labor, irrespective of the source of funds for the research. The cooperation of large numbers of workers will not be achieved unless they know that they will be beneficiaries of an application of scientific method to a field where rule-of-thumb has largely prevailed.

The Directions of Research

The initial task of these research teams would be to search out the specific problems which demand attention. The very fact that they undertake the research would indicate that they are not possessed by the opaque faith that forward strides in technology, howsoever applied, must lead to the common good. They would be expected to think dangerous thoughts. They would not hold cultural and institutional axioms to be beyond inquiry. The focus of their attention would be the institutional arrangements adequate to incorporate the full potentialities for production of an unevenly but continuously advancing technology with a socialization of gains and losses contained in these advances.

During the last decade there has occurred a reaction among social researchers against the earlier tendency to focus on the economic consequences of advances in technology. The center of research attention was shifted to workers' sentiments and social relations on the job. This new emphasis, however, has the defects of its qualities. It is not only the sentiments of workers which are affected by technological change; it is not only their social ties and their status—it is also their incomes, their job chances, and their economic interests. If the new research on human relations in industry is to have maximum pertinence, it must be meshed with the continuing research on the economic implications of labor-saving technology.

Nor can the research be effectively confined to studies of "the worker." To single out the worker as though he represented a self-contained sector of the industrial population is to do violence to the structure of social relations which actually obtains in industry. Presumably, it is not only the worker who is subject to preoccupations, obsessive reveries, defects and distortions of attitude, and irrational dislikes of co-workers or supervisors. It might even turn out that the behavior and decisions of management are appreciably affected by similar psychological patterns and that these, as well as a clear-cut sense of economic interests, go far toward determining decisions on the introduction of labor-saving technology.

In the absence of research jointly sponsored by labor and management and aimed at commonly agreed-upon problems of the role of technology in our society, the alternative is to pursue the present pattern of piecemeal research, directed toward those special problems which it is in the interest of special groups to have examined. It is possible, of course, that this alternative will seem preferable to some. It is altogether possible that the several interested groups will find no basis for agreement on the sponsorship and direction of social research in this field. But then, this too would serve its backhanded purpose. Should research by technologists and social scientists under the joint auspices of management and labor be rejected on these grounds, it would be a significant diagnostic sign of the state which industrial relations have reached.

The Federal Government and the Shortage of Scientific Personnel

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THE RESEARCH AND DEVELOPMENT program of the Federal Government is, for a number of reasons, as large as, and in many fields larger than, during the war. Current expenditures on research and development, which are at about 20 times the 1940 level, will approximate $1,500,000,000 during the year from July 1946 to July 1947, excluding expenditures on the Manhattan Project. This means not only that the Federal Government is conducting or financing a very large share of the total research and development now undertaken in the country but that Federal policies with respect to research affect, directly or indirectly, every industrial laboratory, university, and individual scientist.

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The distribution of these expenditures, as well as their total volume, is significant. Since about 90 per cent of the total research and development expenditures of the Federal Government are accounted for by the War and Navy Departments, development bulks heavy in the Federal program. Construction of prototypes and similar work is very expensive when compared with expenditures on fundamental research, and the armed forces have a direct and primary interest in those applications of science directly related to improvement of the ability of the services to fight an effective war. This concentration of Federal expenditures on developmental work raises significant questions relating to the

rate at which the fundamental knowledge on which development is based can be pushed ahead.

The distribution of the Federal research and development effort among objectives, particularly those that can be classified as military and nonmilitary, is also a matter of national interest. Expenditures on research related to human welfare are large in absolute terms, but small in relation to all Federal research and development expenditures. The Public Health Service has a budget of $11,000,000; the Department of Agriculture, $37,000,000; and the Bureau of Standards, $9,000,000. To these, however, must be added very substantial sums that will be spent by the War and Navy Departments on research in prosthetic devices, medical research, and other work contributing to improved civilian goods and processes. Whether the balance between military and nonmilitary research is a sound one—giving due weight to the urgency of developing more effective instruments of war—is a question that deserves most careful scrutiny.

Finally, the administrative arrangements for the conduct or financing of research by the Federal Government ultimately not only affect the efficiency of work in Federal establishments but also bear directly upon research and development conducted by industry and universities.

Of the numerous questions involved in the administration of research by the Federal Government, some of the most perplexing arise out of the practice of contracting research. During the war it was clearly of vital importance to mobilize all of our scientific resources for effective prosecution of the war. The technique of contracting, widely extended as a mobilization measure, proved to be most effective, and Federal contracts for both fundamental research and development are now being granted on a scale unprecedented in peacetime.

There is, however, the problem of deciding how much, if any, research and development should be done with Federal funds in Federal establishments. No over-all set of guiding principles now exists in this important area.

The consequences of lack of policy are serious. Contractors can offer salaries to Federal employees far in excess of those that the Government can pay. In effect, the Federal Government competes against itself for scarce talent under an extensive contracting system and decides, in effect, to deplete government establishments of good men in order to staff contractors.

Extensive contracting also raises problems of budgetary control. Conduct of research and development under contract rather than in government laboratories frees the project of the many controls over expenditure that are commonly considered necessary in conducting the affairs of the Federal Government. On the other hand, Congress decides what the executive branch ought to do by enacting enabling legislation and appropriations. The Bureau of the Budget was established to ensure that appropriations are spent for the purposes intended by Congress. How far, and under what circumstances, contracting agencies and contractors should be in effect exempted from the usual fiscal controls are matters deserving the most careful study.

In Federal contracts for fundamental research with universities, as contrasted with developmental work, the questions of freedom of research and freedom of discussion are always present. Whether, in the long run, a large proportion of the Nation's fundamental research can be financed by the Federal Government—and particularly by the War and Navy Departments—without influencing the direction of research or without unduly circumscribing, in the name of national security, freedom of discussion among scientists remains to be seen. At the moment, the Federal Government is providing much of the money necessary to prevent a severe decline in the volume of badly needed fundamental research. One of the problems for the future is to decide at what level the support ought to continue and to establish uniform policies ensuring that the research will be free.

Executive Order 9791

The President recognized these problems, and on October 17 Executive Order 9791 was issued.

Under this Order, the Assistant to the President, Dr. John R. Steelman, is directed to undertake a thorough study of the Federal research and development program. He must inventory and classify the major fields of research and development conducted or financed by the Government. The types and numbers of personnel now employed and required eventually for execution of the programs must be determined, and the cost of the program analyzed.

To place the Federal program in proper perspective, the Executive Order directs a review, from readily available sources, of the same sorts of information for non-Federal research—primarily work in process and planned by industries, foundations, and universities with their own funds. The objective of this review will be only that of determining the gross volume of funds devoted to broad areas of research, the total number of scientists and technicians now employed, and the total number needed. This information, rather than a catalogue of the nature and objectives of specific projects, will be adequate to set the Federal program in the framework of the total national program.

On the basis of these studies, the Assistant to the President is to prepare a report to the President containing his recommendations for planning, staffing, and administering the Federal research programs to ensure that the scientific personnel and training and research facilities are used most effectively in the national interest.

The Executive Order established the President's Scientific Research Board, composed of the Assistant

to the President as chairman, Cabinet officers whose departments are engaged in research, and the heads of Federal research agencies (*Science*, November 1, p. 418; December 17, p. 616). On January 2 Dr. Steelman announced the appointment of Dr. J. Donald Kingsley, formerly deputy director of the Office of War Mobilization and Reconversion, as executive secretary of the Board and of a committee of alternates composed of: Maj. Gen. H. S. Aurand, chief, Army Division of Research and Development, representing the War Department; W. John Kenney, Assistant Secretary of the Navy; Edward U. Condon, director, National Bureau of Standards, representing the Commerce Department; Carroll L. Wilson, general manager, Atomic Energy Commission; Thomas B. Nolan, assistant director, Geological Survey, representing the Interior Department; W. V. Lambert, administrator, Agricultural Research Administration; H. K. Jett, commissioner, Federal Communications Commission; John P. Ferris, representing the Tennessee Valley Authority; Mary E. Switzer, assistant to the administrator, Federal Security Administration; N. S. Fairbanks, deputy commissioner, Federal Works Agency; John W. Crowley, Jr., acting director of aeronautical research, National Advisory Committee for Aeronautics; Paul A. Scherer, representing the Office of Scientific Research and Development; and John T. Cox, Jr., manager, Synthetic Rubber Division, Reconstruction Finance Corporation.

A small staff in the Executive Office of the President will coordinate the study. Most of the staff members will be borrowed from the agencies conducting research. These men will discuss with each agency the scope and nature of the data on research projects required for the study and will work with the agencies in drawing material together. Other staff members will secure information from industry, foundations, and universities.

After, and in some cases while, information is being gathered, interagency committees centering around fields of research will be set up to examine the work being done in specific fields. This task of analysis will be undertaken only in those areas where fields of research have not been adequately analyzed by existing bodies with a view to coordination. The Joint Research and Development Board, for example, is working on, or has completed analyses of, a number of fields of research undertaken by the War and Navy Departments.

Interagency committees will also be set up to examine problems relating to the administration of research. One group will concern itself with personnel problems of the type to be outlined below.

All of these committees will prepare reports outlining the facts with respect to the area in which they have worked and their recommendations. These will be collated, reviewed, and incorporated in a consolidated draft report which will be submitted to the President's Scientific Research Board. Taking into account the comments of the Board, the Assistant to the President will then prepare a report to the President on the Federal research and development program which will deal with a number of basic problems:

What, for example, is the proper role of the Federal Government in the field of fundamental research?

What are the implications of financing a large volume of the total national program of fundamental research by the War and Navy Departments?

What is the impact of extensive Federal research contracts on the speed with which new scientists are being produced?

What is the division of Federal research effort between preparation for war and improvement of the arts of peace?

Can the total volume of research and development contemplated by the Federal Government, industry, foundations, and the universities be competently supported by the talent available? If not, what policies are indicated for the Federal Government?

What the Federal Government Is Doing to Increase the Supply of Scientists

In the long run, the G.I. Bill of Rights will undoubtedly prove to be a most significant means of increasing our supply of scientists. The educational benefits provided under the bill are financing a large part of the college expenses of more than 1,000,000 veterans, a large proportion of whom would not have attended college without this financial aid.

The support of research in universities by the Federal Government, while drawing many competent men from teaching into research, also supplies the funds for projects upon which advanced students can work under the direction of more highly qualified men. The opportunity to apply knowledge and intelligence to specific projects is a definite stage in the development of competent research workers. The Federal funds now being devoted to work in universities are giving a large number of graduate students a chance to advance more rapidly than would be the case if such funds were not available.

Aside from grants for the support of research projects, the Federal Government is financing a substantial number of expensive research facilities to be used by universities, particularly in the field of nuclear physics. These facilities are of direct assistance in expanding the number of advanced research workers who can be trained.

Aside from the G. I. Bill of Rights educational benefits, the Federal Government has begun to finance advanced research workers by fellowships. A National Institute of Health Fellowships program was established by Congress in 1945 under the Public Health Service Act. These fellowships are awarded to individuals who have had postgraduate work in institutions of recognized standing in fields of science allied to public health. Junior research fellowships paying $2,400 a year are

available to those who have Masters' degrees, and senior research fellowships are available to those holding Doctors' degrees. The grants are for one year and are renewable under some circumstances. The fellows select the fields within which they will work as well as the institutions where they will work. Thus far, about 100 fellowships have been granted.

Finally, the Federal Government is financing the higher education of able men under the new Navy Reserve Officers Training Program, and the War Department is contemplating the establishment of a similar program.

The entrance of the Federal Government into the field of financing the general and particularly the specialized higher education of individuals is a development of the highest significance. Grants for advanced study are now made on a small scale. Funds for general education are confined to a temporary program for veterans and to a permanent program for Navy officers. But these statutes may well mark the first steps in the establishment of a broader program of Federal aid both to educational institutions and to individual students.

Even though, in the long run, the national welfare depends on broadening the educational base, there are dangers in an uncoordinated, piecemeal program of Federal support to individuals. It is questionable, for example, whether the Federal Government should concentrate solely upon support of students who will become scientists, or Army and Navy officers. There are potential dangers in the uncoordinated proliferation of plans that will draw a large proportion of the most highly qualified young men into the physical sciences or the armed forces.

This question, among others relating to basic questions of national educational policy, is now being considered by the President's Commission on Higher Education.

The Federal Government as an Employer of Scientists

There is little prospect that the shortage of scientists will be relieved in the near future by a reduction in the personnel required to staff research and development programs conducted or financed by the Federal Government.

Given a job to do, Government should, as is true of any employer, try to get the work done as well and as cheaply as possible. This means that the Government ought to attract good men and establish the working conditions that will make them most productive.

Among scientists in general, Civil Service employment has been viewed with a skeptical eye. By and large, this skepticism is based on inadequate secondhand information and upon conditions that are quickly being remedied.

The Federal research program does offer a wide and useful field of employment for scientists of junior grade. After advantages and disadvantages are balanced off, scientific work for the Government in the lower and middle brackets is about as attractive as in industry or universities.

There are, however, a number of problems that hamper the recruitment and retention of top scientists. These problems are not universal by any means, but they are of sufficient significance to merit attention.

The personnel procedures of some agencies impose a number of irksome barriers to maintenance of an effective working group of scientists. In general, these barriers arise out of the rigidity with which the personnel mechanism can operate in the Federal Government. In some cases, for example, salary levels for technical and scientific positions are evaluated more in terms of administrative responsibility than in terms of scientific achievement. It is sometimes difficult to reward outstanding work adequately.

Most important, the upper Civil Service limit of $10,000 is a crippling limitation. While many outstanding scientists have remained in the employ of the Federal Government at salaries of $10,000 per year or less, the upper limit both forestalls recruitment of badly needed men and leads to a continuing exodus of capable scientists from Federal employment. It is difficult to reconcile a decision to invest billions of dollars in research with an inflexible ceiling of $10,000 on Federal salaries.

A broader question raised by salary levels in government, industry, and the universities is, of course, the ability and willingness of industry to pay relatively high salaries to men engaged in developmental work at a time when fundamental research is lagging.

Another general problem concerns the opportunity of Federal scientific workers to acquire and enhance their professional status. In many agencies, opportunities to publish research findings are inadequate, and in most agencies, funds for attendance at professional meetings are meager.

Some scientists in the War and Navy Departments face a peculiar and difficult set of circumstances arising out of their working relationships with officers.

Petty, but irritating, discrimination is a problem. When scientists travel, for example, they are allowed $6 per day for per diem; officers are allowed $7 per day plus tips. Housing accommodations have often been provided for officers but not for equally needy civilians. Top-level scientists are sometimes forbidden to sign letters or reports over their own signatures.

A more basic problem has been the supervision of the work of highly competent scientists by officers who do not have a full understanding of the work for which they are responsible.

Security restrictions have at times proved baffling to civilian scientists in a number of respects. Sometimes there seems to be an assumption that a man in uniform

is automatically endowed with infallible judgment and impeccable circumspection, but that a man not in uniform is an outsider who must be carefully watched. On some projects this has led to a formidable and discouraging array of special security checks, special passes, and restrictions on working hours, availability of data, and freedom of conversation which must be borne by civilian scientists but not by officers.

Finally, restrictions on publication or research findings for security reasons have often seemed overly strict to civilian scientists. Officers in a military hierarchy, trained to deal with matters of primary or sole interest to the armed forces, relatively untrained in matters of general scientific interest, subject to military discipline and military justice, and indoctrinated with the importance of keeping military data secret, naturally lean further toward maintenance of secrecy than civilian scientists trained in another philosophy and environment.

Security policies are also, of course, a major problem in connection with War and Navy Department contracts undertaken by scientists in academic institutions. The imposition of security restrictions on the work of scientists who have a cherished tradition of freedom to talk and freedom to write creates an area within which judgments and attitudes almost inevitably differ.

All of the problems of the Federal Government as an employer have been studied intensively during the past year by the Civil Service Commission, by the agencies concerned, and by interagency committees. Many of the difficulties outlined have been remedied, and specific recommendations dealing with the others are being formulated. A number of them, however, are not matters that can be dealt with by law or by a general statement of policy. They are matters of personnel administration which must be worked out by careful and diligent effort attending over a substantial period of time. Furthermore, many of these personnel problems must be worked out within the agencies concerned.

Below are outlined some of the specific actions that have been taken, or are about to be taken, to make the Government a better employer.

The Civil Service Commission will soon appoint a highly placed official whose task will be to deal with all personnel matters affecting scientists and technicians. The establishment of this post will provide a central point for the establishment and implementation of policies designed to enhance the position of scientists employed by the Government.

Recruitment of scientists is being improved. About 750 special boards of Civil Service examiners, on which scientists are represented, will be set up to recruit professional people, including scientists. These boards will recruit scientists, particularly for junior jobs, through contact with schools. They will set up appropriate examinations, establish registers, and certify eligible names for employment.

The salary problem will be attacked by presenting to Congress the urgent need for raising the upper pay limit for both top scientists and administrators from $10,000 to $15,000.

To provide means of professional advancement, to increase the effectiveness of scientists at their job, and, incidentally, to increase the effective supply of scientific talent, an extensive program of in-service training for scientists is in operation and is being extended. In Washington, for example, about 800 scientists from 15 agencies are taking courses in 22 scientific fields (*Science*, November 22, p. 477). The Army Air Corps at Wright Field has developed a similar program, as have Navy installations at New Haven, and Inyokern, California.

The problems of security restrictions and relationships between military and civilian personnel, in areas where these matters have concerned scientists, are being dealt with intelligently as a matter of top policy. There is an increasing tendency, for example, to establish administrative organizations designed to give scientists a greater degree of freedom and more direct access to policy-making officials. The central research and development staffs of both the Army and Navy are organized in a manner designed to enhance the status of civilian scientists. This development is significant not only to Federal scientists but also the utility of the Federal research program.

A great deal of the credit for these steps goes to the Advisory Committee on Scientific Personnel, under the chairmanship of M. H. Trytten. This group has been most effective in presenting both a philosophy and a program of action to administrators. The President's Scientific Research Board will lean heavily upon them for advice and recommendations in this field.

Sound answers to all of the problems faced by the Government as an employer of scientific personnel must be found if it is to do a good job of research and development. But the Government also has a wider responsibility. As a major competitor for one of our most scarce and valuable resources—highly trained scientists—the Federal Government is obliged to consider the effects of its research and development programs on the distribution of the total pool of available man power. Since the national interest is bound up with the progress of research, the Government must ensure that the supply of well-trained men is raised to an adequate level without drawing into scientific and technical fields too large a proportion of the best brains of the country.

The policies to be followed by the Government in dealing with these problems concern not only Federal agencies. Industry, the universities, and the foundations have a vital stake in the establishment of sound decisions by the Federal Government in this area. All scientists will be affected by the actions of the Federal Government as it charts a course to guide postwar research.