Manpower for Research and Development[1]

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AS GOVERNMENTS become more and more involved in research and development and as the leadership of a nation depends more on its scientific and technical personnel, it becomes increasingly important that some basic rosters and evaluations be made on the proper handling of specialized manpower. Whatever the scientific problem, manpower is one key to its solution. The several studies now being carried on under contract through the Manpower Branch, Human Resources Division of the Office of Naval Research, should give facts that will enable the research administrators to plan and administer a broad and comprehensive research and development program for national defense and for the nation's progress.

Source Files

During World War II, those responsible for the national defense found it difficult to locate and utilize efficiently the nation's supply of trained research and development workers. In order to meet their responsibility, the National Defense Services have undertaken an inventory of the highly specialized research and development scientists and engineers who are guiding and carrying on the research activities in universities, institutions, industry, and government. It is felt that this inventory will not only serve as a source file of qualified and highly selected workers, but will also supply the basic data for such studies as they are needed for the planning of research, the most effective utilization of available trained manpower, and the administration of research, particularly that directly concerned with national defense.

Although this program of research on specialized manpower is being carried on under the administration of ONR, it is, in the main, a joint program of the Army, Navy, and Air Force. Each service has designated a representative who, as one of a "sponsors' " group, has given assistance in planning and securing financial aid. This group has given direction to the several rosters or source files being compiled in this phase of the manpower program.

Other interested government agencies have joined in the planning for these projects. Representatives from such agencies as the Research and Development Board, the National Security Resources Board, the Munitions Board, the Atomic Energy Commission, the Bureau of Labor Statistics, the Census Bureau, the U. S. Employment Service, and the Bureau of the Budget have met with the sponsors' group to discuss, and to be informed of, the progress of the several projects.

In addition, organizations representing the various professional societies with which most of the professional workers are affiliated, and the schools and colleges from which most of the professional workers come, have been solicited for aid and guidance during the progress of the program. In fact, three of these, the National Research Council, the American Council on Education, and the Engineers Joint Council have appointed committees to assist in the program and have undertaken contracts on specific projects. As joint projects, these are excellent examples of cooperation within the Department of Defense, among government agencies concerned, and with the national professional societies.

The first projects undertaken under this program, and those with which I shall primarily deal, are the compilation of a number of rosters or source files of key physical scientists and engineers who have had experience in research and development work or who are potential workers because of their intensive or specialized training in one or more occupational specialties.

Plans were made to compile a file of key research and development physical scientists and of highly specialized research and development engineers, and to make an inventory of all the scientists and engineers, at whatever level, working on research and development problems in any service of the Department of Defense. The two source files are not employment registers for use of the military services or other government agencies, but primarily are for the purpose of having complete information available for any and all problems of research and development manpower that may arise in connection with the scientific program of the national defense. For ex-

[1] Based on an article in the *Monthly Research Report* of the Office of Naval Research, November 1, 1949.

ample, the statement has been made that there are more funds than there are qualified workers available for the research now planned. The rosters should prove of value for effectively allotting this money.

National Roster

Upon the undertaking of the two source file projects, the question was raised as to whether the existing National Roster, or at least its files, could be utilized. Examination revealed that the files were no longer in working order, having been stored without an active custodian. In addition, no data had been collected for a number of years; thus, the files lacked the very important records of World War II experience of the scientists and engineers who would be most valuable in the immediate future. It was felt, too, that the "population" represented in the National Roster was general rather than highly specialized in research and development. This has been confirmed; only 17.0 percent of the National Roster physical scientists have the Ph.D., whereas 75.6 percent of these in the source file have that degree. Furthermore, the median age of the roster respondents was at least ten years less than the median age of 46.1 years for the source file, after making allowance for the period in which the information was gathered. An intensive examination of the engineer registrants of the National Roster revealed similar facts. Thus, the conclusion was reached that it would be both more efficient and economical to make a fresh start.

Although the two source files (Physical Scientists and Engineers) are both supplementary and complementary, and are in fact one file as far as the needs of national defense are concerned, the nature of American education and the professional organizations made it imperative to plan and execute the two projects separately. As already implied, the cooperation of the professional societies is most necessary in compiling the source files.

Information Sought

In the case of the Physical Scientist Source File, the Office of Naval Research turned to the National Research Council of the National Academy of Sciences to undertake the contract for securing the necessary data. The NRC assigned responsibility for this task to its Office of Scientific Personnel. In attempting to select the respondents for such a source file, it was decided to make use of the basic list of such scientists in the publication *American Men of Science,* which has compiled such listings in the past forty years, and which is recognized as an authoritative guide to the leaders in science. The membership lists of the various professional societies do not, as a rule, give any guide as to scientists who should or should not be included in the category of research and development workers. It was felt, however, that major attention should be given to the basic list, namely those younger physical scientists who have been engaged in research and development in the extensive research program of World War II, or who are potential research and development workers. The Office of Scientific Personnel therefore secured the names and addresses of all men granted the Ph.D. in physical science since 1936. This date was set on the assumption that any scientist granted the Ph.D. in 1935 or prior would have been listed in the latest edition (1943) of *American Men of Science.*

It was found that Science Press was planning the issue of a new edition, the eighth, of *American Men of Science.* In order to conserve the time and energy of the respondents, use is being made of the AMS basic list. For financial economy, the NRC entered into a contract, upon approval of the Office of Naval Research, for the AMS to secure the data needed for the source file along with the data needed for their publication. The compilation of the data is practically complete.

Following meetings with representatives of a number of engineering societies, the Engineers Joint Council (composed of the American Society of Civil Engineers, American Institute of Mining and Metallurgical Engineers, American Society of Mechanical Engineers, American Institute of Electrical Engineers, and American Institute of Chemical Engineers) was approached for guidance in the conduct of the task, particularly in making up a list of respondents to be circularized. Here no accepted or authoritative guide, such as *American Men of Science,* was available. It was therefore decided that it would be necessary to list all the full professional members of the some eighteen major national professional organizations of engineers. From such a listing a selection would be made of those respondents to be included in the Research and Development Engineers Source File on the basis of academic training, experience, and function as revealed in the questionnaires. It should be noted here that there are two engineers to each physical scientist in research and development.

Under the sponsorship of the Engineers Joint Council, the American Society of Mechanical Engineers entered into contract with the Office of Naval Research to compile a master list of the professional engineers represented in the eighteen cooperating societies:

American Institute of Chemical Engineers
American Institute of Electrical Engineers
American Institute of Mining and Metallurgical Engineers
American Society of Civil Engineers

American Society of Heating and Ventilating Engineers
The American Society of Mechanical Engineers
American Society for Metals
American Society of Refrigerating Engineers
Electrochemical Society
Institute of Aeronautical Sciences
Institute of Ceramic Engineers
Illuminating Engineering Society
Institute of Radio Engineers
National Society of Professional Engineers
Society of Automotive Engineers
Society of Economic Geologists
Society of Exploration Geophysicists
Society of Naval Architects and Marine Engineers

This yielded, without duplicates, some 97,000 names.

In both the physical science and the engineer mailings, an "Other Names" slip was included to give opportunity for the respondents to "nominate" or indicate the names of such scientists or engineers as they might know who meet the qualifications sought but are not included in the basic lists. These other names have given approximately a 10 percent addition to the original list.

As plans for the two source files were being made and the work of gathering the needed data got under way, it became increasingly clear that the three services needed data on their own personnel engaged in research and development activities in a form comparable to the other rosters. This project is now under way, under the "chairmanship" of the Research and Development Board. Data are being sought from all professional workers in the three services, from P-1 level upward, thus differing from the two files where only the leaders or key workers are to be included. This then becomes an *inventory,* which is a guide to the needs of the services for personnel directly employed. But, as indicated earlier, in meeting problems of research and development for national defense, the military services and all government agencies know that they must depend on universities, research organizations, and industry to supply most of the research and development facilities, workers, and consultants. The data being gathered are needed by the military services for ascertaining what has been done, and for planning, guidance, and contracting for needed work.

Data Gathered

Concurrent with the planning for the two source file projects, several groups worked on the problem of determining what data should be gathered. In the case of the physical scientists, the original draft was prepared under the direction of the Office of Scientific Personnel for NRC, with later review by the Sponsors' Committee. Additions were made to meet the AMS needs when it was decided to use Science Press as the agent for circularizing the questionnaire. Finally, when an acceptable draft had been prepared, it was submitted to the Division of Statistical Standards of the Bureau of the Budget for approval. That division gave assistance and guidance that were helpful, instead of merely dealing with the perfunctory clearance of the questionnaire.

The questionnaire for the Survey of Selected Engineering Personnel was prepared in the main by consultants from the engineering societies, with the assistance of the Bureau of the Budget. That for the Inventory of Research and Development Personnel in the three services was prepared by the Sponsors' Committee under the direction of the Research and Development Board.

In all three projects, essentially the same data have been sought. These include such items as:

1. Personal identifying data—name, age, residence
2. Academic training and specialization
3. Employment and experience record
4. Income (voluntary—some 80 percent returns)
5. Professional society participation
6. Government research—engaged indirectly or directly employed
7. Military service
8. Knowledge of foreign languages and foreign areas
9. Occupational specialty
10. Function—research, design, development, testing, procurement, production, construction, operation, administration, teaching

With the high degree of specialization in science and engineering, frequently without direct relationship to the basic academic training of the worker, it has become increasingly important to discover what are the occupational specialties of the research and development worker, and the functions best performed by the worker in that specialty. Therefore, for each of the projects, a very complete list of occupational specialties was prepared. The experience of the National Roster offered many suggestions along this line. For the physical scientists, some 612 occupational specialties were selected by an Ad Hoc Committee of the NRC; for the engineers, some 290 occupational specialties, by a group of consultants, with a review by the advisory committee of the Engineers Joint Council; and for the three services' inventory, some 590 occupational specialties by the Sponsors' Committee.

As a result of the work on the three lists, it seems that a next step should be that of the preparation of a Master List of Occupational Specialties. This, in turn, will lead to the preparation of a Dictionary of Occupational Specialties at the Scientific and Engi-

neering Level. No such authoritative work as the *Dictionary of Occupational Titles,* prepared by the U. S. Employment Service, and used in industry, is available for work at the professional level.

Handling the Data

Questionnaires have gone to some 50,000 physical scientists. After one year, approximately 90 percent have been returned. In the engineers' study, less than two months after the first mailing, over 30 percent returns have been received.

As the returns come in, the mailing file is checked and the respondent's card removed. After sixty days, follow-up post cards are sent to those who have not responded. The questionnaires are numbered in order of receipt and microfilmed in this serial order. Data are then transposed to transcription sheets by coders under the direction of the Occupational Outlook Branch of the Bureau of Labor Statistics, after which they are transferred to IBM punch cards. Most of the microfilming, IBM card-punching, and listing have been done within the various government agencies concerned. The original questionnaires are to be returned to ONR for custodianship.

Two listings are made through the use of the IBM cards: (1) an alphabetical listing of all respondents with serial number and certain other data (from which any respondent's questionnaire, either original or on the microfilm, can be located in the serial file); and (2) list of respondents by occupational specialties, each respondent being listed alphabetically under each of the three occupational specialties he indicated, with the list keyed as to the first, second, and third field, together with the functions and years of experience in that occupational specialty. With these two indexes, it is possible to locate a scientist or engineer by name, or to locate men with particular qualifications within any one of the several hundred occupational specialties. Through use of the IBM cards themselves, an individual or group of individuals with peculiar qualifications can be discovered—e.g., under 32, with World War II service, knowledge of China, etc.—within the limits of the data punched on the cards. Thus the data become a source file with immediate potential use and a necessary tool in case of an emergency.

The data derived in the compilation of the source files and intraservice inventory are no doubt the most complete so far available for study of the highly specialized professional and technical manpower resources of our nation. The Bureau of Labor Statistics, both on its own initiative and under contract with ONR, is carrying on a number of highly specialized studies, in addition to the gross statistics (based directly on the categories in the questionnaires, such as age, education, earnings, military service, occupational placement, and specialties). Among the special studies under way are:

1. An intensive study of the mobility of selected scientists among the fields of specialization
2. Differences among educational institutions in the production of key scientists
3. Educational level among various occupational specialties
4. Type of employer and employment among various occupational specialties
5. Time lag between receiving bachelor's and doctor's degrees in various disciplines, and among various occupational specialties

Other groups will be making use of the data. For example, at present the Naval Research Council, through its Office of Scientific Personnel, is studying differentials among government, industry, and research institutions and universities. The Atomic Energy Commission, which contributed toward the coding of the physical scientist questionnaire, has made studies of the data applicable to its scientific and technical manpower problems.

When these studies were launched, it was contemplated that the future National Science Foundation would take over the custodianship of the files. The continued operation of the rosters would be its responsibility. If the inception of the source files had been delayed until the National Science Foundation is ready to undertake this responsibility, it was feared a two- or three-year delay might occur. This group of projects was intended to meet an immediate pressing need of the military services, but with the idea that the National Science Foundation in due time could take over the operation and maintenance. With one source file completed and the second nearing completion, and still no National Science Foundation, the question of efficient operation and maintenance is assuming crucial importance. This is now being discussed with the three services; the Bureau of the Budget and other government agencies are being solicited for suggestions.[2]

Related Projects

This account has dealt with the three listings of research and development personnel—scientists, engineers, and Department of Defense workers. However, the Manpower Branch has several other projects under way, or in the planning stage, which are basic for the analysis of supply and demand of research and development manpower. Among these are:

[2] Pending the organization of the recently created National Science Foundation, the National Security Resources Board is establishing a unit in the Office of Education to maintain and operate the two source files.

a) *Scientist resources*: A study of the current output of universities and colleges. The Office of Education, at the suggestion of the ONR, has been gathering annually, starting in 1948, information on the Bachelor's, Master's, and Doctor's majors in each school subject. This is the first time this information, necessary for analysis of the oncoming research and development workers, has been available. The American Society for Engineering Education has for a number of years secured and analyzed data concerning engineering school enrollment and graduation. This, too, at the suggestion of the ONR, is being taken over by the Office of Education in order that more detailed analyses will be available.

b) *Ph.D. list*: The basic list of recent Ph.D. graduates is also being maintained in still another project, which will supply detailed analyses of the data.

c) *Beginning scientists*: Pilot Study of Candidates Resulting from Potomac River Naval Command Board of U. S. Civil Service Examiners P-1 Examination for 1947 and 1948 indicates the type and quality of applicants and appointees resulting from the Navy's tapping the universities for the beginning scientific and engineering worker.

The projects listed in this article are but steps in a program for the assessment of the nation's manpower for research and development. The Manpower Branch plans to support projects in this area which will give a well-rounded description and evaluation of the supply and demand for such personnel, by universities, industry, research organizations, and government.

A Radiation Meter for Disaster Use

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UNTIL THE DEVELOPMENT OF ATOMIC ENERGY, the number of persons exposed to the harmful radiations from radioactive substances was very small. Most of those exposed were well aware of the hazards to life and health presented by such radiation, and could provide themselves with instruments enabling them to measure radiation intensity and avoid overexposure.

The large-scale development of atomic energy sources and the present emphasis in several countries on the production of increasingly powerful atomic weapons have, however, considerably changed this picture. Tremendous and altogether unprecedented quantities of dangerously radioactive substances can now be liberated in a single explosion, or manufactured in a nuclear energy plant and delivered in the form of radioactive poisons, producing radiation hazards of fantastic magnitude. Spectacular as are the immediate destructive effects of the explosion of a nuclear bomb, the aftereffects of the radiation and the contamination by radioactive elements bid fair to be even more decisive in future warfare. In the Hiroshima explosion, 15–20 percent of the casualties resulted from radiation damage inflicted at the instant of detonation: It is estimated that all exposed persons within a radius of approximately half a mile received lethal or near-lethal doses of gamma radiation (*2*). Because the bomb was exploded high in the air, the residual radioactive contamination was negligible. In test Baker, at Bikini, the explosion took place under water, and the instantaneous radiation was largely absorbed. On the other hand, the resulting "base surge" of mist and spray caused a precipitation of radioactive materials estimated to be lethal over several square miles, and the lagoon, together with its plant and animal life, was dangerously contaminated for some months.

When one considers that only a few pounds of radioactive materials are produced in such a bomb and that perhaps some tons would be produced by the neutrons resulting from an H-bomb explosion, it does not seem unreasonable to expect that such an explosion, under suitable meteorological conditions, could render a large city so "hot," in the sense of producing a high level of radiation, that it could not be inhabited for years or even generations. Nor need such a catastrophe be accompanied by an explosion: Thirring has pointed out in a careful and conservative analysis (*1*)