to get a firm foundation in these subjects, but also—and perhaps more significantly—affect the ability of the public in general to think in scientific terms and to understand science. We need to improve teaching in the elementary and secondary schools, and this requires good teachers. The sciences cannot adequately serve their own ends or those of the Nation if too many young people are trained for scientific fields and not enough for other fields.

(4) *Guidance.* All this leads to the conclusion that there is need for the careful selection of candidates for all professions and occupations and careful guidance of all young people early in the educational process. While we cannot dictate to young people the choice of an occupation, we can certainly help them to make the best possible decision consonant with their interests, desires, and aptitudes in the light of the potential supply and demand situation in each occupation. Any help that the scientific professions, through their societies, can give to this endeavor will be a valuable contribution to the country and to the sciences.

Programs for Fuller Utilization of Present Resources of Scientific Personnel

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WORLD WAR II MADE US KEENLY AWARE that America's need for certain resources far outstripped the national supply. Scientific personnel, by common consent, has been proclaimed as one of the most urgent of these shortages.

Enumeration of the present and probable future extent of the over-all shortages of scientific personnel is necessarily far from accurate, based as it is upon assumptions, opinions, piecemeal surveys, replicated counts, extrapolated estimates, fluctuating enrollments, and sheer guesses of future demand. Nevertheless, the unsaturated market for such personnel at present and the prospects for accelerated future demand emphasize the long-range wisdom and present urgency for full utilization of the talents of our human scientific resources.

The last few years have demonstrated the unprecedented returns that can be anticipated from a modest investment in research and development. Those who direct the activities of business and industry, as well as leaders in Federal and private efforts to advance the public welfare and to protect the national security, see clearly the promise of rich returns from the nurture of research. The research rush of 1947 appears to be ushering in a new era of scientific development.

Whether our national supply of scientific talent is numerous or scarce at any particular time, there will always be an insufficient supply of those on whose creative genius the world's progress depends. Full use of their rare talent is a prime responsibility of leaders of scientific activities. This paper reports in brief on some means of contributing to that goal. The thoughts and efforts which will be mentioned are the outgrowth of certain experiences in connection with the work of the Scientific Personnel Division of the Office of Naval Research. This Division was created two years ago—the first of its kind in a government agency—to assist in every appropriate way in improving the climate for research and development in the Naval laboratories, to cooperate with other Federal and private agencies in similar efforts, and to assure the Navy Department that it will be able to carry forward its scientific program with its fair share of an adequate national supply of thoroughly competent scientific personnel.

The research approach of the Division should be mentioned. This function is twofold: first, to see that each program of the Division is based upon as accurate facts as can be obtained by systematic investigation; second, to support research contracts with outside organizations to conduct studies which are basic to long-range planning and management of scientific personnel. For example, it was this Division which initiated by contract the roster activities of the National Research Council. It also initiated a contract with the American Council on Education to make a two-year study of cooperative arrangements with the country's colleges and universities for continuing graduate education for employed scientists.

While such research studies are in progress, the Office of Naval Research and its Scientific Personnel Division have been conducting a number of programs

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to improve the scientific personnel situation, using the best data obtainable. Because some of these programs have widespread applicability, they will be described here. In general, they divide into two principal categories: (1) making the most of the present supply and (2) improving the supply.

Making the Most of the Present Supply

Self-imposed Restraint in Creating Expanded Demand for Scientific Personnel

Administrators are facing the cold facts of reality and are hesitating to embark upon extensive increases in facilities, not so much because of inflated building costs and scarcity and poor quality of available materials, but primarily because of the prospect of unavailability of personnel to operate these facilities once they are built.

One prominent dean of engineering, who is in touch with many industrial leaders, reports that the latter have contemplated expansions in their research and development programs which would require thousands of additional scientists. Because of their anticipated inability to staff new scientific laboratories, these leaders have curtailed their facility expansions so that their need for additional scientists can be counted in hundreds instead of thousands.

As an example of a self-imposed restraint on expanding demand, let me mention that the Office of Naval Research established a Facilities Review Board for the careful screening of all proposed projects which require new or additional facilities. The screening process involves consideration of the urgency of the project in relationship to the probable availability of personnel to staff the facility if and when it should be established. The Research and Development Board of the National Military Establishment and the Bureau of the Budget are also concerned with this problem for the military departments and the Federal Government as a whole.

It would seem desirable that every organization apply the same type of scrutiny to projects which will call for an expanded drain upon our present scientific manpower resources.

Full Employment of College and University Research Scientists on Research Work

While there is general agreement that the present total supply of trained scientific manpower is insufficient to conduct all the research and development that industry, government, and the universities desire to undertake, it must be recognized that manpower requirements for *development work* far exceed those for *research*.

This distinction is generally overlooked, although it strikes at the very core of the present manpower situation. Contrary to general belief, the research manpower resources of this country appear not to have reached their saturation point. Universities are seeking funds to support 50–100% increases in the number and total scope of basic research projects which they wish to pursue and for which they indicate, often by name, the trained researchers who are available for assignment to the proposed projects. While it is not known what the total research capacity of all our colleges and universities might be, even with their present staffs, the Office of Naval Research alone is supporting research projects which now employ 2,000 senior investigators and 2,500 graduate students. At present these projects are scattered among various departments in approximately 150 universities. Judging by the research proposals submitted from these and other colleges and universities on their own initiative, it is evident that they can more than double their present research efforts, measured in terms of the present volume of Office of Naval Research contracts.

In addition, there are large numbers of other institutions with laboratory facilities and with thousands of staff members who are competent research workers but who are not now engaged in research work because their institutional budgets are overstrained to care for the greatly increased undergraduate student load. In attempting to meet the increased demand for teachers, primarily at the undergraduate level, it is probable that many excellent research investigators are being impressed into service as teachers of undergraduate classes, an assignment for which they may be less well suited. We must meet the teacher shortage, but this does not seem to be the best use of research workers.

Restraint in the Preoccupation of Research Scientists on Development Projects

One trend with serious implications is the submergence of research work in favor of developmental and engineering assignments. While the pressures are of different intensities in industry, government, and universities, all are exposed to the financial attractiveness of utilitarian projects.

With a shortage of scientists and engineers to man the full quota of desired developmental work, developmental projects which *can be* postponed without too serious impact upon our welfare and economy should be, thereby freeing research scientists to work on fundamental studies. Even though their results cannot be premeditated, research studies are, in a very real sense, the more important immediate need.

Increased Use of Advanced Scientists as Consultants

No matter how abundant our supply of thoroughly trained scientific personnel may become, there never will be an oversupply of the most fertile and creative minds. Nature, economic opportunity, and individual drive combine to produce a small share of the genius required to cope with the ever-expanding complexity of problems.

Full utilization of our most highly developed scientific talent is more than an idealistic dream—it is a national necessity. We have learned some techniques that contribute to this goal. Among these is the wider use of persons with the most advanced knowledge as consultants to those who will carry programs into action. Consultative service of this type is being employed on specific projects in a variety of ways, including regularly organized advisory committees, special conferences, *ad hoc* panels, individual consultants, and private consulting firms. By using part-time consultants, the ability of a few can be spread to serve many needs. It is a method for multiplying our scarcest resource of all—the highest level of scientific competence. Full-time scientific consultants are being employed more and more within the Navy's scientific program, e.g. the deputy and chief scientist of the Office of Naval Research. Such an arrangement permits the consultant to be used on scientific problems exclusively, free from the drain on his time for the inevitable multiplicity of nonscientific duties which befall one who bears the responsibility of administration.

Reduction of Nonscientific Duties of Scientists

Where the scientist must also be the administrator, we are finding his administrative load can be shared by special administrative assistants who can follow through on the nonscientific aspects of his duties. Without this type of assistance, the administrator would have little or no time for excerise of his scientific knowledge. Too often scientists have lost their competence and eminence as scientists because of the usurping urgency of administrative duties when they have been placed in administrative positions in scientific activities. This is unfortunate for science, the laboratory, and the scientist himself.

Reduction of Low-Level Scientific Duties of Advanced Scientists

The wider use of laboratory assistants and aides to do more routine scientific tasks and adequate clerical, secretarial, and statistical assistance also enable the scientific staff members to devote a higher proportion of their time to work commensurate with their abilities. For example, the 1,000 professional scientists and engineers at the Naval Research Laboratory are supported in their work by 2,000 subprofessional, clerical, administrative, mechanic, and custodial employees.

Fluid Assignments of Scientists to Projects and Research Teams

Another device, which we are presently studying, is a suitable organization and structural pattern of a scientific laboratory to facilitate the most productive and fluid team groupings of research workers. This concept presupposes that each research study or project would suggest its own needs for participation of scientists from various fields of specialization as the problems unfold. At present some research activities are not structurally flexible enough to adapt to ever-changing, unforeseen leads.

Somewhat similar to the last device is the possibility of doing a better management job of classifying the skills and competences needed to carry through a complex scientific program and breaking down the tasks to be performed so that each scientist would be working at his own full level of competence most of the time. It is much more difficult to organize a scientific laboratory to use lesser-skilled workers on lower-skilled tasks, in such a manner as factory production lines are planned. But it may not be entirely impossible.

Facilitation of Placement for Full Employment of Talents

Another waste of scientific talent occurs when a scientist is employed at a laboratory which cannot fully use his special talents. This can occur as the result of, for example, change in the work of the laboratory, professional development of the scientist beyond the tasks for which he was employed, a poor choice of position in the first place, or a change in personal fortunes. Whatever the cause, the Office of Naval Research has found it possible to reduce the number of original errors of this type, and correct misplacements that develop after the scientist enters upon the job, by operating a Navy-wide, central clearinghouse which lists the current scientific personnel needs of all laboratories and refers scientists to those laboratories most likely to need their special skills.

Improving the Supply

Over and beyond the responsibilities of educational institutions in any large-scale, long-term effort to improve the supply of scientific personnel are opportunities for the industrial and governmental agencies to assume more direct responsibility for the professional improvement of scientists already in their employ.

University-Credit Courses for Employed Scientists

University-credit courses for employed workers is not a new idea. For many years educational institu-

tions in metropolitan areas have been offering courses in the late afternoon and evening for employed workers. But a new approach to this plan has recently demonstrated its vitality. After the Japanese surrender Federal agencies were cut back to the normal 40-hour work week. The Navy laboratories and bureaus seized upon the opportunity this shorter week offered to encourage their civilian scientists to enroll in university courses leading toward advanced degrees.

In the Washington area alone some 41 courses with nearly 1,000 students are now in progress at the Naval Research Laboratory, the Naval Ordnance Laboratory, the David Taylor Model Basin, the Naval Gun Factory, and the bureaus of the Navy in cooperation with the University of Maryland and the U. S. Department of Agriculture Graduate School. Students register and pay the regular fees at the university and obtain university credit upon satisfactory completion of courses. Some of these courses are given at the educational institutions, but many are given in the laboratories themselves. A considerable number of the instructors are naval scientists with teaching experience, officially designated as members of the university faculties offering these courses. The great majority of the present courses are at the graduate level. At other naval laboratories and establishments throughout the country, another 500 scientists, engineers, and technicians are enrolled.

Similar arrangements are under way in Army, Air Forces, and other Federal laboratories.

Another interesting and valuable opportunity offered to Navy civilian scientists at several naval establishments is "thesis accrediting." Arrangements have been made with a number of leading universities whereby a man who has completed all his residence and course work requirements and passed his preliminary examination for a Ph.D. may use the research he is carrying on at the laboratory as a basis for his thesis.

These programs require careful planning, careful selection of students and instructors, and close integration with the university programs to insure the highest academic and professional standards.

In-Service Training

In addition to the university-credit courses previously discussed, many industrial and Federal agencies have sponsored noncredit in-service training to help their engineers and scientists become proficient in the special and advanced phases of their professional fields, especially as they relate to their assigned duties. For a long time the National Bureau of Standards has been offering each year a small number of graduate level, noncredit courses taught by their own senior scientists. The U. S. Department of Agriculture has had its own non–degree-granting Graduate School for many years. The Navy sponsors similar courses which are sometimes restricted to scientists of the military establishment and sometimes open to scientists from other Federal or private organizations. These courses range through a wide variety of types, including systematic and comprehensive study of certain special subjects, lecture courses on recent developments, seminars, colloquia, symposia, conferences, and other forms as appropriate to the need. They also range from a single session to a year and a half in length.

Training of Personnel for Undersupplied Fields

The Department of the Navy is actively assisting universities in the development of facilities for research and instruction in fields that require highly specialized equipment not otherwise available to the institution. In this manner a large number of graduates are being prepared for work in certain shortage fields. Such assistance has been given in the fields of electronics, nuclear physics, mathematical computers, aerodynamics, hydrodynamics, oceanography, meteorology, and cosmic rays, to name only a few.

Special Curricula

The Office of Naval Research is encouraging the offering of special curricula in universities to increase the availability of trained workers in certain new and undersupplied fields, such as machine computation.

Opportunities Offered by Research Contracts

Finally, the Office of Naval Research is placing basic research contracts at universities where the contract provides a dual benefit. Not only is the research study carried forward with new knowledge available to all scientists, but, equally important, the project provides the opportunity to train an oncoming supply of research workers. The 700 ONR-sponsored research projects now under investigation at approximately 150 universities throughout the country provide direct research training for 2,500 graduate students.

The programs reported here illustrate that there are a number of ways in which more, and perhaps better, scientific work can be done with the number of scientists and engineers available at any one time. It is hoped that this discussion will stimulate other organizations to adopt similar methods and to develop new and better means of making the most effective use of this country's scientific talent.