25 years was governed by the tradition of the supremacy of the civil over the military authority and the assumption that between wars the standing army would be small and the budgets modest. Officers expected to serve out most of their careers in obscure army posts in the South and on the old frontier; horizons were narrow and prospects limited. It is hardly surprising that Eisenhower's economic, social, and political views leaned toward the fundamentalist. What, in historical perspective, may seem surprising is that Eisenhower and others of his generation performed so well in vastly demanding wartime and postwar roles for which their lives had seemingly not prepared them.

Eisenhower's experience was distilled in his farewell address in 1961, a sort of valedictory to power which is probably the most eloquent and certainly the best remembered of his speeches. His warning against "acquisition of unwarranted influence whether sought or unsought by the military-industrial complex," may ultimately rival in familiarity Washington's farewell warning against foreign entanglements.

Less well-remembered but no less pointed was his caution against the potential effects of what he called the "technological revolution."

"Today," he said, "the solitary inventor, tinkering in his workshop, has been overshadowed by task forces of scientists in laboratories and testing fields. In the same fashion, the free university, historically the fountainhead of free ideas and scientific discovery, has experienced a revolution in the conduct of research. Partly because of the huge costs involved, a government contract becomes virtually a substitute for intellectual curiosity. . . .

"The prospect of domination of the nation's scholars by federal employment, project allocations, and the power of money is ever present—and is gravely to be regarded.

"Yet in holding scientific research and discovery in respect, as we should,

we must also be alert to the equal and opposite danger that public policy could itself become the captive of a scientific-technological elite."

George B. Kistiakowsky, who served as Eisenhower's science adviser during his final 2 years in the White House, says that Eisenhower had the problem of the military-scientific establishment very much on his mind and was concerned with the reaction to his speech. After the speech Kistiakowsky, in fact, took the trouble to issue an explanation of the references to science (*Science*, 10 February 1961), making it clear that Eisenhower was not referring to basic research but to industrial research of a military nature.

Kistiakowsky told *Science* a few months ago that Eisenhower was much in favor of academic science, but that the President perceived that a kind of technological momentum takes over in weapons development. "Once it appears possible to do something," said Kistiakowsky, "there is a tremendous urge to do it. That is what worried President Eisenhower."

Kistiakowsky concurred strongly on this point, but like many other academic scientists, did not agree with Eisenhower's views on everything while he was in the White House. In summing up his own feelings, however, he probably comes close to a national consensus on President Eisenhower when he said he had "enormous admiration and fondness for him as a person. He was a thoughtful and sincere patriot who put the welfare of the American people above everything else. . . ."

—JOHN WALSH

Uranium: Three European Nations Plan To Build Centrifuge Plants

London. Among U.S. government policy makers, "centrifuge" is one of the naughty words of nuclear nomenclature—so much so, in fact, that several years ago the AEC banned public references to it and also asked America's allies to keep quiet about whatever they might be doing in the field. The reason is that centrifugation is a cheaper, though technically very difficult, process for producing enriched uranium. And, since the United States has unswervingly tried to discourage nuclear self-sufficiency in any other nation, it has long looked upon the centrifuge process as something it would prefer not to see come into being.

That preference, however, is now on the verge of being rendered irrelevant, for, last month, ministers of Britain, West Germany, and the Netherlands met here and announced that the technical problems have been solved and that their countries intend to cooperate in building two centrifuge plants for the production of enriched uranium. No costs were discussed, but it is expected that the plants will not be any cheaper to build than gaseous diffusion plants—now the sole source of enriched uranium—of comparable capacity. The advantage lies in the fact that centrifugation requires about one-tenth as much electric power as gaseous diffusion does, and in Europe, where power costs are high, this difference is crucial. Also, unlike the gaseous diffusion process, it is possible to start on a small scale and simply add more centrifuges as more production is required.

The announcement was accompanied by strong assurances that the tripartite undertaking would adhere to existing agreements against the spread of nuclear weapons, and it was stressed that the plants would be constructed in Britain and the Netherlands. Germany, whose big, high-quality nuclear industry raises worrisome suspicions, especially to the east, will house the administrative headquarters for the undertaking but, for the present at least, will be out of bounds both for the manufacture of the centrifuges and for the enrichment plants that will employ them.

Thus, the centrifuge agreement is unlikely to produce any short-term effects of military significance—the stated cause of U.S. concern over the process. But, in its political and economic implications, it may well be one of the most important technological developments to take place in Europe for a long time. For, all at once, it offers the possibility of Europe's ending American domination in the booming worldwide market for enriched uranium, which is expected to reach over $1 billion a year by 1980. To those concerned, the centrifuge agreement offers a reasonable assurance that Germany will move no closer to a wholly independent nuclear capacity, though it should be pointed out that, in view of Soviet sentiments on this issue, the Germans more than anyone else recognize the suicidal implications of a step in that direction. Finally, against a backdrop of France keeping Britain out of the Common Market, the agreement ties Britain into a major European endeavor that makes economic sense—in contrast, for example, to the Concorde supersonic project or to European space efforts, both of which must rely in large part on the dubious banner of "prestige" whenever they run into trouble.

The French, who have followed their own nuclear development program to the detriment of European cooperative efforts, are said to be furious over the three-nation deal and are suggesting that Britain is acting irresponsibly in making Germany a partner in the production of enriched uranium. What this ignores is that the Germans are widely reported to have developed a centrifuge system on their own but, under the agreement, will forego having any of the plants on their own territory.

In view of the fact that a centrifuge plant is neither easy to build nor at all indispensable for a would-be bomb builder, U.S. touchiness on the subject suggests the possibility that commercial rather than military considerations underlie its longstanding concern about the process becoming feasible. Or it may reflect America's self-righteous belief that she alone is sufficiently sensible and trustworthy to possess all the means and materials for building a nuclear arsenal. In any case, for nearly three decades—in fact, since the Manhattan Project first headed toward a centrifugation process and then quickly abandoned it because of technical difficulties—the alternative gaseous diffusion method, because of its necessarily vast scale and matching operating costs, has pro-