the dangers of changing political view and at the same time maintains an effective control to insure a high level of competence.

Canada possesses a wealth of natural resources, and their development will make heavy demands on science. Progress has been encouraging, particularly in the fundamental sciences, but there are still areas in which greater effort is required. Undoubtedly, increasing population and increasing university effort will introduce greater complications in organizing effectively for the future scientific activities of Canada. It seems likely that the trend will be a growth of the National Research Council to a point at which some portion becomes disproportionate in size to the remainder, and that this portion will then be separated and embodied in a new organization, in much the same manner that Atomic Energy of Canada achieved separate status.

Organization of Science Here and Abroad

Varying national patterns for support of science result from basic constitutional differences.

Don K. Price

In considering the merits of various forms of government, and particularly of the various patterns of government organization for the support of science, it is a great temptation to think in conventional mechanical terms. The organization chart has bemused us into believing that we have a simple choice to make between various clear-cut alternatives; as one author recently put the matter, political science is a much simpler subject than any of the natural sciences, because there are basically only a few different forms of government and the problem is simply to select one of them.

But this general symposium, I am glad to see, has not fallen into this way of thinking, which is as obsolete in the 20th century world as Newtonian physics. Hiscocks, in describing a system in which the status of science is intertwined with the rich historical traditions of the Privy Council; Ballard, who looks on government organization in Canada in its complex interconnection with the structure of great international business corporations; and Major, whose account of similar problems in Norway leads us into the background of three Scandinavian dynasties, the future complexities of European integration, and the contemporary arrangements for diverting football pools into the support of research—all of them have illustrated the fascinating complexity of our problem.

But I do not think I can follow their example and give you, with respect to the United States, a summary outline of our scientific organization. My assignment is rather to draw comparisons. This, I think, can be done best not by looking closely at organization charts but by trying to trace some of the main threads of similarity and difference that mark our several systems. And if I note some of the unique points in the American system, no one should take me to mean that I consider them points which other countries should imitate. Hiscocks, for example, was quite right in suggesting that in many ways an ideal pattern would lie somewhere between the British and the American extremes.

I am tempted to define those extremes by comparing the official role of science in British society with the way in which American scientists actually operate. Hiscocks quoted Hooke as defining the role of the Royal Society thus, in the 17th century: "To improve the knowledge of all natural things . . . by Experiment (not meddling with Divinity, Metaphysics, Moralls, Politicks, Grammar, Rhetoric, or Logick)." Science, like administration, has always in the United Kingdom dutifully acknowledged its subordination to, or at least its separation from, politics. If we are to contrast our classic traditions, I would like to recall the chief of the Patent Office in the days of John Quincy Adams who was discharged not for lack of scientific ability but because he grossly neglected his duties in order to spend his time in stirring up republican revolutions in Latin America.

But this is an unfair contrast. Much more to the point is Hiscocks' observation that the British are traditionally strong on the side of basic science; the Americans, on applied science and engineering. We may note a parallel tendency with respect to the type of interest that natural scientists typically take in governmental affairs. For in recent decades it has been the British and European scientists who have shown their interest in governmental affairs by theoretical writings on the relation of science to politics, while in politics, as in science and technology, the interest of leading American scientists has been channeled into participation in specific program fields. For some reason it is we, rather than the British, who are working things out in this business by a pragmatic rather than an abstract philosophy.

If we are to search for an explanation, I am tempted to follow up on Ballard's cue. He noted that "the fact that the distribution of executive and administrative responsibility in the Canadian Government departs from that in the American Government has probably influenced significantly the organization of science in the two countries." For what he says of the Canadian government applies, I believe, to the Norwegian as well, and even more to the British.

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Two Currents of Thought

To begin the story, let me look back a bit into history. Among American scientists, in relation to politics, there have been two main currents of thought. The first was the dominant one in the days of the founding fathers. Men like Thomas Jefferson, Benjamin Franklin, and John Quincy Adams were by modern standards merely amateurs of science. But among them were a few who were accepted as leaders by European scientists of the day, and in no other country did practical statesmen put such faith in the potential contribution of science to public affairs. In France the scientists became Encyclopedists, but the effect of the Great Enlightenment in America was to bring scientists directly into statesmanship, and to make even our lawyers think in terms derived from science rather than from tradition—rather like Chancellor Kent who hoped that our political institutions would draw their strength from "free investigation and faithful experiment."

But like many a revolutionary impulse, this one came from the learned rather than the popular elements and faded rapidly as the popular elements gained the ascendancy. With the Jacksonian democracy the frontier attitudes triumphed. It took many years for John Quincy Adams to persuade the Congress to accept the endowment offered by James Smithson, and none of the early presidents could put over their pet idea of a national university. By mid-century the scientists were disillusioned with frontier democracy and were advocating the creation of a National Academy of Sciences, with a wistful eye on the honorifics and prestige that were attached to the academies of Paris, Berlin, and Saint Petersburg.

But soon science came back as an active force in our politics in forms that Jefferson and Adams could not have foreseen—forms that fit the peculiar structure of our society and our federal system of government, and that have rarely been appreciated, at home or abroad. Perhaps we can identify the patterns of this development best by asking general questions. How well off is the scientist in American government? What influence does the science adviser have on general policy? How is science supported?

If we can distinguish some pattern in the answers to these questions, we may also speculate with respect to the future effect that science may be having on our political, economic, and social institutions.

In Civilian Government

First, then, how well off is the scientist in the American government? The European or Asian intellectual, particularly during the McCarthy period, has been inclined to think that the American scientist, like the American literary figure, has no status or influence in American politics or administration. This notion comes, of course, as a great shock to anyone who grew up in the Washington bureaucracy. For he takes it for granted that in the American civil service it is the scientists who have the greatest prestige and the best salaries. It is the scientific civil servants for whom the Congress earmarks the great majority of positions for whom exceptionally high salaries are permitted, and whom the congressional committees call for independent advice on the most fast-moving fields of public policy. And it is the scientists who move up into the top administrative positions in most of the federal bureaus whose programs have anything to do with science. All of these things happen as a matter of course in Washington; but all of them would be quite impossible in the governments of Canada, the United Kingdom, or most countries in Europe.

The reasons may be seen plainly in the history of the United Kingdom, which set the pattern for Canada and, to some extent, for Norway. The 19th-century reform of the British civil service was not a reform to abolish a spoils system. There was no spoils system to begin with. The merit system, on the contrary, was needed to replace a system of family or semifeudal patronage in which a civil servant acquired almost the same vested interest in his job that he would have had if he had acquired a church living—which was, indeed, in many cases his alternative. This was a system of great stability, high order, and authority; the effect of the new competitive merit system was to make it efficient. And all this was done before the scientists began to enter in great numbers. When they did come in, they came in beneath an administrative layer of high prestige and fixed status, in which the career administrators and the career politicians had studied the same classical curriculum at the same senior universities and were members of the same clubs.

In the United States the story was radically different. Here in the mid-19th century, the greater instability in our public service was at the top. Rotation in office plagued particularly the top administrative jobs. Civil service reform was begun at the bottom and worked upwards. And it moved upwards furthest and fastest when it was the scientists rather than the reformers who took the lead. Not many years ago most of the career bureau chiefs had come up through the scientific and technical fields. This came about in part because there was no fixed career hierarchy to block the way. In part, it was because Congressmen could be persuaded to give up patronage most readily in positions that had highly specialized and scientific qualifications; you could prove that an ordinary politician did not know how to design a lighthouse or build a bridge or work out tables of navigation, but politicians were more confident that they could fill positions requiring general administrative competence. And finally, it was in the scientific and allied professional fields that there was enough *esprit de corps* to lobby for freedom from politics.

The greater status and prestige of the scientists in American administration went so far as to lead to imitation by the nonscientific fields. Indeed, many of the difficulties in our personnel system which scientists protest most bitterly have come about because personnel specialists know they can defend themselves against political criticism most effectively by creating a system depending on detailed objective tests and quantitative methods and involving its own technical jargon. The excesses of politics have been restrained by pushing forward the scientific frontiers, but in the process not enough room has been left for general administrative judgment.

The Military Side

I have been talking, of course, about the civilian side of American government. The contrast with the military side is as instructive as the contrast with the British system. Civilian scientists in the United States military departments complain that their chances of promotion are blocked by the military habit of reserving top administrative positions for career officers—a complaint which British scientists have traditionally made against the civilian administrative class.

In the United States military service, each department's career service is headed by an officer who is unquestionably the peak of the hierarchy. By contrast, in a British military service no officer has an equivalent position of undisputed command; the chief of staff sits as a member of the Army Council (and as the First Sea Lord on the Admiralty Board), which somewhat dilutes his authority and his control over such key matters as top promotions. The contrast on the civilian side between the two countries is in exactly the opposite direction. In the United Kingdom each civilian department is headed, under the minister, by a single career permanent secretary, whereas in the American civilian department there is no career position which even remotely resembles the peak of a hierarchy for policy and administrative purposes.

Yet, paradoxically, this status of the military career officer in the American government confirms rather than disproves the general difference I was trying to describe, because the American military officer won his position in the eyes of the Congress as simply a superior kind of scientist or technician. The ideal of the citizen soldier—the politician leading the troops—died hard, after Washington and Jackson and Theodore Roosevelt. But career military officers won their status by persuading Congressmen that a special kind of knowledge and skill was necessary for positions of command. The process of persuasion, however, required more than a century of advance in military technology, and the rational arguments were buttressed by the political influence of the dams and levees of the Corps of Engineers.

It is this difference in the fundamental status of the career civilian administrator and the career military officer that explains, I think, a major difference in scientific organization among our several countries. In Great Britain it is possible to assign Army and Air Force research to a Supply Ministry, and to make even the Royal Naval Scientific Service a predominantly civilian agency, because the basic decisions on government organization and administration are made by the Prime Minister and Cabinet on the advice of the civilian career administrators. (Much the same might be said with respect to the unification in a single institution of all defense research in Canada, to the membership of a civilian scientist on the Canadian Joint Chiefs of Staff, and to the creation in Norway of a single defense institute).

Hiscocks mentioned that in 1957 the Prime Minister decided to transfer to himself from the Lord President responsibility for the atomic energy program. Let us not overlook the procedural significance of that statement. An equivalent decision in the United States could not be made by the President; it would involve the submission of a bill or a reorganization plan which would be vigorously debated in the Congress, and the possibility of such debate or of the amendment of such a bill would condition the decision about whether the measure should be prepared and submitted at all. Look, for example, at the way in which the National Aeronautics and Space Agency has just been created, or in which the organization of the Department of Defense has just been amended, both after extensive committee hearings, with testimony from all levels of scientific and military authority and endless compromise and amendment by the legislative committees. The equivalent step was taken by the United Kingdom in 1958 with the release of a brief paper on the new organization of the Ministry of Defence; this, the paper said in effect, is a scheme which we decided to try out some time ago, and now that it seems to be working well we think it proper to inform the Parliament and public about it.

If we measure the scientist's status in American government by the possibility of his moving to high administrative positions, it is better than that of his Canadian, or British, or European colleague. By contrast with the classic British system, just as there is no clear distinction in the American public personnel system between political and administrative positions, so there is no clear distinction between scientific and administrative positions. Indeed, much the same contrast can be drawn between American and British industry, since scientists and engineers seem to move more readily into top management and membership on boards of directors in America than abroad. There is no question that here is a significant difference, but whether on balance the difference is in our favor I will not stop to debate. As Hiscocks noted, it is not alway good for science or for administration to make a good scientist into a poor administrator. Some, however, may be tempted (with me) by the nature of our current problems to think that only a certain admixture of scientifically informed individuals can qualify an administrative corps as adequate in the world of tomorrow.

Effect on Policy

Then what influence does the scientist adviser have on policy?

In a broad and general sense, of course, the developments in science and technology have had a determining effect on government policy everywhere. But here we are concerned with the much narrower question: "Are there ways in which the channels of scientific advice to those who determine public policy are different in the United States from elsewhere?"

First of all, I think we can tell even by reading the daily headlines that scientists take their advice directly to the Congress and the public as well as to the responsible executives. When I mention such headlines I am thinking less of Killian than of Von Braun, whose views not only on the technological aspects of space travel but also on the distribution of functions and personnel among various government agencies have received more column inches in the daily press than have the views of responsible agency heads. Such manifestations are a constant source of wonderment to our visitors from abroad.

The differences are partly, but not mainly, a matter of different journalistic habits. Hiscocks has described the parliamentary system in the conventional, and perfectly acurate, terms of a system in which the executive and the legislative body cannot be in conflict with each other, because the executive is in effect a committee of the legislature. This is only a part of the story. With respect to the problems we are discussing, two other aspects of the British parliamentary system are equally important. The first is that under this system the party in power, through its ministers, takes full and exclusive responsibility for policy: that is to say, subordinate officers, administrative or scientific, are not permitted to express their views on policy or to appear at all before the legislature or any committee thereof, and indeed the legislature is not permitted to set up a committee which can have a voice in determining policies within a particular field. The second is that the parties compete within the limits of clearly defined ground rules; they compete on broad policies and leave the basic responsibility for organization and administration to the executive. The Cabinet and the top civil servants together are the heirs to the traditional authority of the Crown; it is they, and not the House, who determine how Her Majesty's Government

shall be organized. It is for this reason that the organization or reorganzation of major functions, as I mentioned above, is not a matter of political debate.

The system in the United States could not be more different. The direct access of scientists to congressional committees on policy issues is not a new phenomenon. It began when the Franklin Institute, with a federal grant for research to find out why steamboat boilers were blowing up, went on with a magnificent disregard for its terms of reference to propose draft legislation for a federal system of steamboat inspection. This was the first federal function of regulating private business; it came at about the same time as the first Factory Act in Great Britain; after these two acts, *laissez faire* was doomed. But while this first step of the House of Commons was proposed by a cabinet minister, that of the United States Congress was recommended to it by an independent research agency. And the Steamboat Inspection Act set the pattern for the 19th century. While political leaders debated great abstractions like states' rights and free trade, the scientists and associations of scientists were the cutting edge of new policy in the functions that were involved in the development of a new continent. In the geological surveys, the mapping and charting of the coasts and inland waters, the development of new types of agriculture, and the conservation of forests—in all of these fields you find variations on the same pattern. Groups of scientists, usually backed by some institution like the American Philosophical Society or the American Association for the Advancement of Science or the National Academy of Sciences, persuade the Government to support new surveys or research activities. Then research contributes to the development of regulatory or service functions. And, given the lack of a strong corps of career administrators, the scientists move on into positions of administration and policy leadership —at the cost of exposure to political pressure and legislative questioning.

Effect on Organization

The same contrast appears in issues of organization that appears in issues of policy. In the United Kingdom the fundamental view has not changed since the House of Commons won a status of apparent omnipotence; it is agreed that the contest over policies, on which the tenure of the executive depends, would give the nation no basis of judgment between the parties if policy issues were confused by being mixed up with issues of organization and administration. Responsibility for the latter must be firmly fixed in the government of the day, which in theory means the Cabinet but in practice means the career administrators.

The American view, by contrast, has not changed fundamentally since the Government was founded through a revolt against constituted order and authority. In spite of the limited powers that have been delegated to the President for government organization, the country and the Congress still basically look on the problems of organizing and administering the Government as a part of the policy issues on the political agenda.

Then how does all this bear on the question of how science should be represented in the high policy councils of the Government?

The greatest advance in this respect, of course, has been the creation of the office of the Special Assistant to the President for Science and Technology—the position held with great distinction by Killian. His office is sometimes discussed in the same breath with proposals for a new Department of Science, but it seems to me that the two differ, not merely in degree but fundamentally in approach.

If the purpose is to enhance the status of science or its usefulness to society (within reasonable limits the two purposes are, I think, compatible), the main strategic question is whether to try to strengthen science as part of nearly all the departments and agencies of government or to centralize it as much as possible in a single department.

A conventional step toward agency prestige in Washington is to get status as an executive department, which by tradition (not law) carries "cabinet rank," or the right to be present in the President's cabinet meetings. But the price paid for this prestige is that a department must get its powers and its funds by legislation, and its head must be confirmed by vote of the Senate; thus the prestige that comes from direct power must be fought for in the political arena. This battle always involves rivalries among departments as well as between parties. Few things in politics seem more obvious than the probability that almost every executive department would join, together with its political friends in Congress, in attacking any proposal to pull its scientific research agencies out and transfer them to a central Department of Science. The secretary of such a department, in order to exist, would be committed to constant political warfare. In such a situation, he would be quite unable to serve as a close and confidential adviser to the President.

Even the National Science Foundation, which was set up with limited functions to avoid such conflict, has had to tread warily. The legislative battles over its creation resulted in a compromise that gave it a large board of directors; the nature of the foundation's functions, its relationships with other agencies, and the complexities of its director's relations with his board, all may have contributed to making it impossible for the foundation's director to serve also as the principal science adviser to the President.

For the President cannot accept anyone in that position whose main allegiance must be to a private group (as is the case with the president of the National Academy), or whose executive responsibilities require him to maintain his own political following vis-à-vis the Congress. Only a man without other operating responsibilities or competing loyalties, and hence one who is not looked on as a rival by the executive departments. can be accepted in such a role.

These considerations are important in the United States simply because the internal problems of government organization and administration are just as exposed to legislative and political questioning as are the issues of basic policy themselves. Here again we see our own situation illuminated by contrast with that of countries in the parliamentary tradition. In the United Kingdom, for example, all the arrangements such as those we have been discussing are generally sheltered from political attack or legislative amendment. It is significant that they are given such status by being attached to a member of the Cabinet who is a survival of the royal prerogative—the Lord President of the Privy Council. Under that kind of shield, a scientific adviser can be given high honorific status without difficulty or danger. But in the United States, to formalize an arrangement by statute is to make it rigid. Such status cannot be given without the possibility of undesirable amendments, and to win and maintain such status, especially at high policy levels, is to jump into politics without protection. Killian's position avoids such difficulties. His close and confidential relationship with the President depends on a lack of independent political status rather than on having such status given him by statute.

Financial Support

Then we come to our third question: How does science get financial support? We have learned from Hiscocks, Major, and Ballard of the various arrangements made for this purpose in other countries. All these arrangements have as their primary objective the guaranteeing of a measure of independence and detachment to scientific research, while giving it support through political processes. Thus we have heard how Canada, in order to support advanced research, tacitly assumes that postgraduate education is not education at all, so as to avoid having it come under the ban against federal support of education in a country whose provinces are even more jealous of federal authority than are our states. We have seen how Norway channels gambling revenue into the support of science through the laws regarding its football pools—a method neglected in this country since the Puritan Commonwealth of Massachusetts conducted a state lottery to build Holworthy Hall for Harvard in 1812! But the two methods that are worth special comparative comment are those of Great Britain—the industrial associations and the University Grants Committee.

Block Grants

The common element in these two devices is the idea of the unrestricted block grant, in contrast to the provision of funds through grants or contracts on a project-by-project basis. With respect to the industrial associations, where the scheme is for the Treasury to supply part of the costs for the support of a laboratory serving a trade association, the American antitrust lawyer would undoubtedly shudder with horror at the very idea. But the fundamental issue is broader and one on which the industrial associations have a common position with the universities—and for that matter with counties and municipalities, which also draw a heavy proportion of their revenue in the United Kingdom from the national Treasury. All of them rely largely on block grants, and all of them dislike the grants which are tied to specific purposes, as were most municipal grants some years ago.

The idea of block grants has a great deal of appeal, on the surface, to American educators, who with reason dislike the idea of federal authority being extended over their institutions in a piecemeal project-by-project fashion. But the U.S. Civil Service Commission and the U.S. General Accounting Office are monumental reminders that imitations of British public institutions sometimes work quite differently in the United States. What would happen if we tried to create a university grants committee?

It is worth noting that in the United Kingdom the University Grants Committee system covers up all sorts of implicit issues which never reach the attention of the House of Commons. That is its purpose. To take only a single example, grants from the UGC to Oxford and Cambridge go to support a system of education (the tutorial system in the residential college) that is very much more expensive per head than the system followed in the provincial universities. This can be done only because the members of the UGC, no matter what their present connections, find it possible to concede that Oxford and Cambridge provide a superior kind of education, and that it is in the national interest to pay extra for it. This is admittedly a matter for political judgment, but I do not believe that a similar committee, representing the land-grant institutions, the state universities, the church-supported colleges, and all the rest, would ever concede any such point on the American scene, and if they did I can well imagine what would happen in an appropriations subcommittee the following year.

Project Grants

It was to avoid the danger of converting federal aid into political patronage that Congress, as it began to authorize grants to state institutions for various programs (such as agricultural experiment stations) generally provided that the grants be calculated on the basis of some statistical formula. This approach will work if the purpose is to spread a system uniformly over the country. But if the purpose is to build up various centers of excellence, or to get specific jobs done, in private institutions, a different approach becomes necessary; hence the development of the system of grants and contracts for individual research projects. Only this system can anticipate and satisfy political criticism, which is reflected most vividly—although it by no means always originates—in congressional committees. A system of grants can be defended most easily if it seems to be based on objective judgment and to be closely related to the purpose of a specialized program. It helps, of course, if the field in question possesses a strong and well-organized professional society, which is eager to defend the integrity of professional judgment against interference on general political grounds. Thus, the Office of Naval Research or the National Science Foundation or the National Institutes of Health can administer grants to individual institutions on a discretionary basis without too much political trouble. For the very specificity of their purpose is the best defense against their being required either to pass out funds on a per capita basis or to yield to demands for patronage.

It is surprising not that basic research has lagged in the United States but that it has been possible to find federal funds for it at all. The distinction between basic and applied research, however, is as fuzzy as the distinction between applied research and procurement. And the very fuzziness of the distinction has been a great advantage. Until the end of World War II nobody supposed that it was a basic purpose of the Federal Government to support basic research at all, and even since the creation of the National Science Foundation it is doubtful whether the motive of adding to basic knowledge provides an adequate political support for the sums of money that now go to fundamental science.

Political executives and legislators are not in the best position to decide, on general grounds, what fraction of any given budget should go to basic, as contrasted with applied, research. They are reasonable enough, however, to go on the tacit assumption that such decisions can best be made by the people working in the field, especially if the structure of that field is such that scientists can attain positions of authority within it. John Quincy Adams and the presidents who went before him lost in their attempts to create a national university for the support of scientific research; they lost only because they insisted on thinking in terms of a model which did not fit the American federal pattern. They lost, but only to see the same purpose served many times over, first by the creation of land-grant colleges and next by the allocation of federal funds for the support of research to a wide variety of institutions, public and private alike.

The approach that has served well in the past may not be the best for all time to come. Whenever the general public and the Congress become persuaded that the support of basic research is important enough as a national purpose to warrant the setting aside of considerations of partisan, sectional, or local ad-

vantage, perhaps we can then move to another system involving federal grants for general support of the best scientific institutions in the country. But in the meantime, the project grant or contract has provided considerable support for research without interference from partisan politics. Thus, it has paradoxically served the same purpose in the United States that the University Grants Committee has served in Great Britain, even though in form the two approaches are entirely different.

Science and Society

If this is so, it suggests that science may be having a profound effect on our governmental and economic institutions —not merely through the effects of technological change or government programs but also through the form of institutional response that is made to such change, or even through the institutional arrangements for bringing about such change. Many scientists who are properly concerned with the unique contribution of the individual human intelligence to research are made uneasy by any talk of science as an organized system. But there is no way out of it. As Whitehead pointed out, the greatest invention of the 19th century was the invention of the method of invention, and very few scientists indeed are purist enough to take no interest in the contribution of science to technological advance. But even if we should be interested in science only for its advancement of abstract knowledge by basic individual research, we still, under modern conditions, have to think of it as an organized form of activity. For to give the scientist protection against other demands on his time and the laboratory and other tools needed for his job requires a highly organized system within our society.

So now I come back to the interesting point of speculation on which I touched at the beginning. Why did so few American scientists follow Bernal and Joliot-Curie and their many colleagues in Europe and Asia in accepting the Marxist view of the relation of science to human society? Perhaps it was because Marx had been looking at the 19th-century problems of an industrial and urban society, while the basic patterns of a large part of American science in its relation to government were set during the 19th century, in an agricultural and rural nation. In a sense, the frontier was a force for freedom. But this was only because we worked through free institutions to develop it; Siberia too was a frontier, but its name became a synonym for something quite different. What we developed was a system too fluid and dynamic to bear any resemblance to Marx's rigid class assumptions. And we did this because we conquered our frontier by combining federal support for science with a system of free federal institutions.

We were dangerously late in developing, on our urban and industrial side, an equivalent approach to the proper role of science in society. For it was harder to bring the institutions that were the dynamic powers in that society—the great industrial corporations—into the kind of balanced relationship with the national government that had been attained between the states and the federal authorities.

But as was suggested by Vannevar Bush's metaphor—*Science, the Endless Frontier*—the new programs for government support of science may be creating a new drive and a new balance within our industrial economy. Some of our leading economists, for example, have suggested that it was only technological change, based on 20th-century research methods, which prevented the stagnation and stratification of our society after the closing of our frontier; that the discovery that enormous amounts of research could be carried on for profit was one of the most revolutionary economic discoveries of the century; and that this discovery has invalidated the Keynesian theory of investment, by continuously creating new research opportunities. Since business, however, cannot afford as much research as it would be in the interest of the entire community to have, this idea suggests that we have been saved only by the fact that a great deal of our massive military research also has civilian application (*1*).

Does this suggest that the system of government research contracts for industry may come to be the equivalent, on the urban side of our society, of the federal system of agricultural research? There were, of course, federal research programs in aid of industries before the contract system was developed. Through the National Advisory Committee on Aeronautics, for example, the Federal Government supplied the research needs of a rapidly growing new industry. But recently the NACA, transmuted into the new National Aeronautics and Space Administration, has followed the new pattern of much of the military and atomic energy research and has shifted to an approach of awarding many of its research and development contracts to private agencies.

So we now seem to be developing a system in which some of our most dynamic industries are those in which, as in agriculture, the Federal Government gives heavy support to the research needed by the entire field—and does so not mainly in its own laboratories but by contracting to support the work of private institutions, profit and nonprofit alike. The advantage to our society as a productive machine are obvious. The advantage to our society as a free political system are less obvious, but may be even more important.

For we can never again rely entirely, as some of our Jeffersonian rural ancestors did, on private property as an adequate guarantee of freedom from central authority. To preserve a balance between freedom and authority, we have been moving in the direction of operating patterns which may accomplish central policy without destroying corporate or academic independence. A university or industrial laboratory which depends in part on federal research contracts may have somewhat less independence than it had formerly, but its ability to maintain an independent point of view, and criticize central policy, is far greater than would be that of a laboratory operated entirely under government auspices There is danger of course that this advantage, if it be one, may be purchased by a weakening of the central leadership and authority which, in certain particular fields, the needs of the next decade may require. On this issue it is too early yet to draw up the balance sheet.

A Political Force

The great danger, of course, is that this new system has been financed in the main through military channels and for military motives. But the exceptions are important. The National Science Foundation, the National Institutes of Health, and the Atomic Energy Commission and National Aeronautics and Space Administration themselves, have acquired a measure of support in their own right that gives them a degree of independence and promises continuity even in the unlikely but desirable contingency of a great lessening of international tensions. A mere two decades ago, federal support of science in private institutions was a distant dream. Today it is an established political habit—indeed, a vested interest. If I may yield to the dangerous temptation of using a scientist's term as

a political metaphor, I suspect that research as a political force has already attained its critical mass. It may not yet be a farm bloc. But there are enough people and institutions directly interested in it, and enough others persuaded of its importance, so that I doubt that even the sudden outbreak of peace on earth and good will in Moscow would have as much effect on our research as on our military budget.

But already the scientists have gone further with their processes of analysis and experimentation, with respect to governmental institutions, than most observers would have guessed. The contractual system has gone far beyond the process of buying recognized services from well-established companies or institutions. It has come to the point of creating private corporations specifically or exclusively for governmental purposes. Some of these corporations are doing work which in other countries would be considered to be at the heart of the most delicate and confidential aspects of military or diplomatic planning. The analytical approach of science could hardly go further than to break down the concept and the institutions of sovereignty to this degree. Such a far-reaching idea may lead some day to an even more radical notion; if the purposes of these new corporations are of such importance as to require administrative staffs of the highest degree of flexibility and competence, perhaps some day we will recognize that the function of creating them, coordinating them, and judging their products requires an equally high level of competence within the government. But that day is not yet with us.

Science and Freedom

My colleagues from Canada, Norway, and the United Kingdom and I have been making comparisons among institutions that are different enough but that nevertheless rest on the basis of a common assumption of freedom. All of us, however, have doubtless been making an implicit comparison not with each other and with our other free brethren but with the authors of sputnik.

All over the world people are comparing the institutions designed to assure the freedom of science with those which maintain science under a dialectic of dictatorship. It is significant, however, that at the time of the triumph of Russian technology, the prestige of communism among scientists throughout the world seems lower than it was in the days when Soviet science was still being discussed in largely theoretical terms.

Among free nations we will doubtless continue to manage our affairs and support our science in different ways. In the United States, it seems to me, our best hope is for a science which will grow, not as a guild under the patronage of a traditional sovereignty, but as a most important element in a highly diversified and free system. In this system the scientist gets his influence not from a complete detachment from politics but from sharing in the political obligations of society. And in this system, too, politics may get its strength not by meddling with the processes of research, and not by strait-jacketing science in an ideology, but by freeing science to question and improve all aspects of policy, all forms of social organization.

The economic and political system that Marx attacked is almost as obsolete as the one he envisaged. We have created something new in the United States through the influence that science has had on our society, and we are only beginning dimly to understand it. But we need to learn how to use it better if we are to continue to promote the general welfare as well as provide for the common defense. And we need to learn rapidly—to learn political wisdom and administrative competence as well as scientific ability—or there will not be any posterity to inherit the blessings of the liberty that we find so enjoyable.

Note

1. This is a layman's summary of the point of view expressed by Sumner H. Slichter in "Technological research as related to the growth and stability of the economy" [in National Science Foundation, *Proceedings of a Conference on Research and Development and Its Impact on the Economy* (Washington, D.C., 1958), p. 107].

News of Science

Power Projects for Atomic Energy Industry Examined in Annual Review by Congressional Joint Committee

Hearings on the status and future of the atomic energy industry got underway last month before the Joint Committee on Atomic Energy of Congress. More than 30 witnesses from government, industry, and other fields testified during the annual review which is required by the Atomic Energy Act of 1954. Clinton P. Anderson (D-N.M.), chairman of the committee, opened the sessions by welcoming John A. McCone on his first public appearance before the full committee since he became chairman of the Atomic Energy Commission.

Atomic Power Program

The sessions were concerned primarily with the AEC program for new power projects during the coming fiscal year. In his testimony before the committee, and in an earlier news conference, Chairman McCone said that the fundamental change for the immediate future would be a shift from a diversified program in which many alternatives are considered to a concentrated emphasis on developing those types of reactors which have shown the greatest promise. The primary concern reflected here, as the news conference indicated, is economy. Carrying a number of lines of research from theory to prototype is an exceedingly expensive process and, in an economy-minded administration, it is not something easily justified. Within this framework, the objective for the near future is nuclear power which can compete economically with that generated by fossil fuels in certain areas of the country. To this end the commission plans to have designed and under construction by the end of fiscal 1960 six experimental reactors. Three reactors will be used for experiments in cooling. The media to be tested are gas, sodium, and an organic compound made of terphenyls. This last coolant is being considered because it has a lower vapor point than water and therefore does not require the heavy