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SCIENCE ADMINISTRATION, EDUCATION, AND CAREER MOBILITY. SUMMARY OF PROCEEDINGS AND WORKING PAPERS OF THE UNIVERSITY-FEDERAL AGENCY CONFERENCE (NOVEMBER 7-9, 1965).

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THE 1965 UNIVERSITY-FEDERAL AGENCY CONFERENCE FOCUSED ON THE MIDCAREER TRAINING AND EDUCATIONAL NEEDS OF FEDERAL SCIENTISTS. PARTICIPANTS REPRESENTING GOVERNMENT, INDUSTRY, AND UNIVERSITIES EXPLORED IN DEPTH THE POTENTIAL UTILITY OF CLOSER COOPERATION AMONG ALL THREE SECTORS TO PREVENT OBSOLESCENCE OF VALUABLE SKILLS AND, BY USING THE UNIQUE FACILITIES OF ALL THREE TYPES OF INSTITUTIONS, TO DEVELOP INDIVIDUAL CAPABILITIES AS EFFICIENTLY AND FULLY AS POSSIBLE. THE PROCEEDINGS COVERED THE DIMENSIONS OF OBSOLESCENCE, THE NEED FOR A TECHNOLOGICAL STRATEGY, SKILL NEED AT VARIOUS LEVELS, REMEDIAL OR CONTINUING EDUCATION, TRAINEE SELECTION AND MOTIVATION, COMMUNICATION AND COOPERATION BETWEEN UNIVERSITIES AND FEDERAL AGENCIES, AND PROPOSED FACILITIES. THREE PAPERS WERE PREPARED ON THE RECRUITMENT AND CAREER DEVELOPMENT OF ENTRY LEVEL (GS-5 - GS-11) SCIENTISTS AND ENGINEERS, MIDCAREER AND SENIOR FEDERAL RESEARCH AND DEVELOPMENT EMPLOYEES (GS-3 - GS-18), AND FEDERAL LABORATORY, SCIENTIFIC, AND TECHNICAL DIRECTORS. ALSO INCLUDED WERE NUMEROUS CHARTS AND TABLES AND A LIST OF CONFERENCE PARTICIPANTS. THIS DOCUMENT IS ALSO AVAILABLE, FOR $2.00, FROM THE INSTITUTE OF PUBLIC ADMINISTRATION, INDIANA UNIVERSITY, BLOOMINGTON 47405. (LY)

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science administration, education, and career mobility

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Science Administration, Education,

and

Career Mobility

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Summary of Proceedings and Working Papers
of the
University-Federal Agency Conference
Sponsored by
Purdue and Indiana Universities
for the
United States Civil Service Commission
November 7-9, 1965
Chairman, John W. Macy, Jr.

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THE WHITE HOUSE

Washington
November 8, 1965

I have a deep personal interest in the matters that will be taken up at the University-Federal Agency Conference when Federal officials meet with distinguished educators from Indiana and Purdue Universities. My heart is with you as you search for meaningful answers to some profound questions.

There is a pressing need for university and Government people to get together -- sincerely and often -- to come to terms with today's questions and to anticipate tomorrow's. Both sides can benefit from the exchange of ideas.

We especially want to improve the competence of scientists and engineers in Government, those already in as well as those who will be entering. Educators can help us. We are working on many fronts to improve the lives and the aspirations of men. Meantime, we fully expect our scientists and engineers to work just as diligently to improve the level of technology. The progress they make will have a basic impact on the general economy, the earnings of individuals, and the betterment of our society. Together, we are obliged to keep our scientists and engineers sharp and responsive.

On the other hand, Federal scientists and engineers, every day in the year, are working in matters that are often new to the college classroom. We must share this information as readily as we share our problems.

I hope this meeting of people will result in a better meeting of minds, and I commend the Civil Service Commission for arranging the conference.

/s/ Lyndon B. Johnson

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I. Summary of Proceedings

This conference focused on the mid-career training and educational needs of federal scientists. Participants representing government, industry, and the universities explored, in depth, the potential utility of closer working relationships among all three to advance continuing education of scientists and engineers--not only to prevent obsolescence of valuable skills but to develop individuals to the limit of their potential in the most effective manner by utilizing the unique facilities of all three types of institutions represented by the Conference.

A. Technical Obsolescence: A Critical Problem

The creative fronts in science are changing content and direction so rapidly that one can no longer count on a basic technical education to serve an individual for a lifetime or even a decade. The recognition of this rapid decay of basic technical skills and inability to keep up with changing technology led the conferees to focus on methods of dealing with obsolescence on both a remedial and preventive basis. It is important to correct obsolescence, when recognized, but it is even more important to establish a positive strategy of continuing education to keep technical personnel at the creative forefront of modern science.

Technical obsolescence was seen as a key aspect of the general task of continuing education among government scientists and engineers. The conference differentiated between two forms of technical obsolescence: 1) obsolescence within a field and 2) obsolescence of a field. Obsolescence within a field occurs when the "main thrust" of the field is shifted from the traditional lines or past patterns of individual or group research. Obsolescence of a field occurs because it loses its importance and is supplanted by other fields of study or a more advanced technology.

B. The Need for a Technological Strategy

Organizations differ widely in their objectives. Each must develop a technological strategy that is appropriate to the accomplishment of these objectives. Scientists and engineers are employed to accomplish the mission of the organization. Continuing education for such technical personnel, therefore, must be relevant to these objectives. Management is the transmission belt for making existing or developing skills effective in the solution of organizational problems. Most conferees felt that management might concentrate somewhat more diligently on the problem of developing a total technological strategy for the organization. This, in turn, would identify specific problems and issues of continuing education which could then be the subject of discussion as to how universities might be used to assist in providing resources for continued growth and development.

The requirements of the Department of Defense, for example, are not the same as the requirements of the National Science Foundation or the Public Health Service where objectives are directed to the advancement of science and technology in general throughout the country. The needs of special service organizations such as the Weather Bureau impose a different set of requirements. The State Department, as an additional variant, requires that science be integrated with other skills to provide individuals with a broad cultural background in its attempt to represent American civilization to the world.

The key problem is that of providing opportunities for such self-renewal for individuals to equip themselves with competence to support the technological strategy of the agency. Is the key to this self-development agency training, university involvement, the individual's motivation and interest, or combinations of these?

C. Varying Objectives Require Varying Skills

The conference noted that there are several types of employees generally classified as scientists and engineers. 1) There are technical personnel (established researchers) engaged in basic research in the attempt to advance science and technology. These scientists know one specialized area of knowledge very well. Their problem is to earn a new Ph.D. about every seven years or its equivalent in intellectual competence. The scientist or engineer must broaden his experience by penetrating new fields of knowledge <u>in depth</u> at regular intervals to stay alive scientifically. They can keep abreast of their original specialization through reading and research; however, unless they are willing to learn new fields of specialization in depth, they face obsolescence. 2) There are younger people (apprentice researchers) who have not yet developed expertise. Their problem is to develop the first specialization. 3) Finally, there are applied engineers and technicians (professionals) who are engaged in applying technology. Engineers must not only be concerned with the new knowledge coming from research but also the advances being made in their own and other branches of engineering and applied sciences. Re-education and retraining for large numbers of employees emerge as a problem at this level.

Using these distinctions the Conference considered that established scientists and engineers could best be aided by the opportunity to study new fields. They should be encouraged to take sabbaticals at centers where experts in the field to be learned are at work. If this is not possible, alternatives such as bringing outside instructors into agency training programs and various short term experiences might prove useful.

Apprentice researchers, on the other hand, might best be trained within the agency through organized training programs, seminars, and lectures. Such education is more likely to be relevant to the tasks of the agency and to eliminate the problem of retraining university graduates for agency research. But there is a danger of a closed-loop circuit that only perpetuates the kind of people that are already in the laboratory. If the seminars are taught by the "old hands" of the agency they may teach traditional ideas of the organization; whereas, creative work demands new ideas, different approaches and different experiences. There was only limited discussion by the conference of the specific methods of continuing education for the professionals concerned with practical applications of technology or for technical assistants who make possible the work of the researchers.

D. The Need for Aggregating Mechanisms

Since organizations and individuals differ widely in their requirements, it is necessary to cluster these needs in some manner so that they can be "digested" effectively by universities. The excellent program of the National Institute of Public Affairs was mentioned as a model of such an aggregating mechanism. What others might be developed? Might the Civil Service Commission do this on a broader basis for the entire Federal service? The universities might respond somewhat more enthusiastically to such clustered requests than they do to individual needs requiring a great deal of restructuring of standard graduate offerings.

Naturally, universities differ. The large state university, the ivy-league college, the small state or private college, the junior college, and training schools have the capacity to render very different types of assistance in continuing the education of scientists and engineers. This conference concentrated primarily on the role of the larger universities and colleges.

It was realized that universities are not necessarily the best institution for dispensing up-to-the minute technology. Often the time lag for incorporating technological advances is greater in the university than in government or industry. The demand that universities provide immediate information places them in an inappropriate role. The university is organized to perpetuate knowledge. It has the capacity to relate modern technology to the fundamentals of a field and, because it is universal or multifocal, to many fields of study. In short, the government can properly expect the university to provide scientists and engineers with the basic science to bridge the gap between their classical training and what they must know to be doing effective work.

A useful technique for dealing with obsolescence in university technological knowledge was developed in the field of agriculture. Schools of agriculture, experimental stations, and the extension services were brought together in a cooperative relationship, including "inter-locking" personnel. This system allowed the schools of agriculture to keep on top of technological advances. Although agriculture is a form of applied research, this pattern might usefully be employed in other fields. The State Technical Services Act is a step in this direction since it makes possible on university campuses a joint activity at the forefront of technology and applied science.

If the role of a university is not simply one of dispensing technological information, what contributions can universities make to combating obsolescence? The general contribution of providing basic science education has already been mentioned. However, there are other specific contributions. A fundamental contribution of universities should be to organize and simplify the learning of complex fields. Universities should continue to provide their usual degree courses, correspondence courses and evening classes. Universities can design special courses to meet the needs of a specific agency. University mechanisms for coping with obsolescence can serve as models for government efforts. Lastly, universities can participate in a faculty and research personnel exchange with government.

The conference heard a report of a recent survey by the President's Committee for Manpower of the kinds of continuing education now utilized by government engineers in sixty-nine agencies. These agencies, which employ 26,382 engineers, provided 30,000 training opportunities in 1964. In order of the number of opportunities, these were: 1) technical society meetings, 2) in-house lectures, 3) technical lectures outside the agency, 4) tuition refund programs, 5) job related teaching, 6) educational leave, and 7) post doctoral training. The total man-hours involved were 277,536 (about ten hours per man). In order of man-hours the rank of these opportunities was reversed (educational leave the highest and professional meetings the lowest). The report concluded that federal agencies are concerned with continued education; and through a diversity of techniques and decentralized decision making they are attempting to meet these needs. The agencies are, however, doing less to provide the training necessary for an engineer to become a manager than to maintain technical competence.

E. Remedial or Continuing Education

Management has the responsibility, the authority, the discretion, and hopefully the foresight to keep the expertise of the staff of the organization sufficiently attuned to changing technology that crash remedial programs to solve problems of obsolescence need not arise. The alternative to crash programming is consistent, positive, aggressive identification of the needs of employees for continuing education. It is no longer sufficient for management to rely on employee self-development as the sole method of meeting these broader projections.

Maximum creativity comes from exposing people to new fields--uniting the old with the new. There is a clear requirement in any scientific organization to constantly expose people to change in new fields of science and technology at the graduate level.

A special point discussed by the conference was the lapse between graduation and future graduate study. If four or five years elapse, it is difficult to begin again. Government employees just out of school should be encouraged to take part-time or night courses. While this may not be the best way to obtain a degree, it does keep one familiar with the demands of university study and makes the transfer back to full time study easier.

Government administrators without previous experience in science who are now in positions of responsibility in organizations that are heavily influenced by scientists and engineers (and many interested adults who feel deficient in science and engineering) desire to go to a university to learn something about science and engineering. However, there are no good courses available to which one can direct such persons. What is needed is not the traditional "introductory" science courses but an indepth study of some particular area. This would allow the adult student to begin to understand the vastness and complexity and way of thinking in this field.

Often in recent years universities have been requested to provide special courses and tailored degree plans for scientists and engineers. To an ever-increasing extent faculty members and universities have responded to these requests. Naturally, the response differs from region to region and even between departments of a given university. In general, collaboration is easiest and most satisfactory where a government laboratory and university are near each other or where the government lab arranges with a university to establish on its facilities the equivalent of another campus. It must be recognized that the cost to universities of establishing special courses and degree programs is high, not only in terms of dollars but also in precious quantities of faculty time. Universities cannot assume too many temporary jobs at once and many of the courses for which government agencies are now asking have no guarantee of continuance. Even if the universities can provide special courses and programs for the current demand, they may not be able to do so should the rate increase to fifteen percent of all mid-career scientists per year.

The question of whether all university-taught courses should offer degree credit was debated. On the one hand, it was maintained that there were two different kinds of continuing education. The first type requires the opportunity to study a once-learned or new field in depth. This is properly related to a degree granting program. The second type is for the maintenance of professional skill and the mastery of new technology. In this case, short term courses, perhaps utilizing guest lectures, are ideal and the proper award for thus maintaining professional currency is additional responsibility rather than a degree.

A degree means that its holder has met relatively uniform standards. There was a particular concern expressed at the conference that the graduate study centers at government installations meet these standards if they are to offer degrees. On the other hand, standards may be more flexible concerning short term non-credit courses. The general consensus was that both Ph.D. courses (appropriately planned for adults) and short term programs are required for different aspects of continuing education.

The conference was reminded that the degree is important to individuals in government service because it is the only publicly recognized symbol that they have gone through the education process. In theory, whether a man has a Ph.D. or M.A. should not make a difference in advancement. In fact, the prestige of a degree and the likelihood that it will affect advancement are such as to negate theoretical estimates of its value. One alternative to the present situation would be for universities to offer a different degree than the Ph.D., which is primarily a research degree. Some universities have experimented with this, but it is difficult to tell whether the practice is growing or dying out. Another alternative might be for the government to issue a title of its own for outstanding work. For example, the British government issues the title P.S.O. (Principal Science Officer) to outstanding civil servants. But as long as the term "Doctor" cannot be applied to a government award, it may not be a prestigious enough substitute.

Tailor-made degree training programs do exist. The flexibility of degree requirements is increasing with some universities abolishing course requirements entirely. The best pattern for developing special degree programs begins with a discussion by the university and the agency of the objectives of the program. Then the people who are to administer the program locally are left to work out the details.

In providing regular courses for students, including government scientists and engineers, universities face several difficulties. The primary problem is that different approaches are needed to teach 35 year old adults as opposed to 17-21 year old undergraduates if learning is to be maximized. In the area of mid-career learning there is much which isn't yet known as only three or four important studies have been published on the subject. Further research on adult education is, therefore, a necessary priority. Nonetheless, from what is known we may be confident that the differences in motivation and background of the mid-career and under-graduate student require a different style of teaching and a different type of course. One suggestion for improving current university courses is to provide a full-time faculty within the traditional departmental divisions that is concerned and trained to teach adults. This, in turn, demands that faculty members be willing to be drawn away from other tasks such as research, undergraduate and graduate teaching. Sufficient numbers of faculty are unlikely to be drawn into adult education unless (1) the job is respected by the department and university, and (2) there exists an in-group of colleagues similarly involved who can offer mutual social and psychological support.

F. The Management of Motivation

The conference was concerned about the problem of motivating employees to assume the burdens of further personal development. Who should be selected? What proportion of the staff, statistically, should be tapped for further development? A figure of twenty percent was suggested. This was countered by the argument that it might be eighty percent, depending entirely upon the skill of management in stimulating employees to become meaningfully involved in productive continuing educational efforts.

Participants agreed that selection for further educational opportunities should not be governed by any false premises of equalitarianism. Management has the responsibility of finding those who are most promising. It takes courage to make decisions and it is necessary to educate managers to use this discretion in selecting people for further development. Not everyone can profit from a Ph.D. every seven years. As one representative stated it: "I found that in some industries the vice president in charge of personnel felt that he must be democratic and therefore provide the same opportunities for everyone who applies. I think this is ruinous for any situation."

The decision as to who is trained is squarely up to management. Too many hide behind budgetary limitations but comments of many of the participants were to the effect that the manager had considerably more discretion in this than was exercised normally.

One participant thought it was possible, through good management, to stimulate practically the entire work staff to participate in personal development.

One major problem is that of placing the responsibility for this on subordinate managers. As one participant said "such a manager gets negative brownie points for sending a man to school. He still has the day-by-day operating pressures but one less employee to help out."

Thus, the supervisor is penalized for sending a good man to school. The manager must build a climate in the organization that rewards the good supervisor who does try to develop his staff for the good of the organization. Subordinate managers should be judged for promotion on how well they have planned for the development of subordinates.

The question was raised as to how much up-grading of an employee should be permitted. If one is going to lose him in five years, should he be given the same consideration as his counterpart military officer where the armed services know they can keep him for twenty years?

Perhaps a variety of experiences might be required for advancement to higher-grade postitions. There must be, at least, a more vigorous evaluation of an individual's potential before he is advanced in the organization.

What is the responsibility of the individual for his own personal development?

This depends somewhat upon whether the individual feels that he is "on his own" or if he is a member of a corps and owing allegiance to the corps. Should he make decisions on the basis of loyalty to the corps or on the basis of personal self-aggrandizement? If the person plans to stay with the government only so long as it is fun and lucrative, government should possibly make as few commitments as possible in such entrepreneurial types.

Management, as a minimum, has the responsibility of recognizing what the individual does in the way of self-development. This should be rewarded appropriately by the career development standards of the organization.

Where technology changes through no fault of the individual employee, management has a clear responsibility. It has the responsibility of anticipating change and potential obsolescence and counseling and directing the individual away from it. The man may be keeping up to date but he may be doing so in an obsolete technology.

Universities employ various methods to combat faculty obsolescence: 1) the sabbatical year, 2) research activity, 3) contacts with professional societies, 4) travel to other institutions and conferences, 5) a workload which leaves time for individual professional improvement, and 6) consulting arrangements with industry and government. Of these mechanisms the sabbatical was the most thoroughly discussed at the conference. Although a number of universities have abolished the traditional sabbatical, most have retained similar leave of absence programs. If government were to adopt a modified sabbatical program, scientists and engineers selected by management as capable of fruitfully utilizing the experience might be encouraged to take up to six months off the job every three years. Alternating between university and industrial opportunities during these sabbaticals would provide a healthy mixture of experiences.

G. The Management of Innovation

What happens to a man during the course of his career? He tends to become increasingly narrow and loses the creative spark. An educational experience of significant length of time can go far toward rekindling this creative spark in the individual. This may remain alive if bureaucratic routines do not again deaden imagination. Management must make a major effort to establish a climate which encourages innovation and imaginative work performance.

As helpful as outside educational experience might be, the conference felt the most effective device for continuing education was the job. "This is where you really learn" said one participant. The problem is to confront the individual with a whole new series of duties and responsibilities occasionally. To assume new duties one needs new capabilities. The assumption of duties builds new capabilities. It is a two-way street.

Duties and responsibilities thus arrayed can be turned into the equivalent of a "Ph.D. every seven years" suggested some who thought conferees were relying too heavily upon universities as the sole source of innovative insights. One participant catalogued government scientists and engineers as follows:

> First is the scientist or engineer who is no longer a practicing technician. He is at the policy level of development. What does he need to make him a more valuable employee? How does he learn the politics of

science?

The second kind of person is the one who is concerned primarily with laboratory management. He is still closely related to the scientific program. How does he learn to be a better manager?

The third is the bench research scientist and practicing engineer. This is still a very different kind of job requiring different skills.

The fourth is the man in the government laboratory who is engaged in departmental work.

The fifth is the man who is engaged in testing on a very routine basis.

The sixth variant is the technical man who is engaged in technical services.

Each of these categories requires a different prescription for continuing development.

H. University-Federal Agency Cooperation

How can universities facilitate the transfer from the "bench" to laboratory administration? How can the government and universities cooperate in producing for the government, and then indirectly for the university, the kind of managerial capability that has the understanding, the sophistication, and the cabability of directing and controlling the conduct of a research and development operation?

This question was directed at the following specific problems.

1. The direction of government laboratories;
2. Improving relations with universities and with industry; and
3. Synthesis of above involved in carrying out public policy.

Some participants felt that the codification of available knowledge tended to be lodged in the university and that eudcational institutions, therefore, had a vital role to play in the upgrading of scientists and engineers. Conversely, it was also felt that the practitioner might contribute to university development through research, teaching, and administration.

The conference distinguished between science managers concerned with the management of scientific work and scientific politicians concerned with public policy in scientific areas. For the scientific politicians, a different form of training is necessary than those programs already suggested. Moreover, successful management requires both good managers and receptive employees. Perhaps some seminars for employees or for both managers and employees should be developed to foster a better understanding of good management.

Finally, the conference reflected upon the possibility that science managers need not be scientists in their own right. It was felt that they needed a knowledge of science and sympathy for the scientific endeavor, but that they did not necessarily have to advance scientific knowledge through their own research. In the future it may be possible to educate science managers for their task from the first, rather than training them to be scientists in the beginning and retraining them later as managers. An analogy proposed for consideration was hospital management--the manager need not be a doctor.

Such generalizations, however, are not without their hazards. One dissenting argument was to the effect that quite aside from sound financial and personnel management, the manager must be competent to make a scientific audit of the quality of the work under his direction. Since there is no immediate dollar measure of this quality, the good manager must be competent to make a scientific measure. Moreover, from time to time even the best scientist will reach a dead-end without realizing it because he is too close to his subject. Here the skillful scientific manager will lead him into new pathways, delicately and gently. This management technique is essentially impossible to apply by the non-scientist manager. Yet the greatest waste of funds can occur in a tightly managed enterprise whose real scientific progress cannot be audited.

There are technical and personal problems to be overcome if the flow of personnel between universities and government agencies is to be increased. It may be difficult for senior scientists to leave their family of cohorts at the university. They have doctoral students and current research grants to consider. There are two ways to solve the graduate student problem. A scientist may either be allowed to bring graduate students with him to work in government or he may be allowed to return to the campus several times a year to check on their progress. In these exchanges the government should pay the incidental costs (travel and moving costs, fringe benefits) and at least part of a professor's salary. When government scientists and engineers go to universities, they should be kept on the government payroll to encourage their return and to avoid any conflict of interest in future policy decisions.

It was recognized that universities have a part in the general broadening of the interests and knowledge of persons employed in government. It was thought to be particularly important that scientists and engineers (especially those who will later become managers) achieve breadth in undergraduate education. With a basic education including sophistication in the social sciences they should be better able to interpret and learn from their experiences.

The NIPA fellows have found that the general university curriculum often is adequate in their area of specialization; however, they have had difficulties in gaining social science education. This problem stems from the inclination of the social sciences to produce researchers and teachers. There are not enough courses available on public affairs and the application of social science knowledge to government policy making.

In all three areas--technical obsolescence, underdeveloped managerial capacity, and general narrowness--there is need for further self-study and collaboration by government agencies and universities. On the one hand, universities cannot adjust their programs if the needs of government are not known. On the other hand, it is difficult for government to spell out its variant requirements. Hence, the need for aggregating mechanisms described above.

One of the problems seen was the tendency of research on campuses to become less and less related to the operational needs of organizations. "The most pure, the most life-unrelated research is the one that earns the highest kudos" said one participant. It was agreed, however, that research on the campuses should be related to education and not problem solving. This raises a question of adjustment of the practicing scientist. He comes to the university thinking of a whole series of unsolved problems basic at the laboratory and wants the professor's help in solving these problems. The professor, on the other hand, is not tuned to such a pragmatic wave length and is not likely to give such questions much consideration.

One way of approaching the integration of these different value orientations is that of the development of inter-disciplinary programs, such as materials research centers or electronics program centers. The Defense Department will give a university a contract with financing of $500,000 to $1,000,000 with the specification that it will do basic and applied research in a "region" of science of potential value to the military. The local university manager of a program keeps in close touch with specific needs of the military and is able to interest graduate students and others in involving themselves with such problems in terms of basic and applied research. The Defense Department thinks there is a great potential in such programs and plans to expand the number in operation.

Many beneficial aspects of these large programs were pointed out. Funding is more rational--it is not necessary to apply for four projects to obtain funds for two. Allowing specific projects to be determined locally stimulates the university to contribute more to the program. Large programs are easier and less time consuming to monitor than many smaller projects. They contribute to better university-government relations by developing local managers familiar with the problems of government and in close contact with an agency. These local managers alert local professors to problems being faced by the government and often these managers go on to serve in the agency itself. These programs may have a subtle deflecting effect upon research but it is not an undue pressure. The programs are most successful where unique facilities are involved. In sum, such programs strengthen the university while accomplishing government research goals.

The university has problems. Its organization tends to perpetuate old fields. It is handicapped in any kind of innovative design to update itself by the institution of tenure. The new technologies--computer technology, information technology, systems engineering, microelectronics, transistor technology--have not been well digested by the universities. While they may make considerable contributions in the design of advanced research projects, they can make only limited contributions in these emerging technological areas.

The universities should be utilized in areas that require exposure to the fundamental basic sciences to provide the background at least for reading professional journals concerned with the newer technologies.

There was considerable discussion about the feasibility of exchanging personnel between universities and the government. An example: university "X" would permit three people to work in bureau "Y" for a year in exchange for which bureau "Y" would send three persons to university "X". No one-to-one relationship was visualized in this exchange. The individual from bureau "Y" would not attempt to take over a specific course taught by the exchanged professor but could teach another course in the general area which might be just as valuable for graduate students, or he might do some research to free a research man for teaching. This proposal was considered to have great merit by the conferees.

Other observations were directed at the possibilities of providing for meaningful management assignments in universities on the theory that the development of a curriculum or directing a research project might be just as valuable as formal course work.

Mid-career programs should not be degree programs in order to provide for maximum flexibility for tailoring programs to needs of the individual in terms of where he is going in the future. Degree requirements tend to strait jacket and confine the area of choice. Undergraduate curricula and graduate curricula are not well designed to meet the needs of the individual. Can one maintain rigor without degree requirements? The MIT program was cited as one that was particularly good in protecting high standards even though not primarily a degree program.

What are the constraints on employees going back to school?

They may have a great deal of intellectual insecurity if they have not been in the habit of studying. They may feel uncomfortable with other graduate students who have spent the previous immediate years in graduate school. Furthermore, the employee may be so far behind in the technology that he is studying that he may not be able to catch up without considerable retooling. If an individual attends school with others of his age group, much of this insecurity may disappear.

A large number of employees will return to the university to learn the relationships between their technology and public policy. There are very few courses oriented in this direction. The universities can make a vital contribution in this area. Most, however, concentrate on training personnel for research and teaching and exhibit little interest in developing courses dealing with public policy.

I. Science Administration Centers

Science programs are now sufficiently complex and long-lived that no one person can possibly obtain more than a fraction of the knowledge necessary to be a good manager. Most managers now come from within the organization to be managed. It was felt that some way must be found to broaden managerial horizons.

In order to provide for a wide variety of experiences and to bring the unique contributions of the university to bear on the development process, it was proposed that science administration centers be developed at three or four selected locations throughout the country.

These centers would administer a two year program for about twenty middle level career people selected from government, industry and the universities. Participants would spend one year in residence studying management and one year as interns with an organization in a management capacity. The purpose of this would be to provide as broad and varied an experience as possible to those with a capacity for assuming larger responsibilities in science.

It would be based on the same principles as business administration schools but the curriculum would be directed at the problem of science administration.

As a start, one might combine the offerings of a school of applied science and engineering, a school of business, and a department of public administration.

These centers might accommodate approximately one hundred people a year in the aggregate. The several centers might have a different focus for their curricula. One might concentrate on developing individuals as laboratory managers while another could concentrate on an experimental program for those concerned with public policy issues in science and engineering.

Case studies, simulation exercises, exchange of experiences and problem solving were felt to be useful educational devices with possibly more validity than lectures.

The internship feature would provide individuals with an opportunity to learn management "at the feet of a master." These would be working assignments with maximum involvement in the organizations to which the man was assigned.

For persons already in senior positions, a somewhat more abbreviated version might be offered (such as a concentrated two week program in successive summers). In any event, it was felt that senior personnel should spend significant periods of time in residence with the trainee group to provide maximum opportunity to exchange experiences.

This proposal stimulated a great deal of interest. Participants felt that this was one action possibility that should be implemented at the earliest possible date.

II. Working Papers: A Profile of the Federal Research and Development Workforce

Introduction

The papers comprising this study are intended to provide background material on the Federal research and development workforce from entry level to senior grades, and including laboratory, scientific, and technical directors. Papers in this series have been prepared by William A. Medina (Paper 1), V. Wayne Cobb (Paper 2), and Melvin W. Wachs (Paper 3), of the Office of Career Development staff.

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A Profile of the Federal Research and Development Workforce

1. Recruitment and Career Development of Entry-Level Federal Scientists and Engineers

This paper, the first in a series of three designed to provide essential background material on the Federal Research and Development Workforce, deals exclusively with the entering scientist and engineer, GS 5-11. Because there are no government-wide statistics on this population, this paper draws upon a collection of small studies to extrapolate a profile of the entering R&D employee in a laboratory or test facility. Its concern is with the recruitment and subsequent development of these individuals.

A. Factors affecting recruitment of entering personnel.

B. Statistical summaries of acceptances and declinations of offers of Federal employment.

C. Statistical data concerning the number and quality of entry-level engineers, mathematicians, and scientists, 1961-1964.

D. Career development opportunities for the entering scientist or engineer.

E. Types of social science research being conducted on entry-level professionals.

2. The Mid-career and Senior Federal Research and Development Employee

The second paper describes in comprehensive fashion, utilizing statistical and graphical techniques, the background and career progression of 22,230 mid-career R&D employees (GS 13-15) and 757 senior personnel (GS 16-18). Although centered largely about graphically presented data, both data and succinct summaries portray the mid-career and senior scientist and engineer in great depth and detail. The reader, utilizing the full range of materials made available in this paper, may in turn draw inferences and examine interrelationships which--in the interest of brevity--the paper discusses but does not attempt to describe in great detail. Data for the analysis was derived from the CSC Roster of Scientific and Engineering Personnel and the Career Executive Roster.

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3. The Federal Laboratory, Scientific and Technical Director

The final paper in the "profile" series examines the background, educational and job experience, occupational categories and career development of the Federal civilian laboratory, technical and scientific director. Drawn from current detailed resumes of over 95% of the senior managerial community, the paper utilizes statistical, graphical and analytical summaries to present comprehensive background on the group. In addition to prior formal educational experience, the paper also makes available data and analysis of continuing education received during their careers and relates this to patterns of career evolution from technical employment to management responsibilities. The senior group is also examined in terms of job mobility.

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1. Recruitment and Career Development of Entry-Level Federal Scientists and Engineers

Introduction

The last decade has featured a dramatic growth in the number of scientists and engineers employed by the Federal Government. Since 1962 over 11,000 young scientists and engineers have joined Federal service.* Current estimates are that professional employment through Fiscal Year 1968 in the physical sciences will increase by approximately 25%, engineering 21%, and mathematics 58%. The percentage of growth which will be met with young scientists and engineers is difficult to predict. However, it is certain that a significant number must be recruited to meet anticipated needs. This paper collates existing data concerning Federal agency recruitment and subsequent career development of entering scientists and engineers.

Recruitment

Starting salaries are a factor in recruitment. Studies have demonstrated that a disparity in entry-level salaries existed between industry and government in recent years. For purposes of perspective, it should be noted that in 1948 average salaries for GS-5 engineers and their entry-level counterparts in industry were almost equal at $3000 per year. In 1952, the government's GS-5 salary was even higher than

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* U.S. Civil Service Commission "Ten Agency Study." This covers about 85% of the scientists and engineers employed by the Federal Government.

industry's average rate for entry-level engineers. Since 1953, industry's entry-level salaries increased faster than government's.

The Bureau of Labor Statistics' study of February-March 1964 indicates that in 1964 the average annual salaries in industry for Engineers I (comparable to GS-5 or $5,990) was $7,344. Chemists at the same level were paid an average of $6,456. Engineers II and Engineers III (comparable to GS-7 at $7,050 and GS-9 at $7,710) earned $8,004 and $9,204 respectively. Industry predictions for 1965 concluded that starting salaries for engineers with bachelor's degrees would rise again.*

Depending upon their relevant experience and/or degrees and class standing, entry-level technical professionals join the Federal Government at the GS-5, 7, 9, or 11 ($8,945) level. Congress has authorized the President to establish higher salaries at entrance level grades when salaries in private enterprise "are so substantially above the salary rates of statutory pay schedules as to handicap significantly the government's recruitment and retention of well-qualified persons." The limit placed upon this increase in the minimum salary

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* The Endicott Survey, reported in <u>The Conference Board Record</u>, February 1965, Vol. II, No. 2.

rate is the seventh rate prescribed by law for the grade or level (each level has 10 separate salary rates).* The differences between the regular statutory schedule and the maximum rates of the special shortage schedule can be seen in the following table.

Grade	Entrance Rate, Regular Schedule	Maximum Entrance Rate, Special Shortage Schedule	Difference
GS-5	$ 5,000	$ 5,990	$ 990
GS-7	6,050	7,050	1,000
GS-9	7,220	7,710	490
GS-11	8,650	8,945	295

It is obvious from the table where the competition is felt most keenly. The use of the authority to augment the regular pay schedule signals recognition of the problems faced by the government in recruiting junior scientists and engineers.

Recent graduates with bachelor's and master's degree are generally hired at the GS-5 or 7 level. However, these individuals may be hired at the next higher grade level (GS-7 and 9) if they are considered graduates.**

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* Public Law 87-793, 87th Congress, H.R. 7927, October 11, 1962.

** Quality graduates are defined in the following manner: Bachelor's degree graduates must stand in the upper 25% of their class and/or have a "B" or better average. Other criteria are a "B+" or better average in the major field of study, or the achievement of high scholastic honors such as election to Phi Beta Kappa. Finally, specific examinations can also qualify an individual. A graduate degree holder can also qualify if an appropriate faculty member certifies that the candidate has demonstrated superior ability in his graduate studies. This quality feature at the 9, 11, and 12 levels, applies only to professional positions in research and development fields.

Reasons for Declining Federal Positions

How important is salary level to entering scientists and engineers? The Board of U.S. Civil Service Examiners for Scientists and Engineers in Pasadena services Naval laboratories in California. Annually, the Board surveys applicants who have declined appointments to junior research and development positions. In each survey since 1955 "pay" has been singled out as the most important factor to those individuals who declined appointments to Naval laboratories. Although other factors varied in rank order of importance in different years, "pay" has held constant in its top spot annually. For example, the 1963 survey by the Board of U.S. Civil Service Examiners in Pasadena reported the relative importance of factors influencing graduates to decline Naval laboratory positions as (in rank order):

1. Starting salary
2. Long-term salary prospects
3. Interest in work
4. Professional development
5. Advancement opportunities
6. Educational opportunities
7. Location
8. Incentive
9. Efficiency of government
10. Lack of interview trip
11. Prestige
12. Conduct of interview

Lack of first-hand information and distorted images, both of which might be corrected by on-site interviews, dissuade some entry-level engineers and scientists from accepting Federal positions. On-site interviews are used by many large companies to attract highly qualified individuals. Legislation currently before the Congress will, if enacted, permit agencies to use funds for these types of interviews.

In the 1950's the lack of reimbursement for relocation expenses for recently hired individuals was an important impediment to government employment, since many companies were paying these expenses. Additionally many young scientists and engineers were already married when seeking their first job. A surprising number of candidates surveyed by the Pasadena Board were married.

Marital Status of the Total Respondent Group (1961)

	N	%
Married, without dependents	23	8.9
Married, with dependents	131	50.8
Single	104	40.3
	258	100.0

Relocation expenses are important to the young scientists and engineers who are married. In 1960, Congress amended the Administrative Expenses Act of 1946 to allow agencies to pay for the relocation expenses of newly appointed individuals within the United States if they were determined to be in man-power shortage catagories. As most scientific and engineering occupations fall under this classification, the problem has largely been solved.

Flexible Recruitment Methods

Since much recruiting for entry-level personnel is done on college campuses, the Civil Service Commission instituted a program in mid-1964 to provide speed and flexibility in the recruiting of GS-5 and 7 engineers. Washington area technical agencies are now permitted to rate engineering applicants on the spot during their college visits. Subsequent to the rating, the agency representative has the authority to make an offer of employment and negotiate for entry on duty. Agencies have reacted enthusiastically to this new authority and have scored impressive first results in their recent recruiting programs. Plans are now being made to extend this authority nationwide.

Reasons for Accepting Federal Positions

Despite the problems of distorted images, Government employment can also be attractive to young graduates. A 1961 Naval study described the most important reasons why graduates accepted employment (in rank order):

Reason	% of Respondents
1. Interest in type of work	64.5
2. Location	41.9
3. Education and training program	35.5
4. Work conditions	25.8
5. Opportunity for advancement	16.1
6. Job security	12.9

7.	Fringe benefits	9.7
8.	Salary	9.7
9.	Recruitment practices	9.7

An in-depth study of a smaller number of scientists and engineers at the Naval Ordnance Test Station indicated that interest in type of work, chance to gain experience, training program availability, professional development, and educational opportunities were--in that order--positive factors favoring government employment. Most individuals interviewed believed that during the first few years after graduation, experience gained in a Naval laboratory was more valuable than initial training in private industry. What made the experience valuable was the variety and scope of the work and the early assignment of responsibility. In both studies, government education and training policies and programs were important to the interviewees. Although these studies involved only a small number of people, the relationship of education and training to recruitment is corroborated by many other sources involving a substantial number of scientists and engineers.

Recent government reports from the agencies employing most of the Government's scientists and engineers are unanimous in their belief that recruitment and retention are interwoven with education and training. The Director of a Veterans Administration Hospital wrote: "It is appropriate to state--that a majority of the professional staff would not be here if this training program did not exist." The National Institutes of Health reported that a key factor in the recruitment of its professional staff is the promise of continuing job related education. The National Bureau of Standards reports that "scientists considering Government service are increasingly concerned about the opportunities for advanced job-related study." Another agency stated that its positive training policies were well known among professional organizations and their members, and that this knowledge was a "definite stimulus to recruitment." Many agencies reported, as did Food and Drug Administration, that not only did the prospect of training "significantly influence" individuals to join their staffs, but it also was important in their retention.

Critical Function of Advanced Training

Education and training opportunities have become, as reported by the Department of Defense, "well established fringe benefits within the research community." Agencies report that they must compete with the "elaborate training programs provided by industry." Apparently many of the new scientists and engineers hired by government believe their agencies compete favorably in the education sector. Accelerated training programs by agencies have been used by all major employers of scientists and engineers. Under special arrangements with the

Civil Service Commission, agencies may devise training programs for scientists and engineers that upgrade their qualifications. These enable earlier promotion. This permits, for example, a quality graduate with a B.S. hired at GS-7 to be advanced as high as GS-11 within 18 months instead of the usual minimum 24 months. Thus the prospects of a planned training program at the outset, with additional virtues of qualification for an accelerated promotion and higher pay, have become important incentives in attracting many young scientists and engineers to the Federal Service.

How successful has the Federal Government been in enlisting the services of talented young engineers and scientists? On a composite average, NASA has found that of every twenty-five interviews at schools, it receives eight applications. From those applications, four offers are made for each acceptance. A 1963 Board of Naval Examiners report indicated approximately the same ratio.

On a nationwide basis, the Civil Service Commission's "Ten-Agency Study" reveals the percentage of offers accepted by engineers and scientists at the GS-5 and GS-7 levels:

	Engineers, GS 5-7	Mathematicians and Scientists, GS 5-7
1961	37.0%	52.0%
1962	29.3%	45.7%
1963	36.5%	47.8%
1964	35.9%	46.0%

Offers accepted by mathematicians and scientists at the GS-5 level have markedly declined from 1962 to 1964, whereas at the GS-7 level they have accepted positions at an accelerating rate.*

Industry, on the other hand, reports the following figures in its recruitment of "technical" personnel: 1962 - 1 offer made to every 5 interviewed, 1 acceptance for every 3.9 offers; 1963 - 1 offer made to every 6 interviewed, 1 acceptance for every 3.1 offers; 1964 - 1 offer made to every 6 interviewed, 1 acceptance for every 2.9 offers.**

The quality of individuals can in part be ascertained by an examination of the Quality Graduate Hiring Rates derived from the same Civil Service Commission Study.

	Engineers - B.S.		Mathematicians and Scientists - B.S.	
	No. Hired	% Quality Graduates	No. Hired	% Quality Graduates
1962	1,815	24.1	1,517	50.6
1963	2,133	39.5	1,472	52.6
1964	2,159	38.2	1,085	47.6

Averaged together the 1964 hiring rate for quality graduate

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* See Appendix I and II, pp. 51 and 52.

** The Midwest Survey, The Conference Board Record, February 1965, Vol. II, No. 2.

engineers, mathematicians, and scientists is 41.2%.

Career Development

Entering scientists and engineers receive considerable attention from their agencies and laboratories. Carefully planned training programs have been developed over the years by technical agencies, and agencies employing the majority of scientists and engineers have training agreements with the Civil Service Commission. The agreements with the Commission may allow accelerated promotion, as described above, while the participant is taking part in a training program which has as its objective the development of the trainee to full productivity in the shortest possible time by extending his engineering or scientific skill and knowledge. In many situations, programs bridge the gap between formal academic training and the needs of applied technology within the agency environment. The programs also orient the individuals to the broad spectrum of the agency's technical missions.

Progressively more difficult and complex assignments are given the trainee, and his level of performance is expected to improve, reflecting the results of previous training. Periodic progress reports are submitted by his supervisor to management. The program may have rotational aspects which involve moving around in the organization on a planned schedule. Often included in this pattern of early mobility are field assignments lasting from a few weeks to a few months. These programs ensure pre-planning and significantly increase the chances of making the trainee's first year or two successful. The programs also demonstrate management's interest in the trainee's professional development. In addition to planned on-the-job training, management also makes available to the trainee a wide variety of training programs within and outside his agency, as well as educational opportunities in universities.

In recent years the number of in-service training courses directly related to the agency's work has increased. In most organizations, leading staff members are drawn upon to teach in-service courses. Many of these courses are held during duty hours, and the text books are often provided by the agency. Their scheduling and length approximate regular university courses. The National Bureau of Standards offers in-service courses ranging from Scientific Russian to Modern Molecular Rate Theory. Specialists outside of the immediate geographic area of the government installation are brought in on a contract basis to teach one or two-week courses. These intensive courses expose the participants to senior, experienced professionals, and entry-level scientists and engineers are frequently given priority when agencies select employees to attend in-service courses.

Quantitative Aspects of In-Service Training

The quantity of agency in-service training in technical subjects may be measured by such examples for the fiscal year 1964 as those of NASA, 8,000 classroom hours; and the Atomic Energy Commission, 11,252 classroom hours. NASA also reported 33,284 classroom hours of short-course training at non-government facilities in fiscal year 1964. Significantly, 49% of those attending the in-service and outside technical training programs offered by one NASA laboratory were junior-level scientists and engineers. Of all the scientific and technical training sponsored by the Atomic Energy Commission, 58% of the recipients were junior-level scientists and engineers.

Not all agencies have such extensive in-service programs, but all of them may avail themselves of the opportunity to utilize the facilities of universities. Depending on agency policy, employees may attend during the day or evening at total or partial government expense. A total of 2,108 NASA scientists and engineers took graduate level courses for credit in fiscal year 1964. The Langley Research Center will soon draw upon the resources of the Virginia Associated Research Center, a cooperative venture between the University of Virginia, Virginia Polytechnic Institute, and the College of William and Mary. Another imaginative program for graduate education is Goddard Space Flight Center's three-quarter credit program with Catholic University of America. This program is an intermediate step between night school study and assignment for a full year at an educational institution. Participants work part-time at the

Space Flight Center and attend the University part-time. A similar program has also been recently established with the University of Maryland.

The small but growing number of individuals participating in long-term training is important to the government's scientific and engineering community since it is the principal beneficiary of this program. In fiscal year 1964, 509 individuals participated in training lasting more than 120 days at non-government facilities. A study of nine agencies that employ a substantial number of scientists and engineers reveals that these organizations accounted for 450 of the 509 individuals away at long-term training of whom 82% (368) were scientists and engineers. Junior-level research and development staff comprise 49% (182) of the total. Fewer than half (46%) of the scientists and engineers were in at the middle grades of GS 12-14. The availability of graduate education is a strong incentive for many top quality graduates to consider government employment.

Summary of training of more than 120 days duration at non-government facilities for scientists and engineers of nine government organizations (FY 1964)

Organization	Total Participants	Technical	Junior Level
AEC	27	25	24
Agriculture	53	23	15
Air Force	76	63	27
Army	47	38	7

Commerce	50	46	13
HEW	33	21	9
Interior	26	17	11
NASA	59	56	34
Navy	79	79	42
Totals	450	368	182

A leading government training officer recently stated that his agency must "grow its own" graduate degree holders. The Naval Ordnance Laboratory in Silver Spring, Maryland has had 169 employees earn master's degrees and 61 individuals earn doctor's degrees through its graduate study programs.

Career Perspectives: Technical and Organizational

Much more is known about why scientists and engineers join an organization or leave it than how they develop within it. An unpublished 1963 M.I.T. study by David R. Peters of research-oriented scientists and engineers in government laboratories showed that at the time of graduation most of them had very vague career plans and that few had carefully searched the potential job opportunities. Most of them focused on several large and visible organizations as places to begin their careers. There was a general desire to settle into a research niche for a period of technical learning and growth. At the outset their value-orientations were essentially professional and technical, especially among those with graduate degrees. Most felt no identification with or commitment to their agency. Heavy emphasis was placed upon the educational value of their early years with the view that this experience would be useful as a "stepping stone" toward some other opportunity. The exceptions to this orientation were the few who had explicit managerial aspirations, were B.S. degree engineers in development work, or "co-op" students. However, all of them perceived their future growth to be in technical competence, while older, more experienced scientists and engineers viewed their past growth to have been in terms of improvement in "dealing with people," organizing, and self-confidence.

"Getting ahead" was viewed as having to do with factors in one of these four categories:

- technical performance
- recognition-getting
- personality
- one's relationship to some organizational phenomena

Quality of technical performance was emphasized in the first factor, while "being visible," was important in the second. Personality referred to having tact and handling people effectively, while "being on a hot project" was an example of the last factor.

David Schein's work at MIT has shown that in a large organization, such as government, the technically trained "new" man has problems in locating a membership group and in defining his own identity. He has difficulty adjusting to the human organization. The very people who viewed complex technical problems as challenges found human problems "illegitimate and unworthy" of their efforts. The necessity to promote and compromise one's ideas was seen as "selling out" to a lower value system.

Most junior level professionals suffer the frustrations of communicating their veiws upward through many organizational layers to top management. A few Federal laboratories have sought to solve this problem by instituting Assistant Management Boards. The U.S. Naval Propellant Plant uses these boards to profit from the fresh thinking and new ideas of young professionals and to create a climate wherein young junior scientists and engineers feel they can have their views considered by top management. Additionally, those fortunate enough to be chosen to serve on the Board have a unique opportunity to develop managerial skills. The principal value to the Board members is exposure to an overall organizational outlook which enables them to acquire insight into management problems.

Conclusions

Pay has been a factor in the recruitment of entry-level scientists and engineers. However, the opportunity for professional growth is growing steadily in importance as an employment attraction among members of this group. The Federal Government has responded effectively to the challenge of recruiting young professional talent. Special salary schedules, a large number and variety of training programs, and opportunities for graduate education await the candidates for positions as junior scientists and engineers in the Federal service. Additional research about the career patterns of scientists and engineers in the Federal government is necessary because of its importance to the recruitment, development, and retention of quality personnel.

Appendix I

Percentage of Offers Accepted
Engineers: 1962, 1963, & 1964

Ten-Agency Study

Series			Percentages					
			GS-5			GS-7		
			1962	1963	1964	1962	1963	1964
801	General	Engineer	---	53	42	---	35	45
803	Safety	Engineer	---	80	100	---	100	33
804	Fire Prevention	Engineer	---	---	---	---	---	---
805	Maintenance	Engineer	---	---	100	---	---	---
806	Materials	Engineer	8	13	100	---	13	100
807	Landscape Architect		17	40	29	32	24	33
808	Architect		27	48	88	33	17	40
810	Civil	Engineer	26	33	33	36	42	41
811	Construction	Engineer	---	43	33	---	63	57
812	Structural	Engineer	9	29	100	30	29	77
813	Hydraulic	Engineer	27	29	52	26	52	28
819	Sanitary	Engineer	---	---	57	---	50	50
820	Highway	Engineer	18	14	17	40	44	30
824	Bridge	Engineer	---	---	---	50	---	100
830	Mechanical	Engineer	26	29	49	27	35	46
832	Automotive	Engineer	---	---	---	60	---	---
840	Nuclear	Engineer	47	15	33	19	22	38
850	Electrical	Engineer	18	29	30	27	34	32
855	Electronic	Engineer	22	25	29	33	33	31
861	Aerospace	Engineer	30	33	37	40	41	37
862	Airways	Engineer	17	10	---	25	12	---
870	Marine	Engineer	55	36	31	59	55	45
871	Naval Architect		22	28	18	39	27	40
880	Mining	Engineer	33	64	36	56	43	43
881	Pet. Prod. & Nat. Gas		100	---	---	22	80	---
890	Agricultural	Engineer	48	48	41.9	41	52	23
892	Ceramic	Engineer	80	44	---	---	---	---
893	Chemical	Engineer	31	33	39	38	32	42
894	Welding	Engineer	29	40	25	100	50	50
896	Industrial	Engineer	41	31	31.5	29	38	38
897	Valuation	Engineer	9	---	---	100	---	---
All Engineers			25.3	35.4	35.1	34.1	37.4	36.7

All Engineers, GS-5 & GS-7

1961	1962	1963	1964
37.0%	29.3%	36.5%	35.9%

Appendix II

Percentage of Offers Accepted
Mathematicians and Scientists: 1962, 1963 & 1964

Ten-Agency Study

Series		GS-5 1962	GS-5 1963	GS-5 1964	GS-7 1962	GS-7 1963	GS-7 1964
1221	Patent Adviser	---	59	---	---	62	---
1224	Patent Examiner	51	65	41	69	66	63
1301.1	Physical Science Subseries	12	36	61	33	36	51
1306	Health Physics	---	100	---	29	100	---
1310	Physics	50	51	38	47	51	47
1313	Geophysics	50	35	55	48	70	46
1320	Chemistry	59	44	57	51	42	46
1321	Metallurgy	50	57	20	37	63	50
1330	Astronomy and Space Science	100	100	46	31	65	79
1340	Meteorology	62	30	57	54	54	75
1350	Geology	50	71	61	74	80	56
1360	Oceanography	77	69	74	67	56	61
1372	Geodesy	57	67	46	37	100	89
1380	Forest Products Technology	---	---	---	---	100	75
1390	Technology (certain specializ'ns)	---	---	57	---	---	---
1510	Actuary	---	---	---	---	---	100
1520	Mathematics	42	46	34	45	49	44
1529	Mathematical Statistics	100	50	53	25	44	54
015	Operations Research	---	---	50	---	64	100
All Mathematicians and Scientists		48.7	49.2	41.9	44.2	47.2	48.6

All Mathematicians and Scientists, GS-5 & GS-7

1961	1962	1963	1964
52.0%	45.7%	47.8%	46.0%

2. The Mid-Career and Senior Scientist and Engineer

This paper describes Federal scientists and engineers in the middle and upper grades (GS-13 through GS-18) and draws a number of profiles based on factors such as age, experience, education, and length of Federal service. Accordingly, it continues the description of Federal scientists and engineers begun in the first paper of this series. To a certain extent, it also overlaps the material in the third paper in the series; but this overlap is not considered significant because of the difference in the way in which laboratory scientific and technical directors are treated in the two papers. In this paper, they are included with other individuals having similar characteristics and are treated merely as a part of the whole statistical unit. In the final paper they are dealt with exclusively.

Data Sources

Data for this paper has been taken from two primary sources--the Civil Service Commission's Roster of Scientific and Engineering personnel (for grades 13 through 15) and the Career Executive Roster (for grades 16 through 18).* As a result, it has not been possible to separate "bench" scientists and engineers from individuals whose basic academic preparation and work background

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* Forms for the Science and Engineering Roster date from 1961 to 1963, while the Career Executive Roster data dates, variously, from 1962 to 1965.

have been as scientists and engineers but who now occupy administrative positions.

The population studied totaled 22,987, of whom 22,230 were in General Schedule (GS) grades 13-15 and 757 were in grades 16-18. Our approach has been through selection of various tangible background items common to a substantial number of individuals, collection of available data regarding these items, and collation of relationships which are perceived to exist between various combinations of items. The two major premises underlying our analytical approach are:

1. That an analysis of the backgrounds of a sufficiently large sample of high level (GS-16 through GS-18) Federal scientists and engineers would provide a basis for useful conclusions regarding areas and levels of development, which might in turn prove particularly appropriate as bench marks in establishing total developmental goals for mid-career employees.
2. That a similar analysis of mid-career scientists and engineers would, when compared with the analysis of the higher-level group, yield useful information concerning both the kinds and amounts of training required for the mid-career group in the immediate future.

Findings

General

One of the most obvious, tangible, and quantitative differences existing among the individuals comprising the total sample is that of the level at which their formal education was terminated. As shown below, the higher graded group is also the better educated group, with only 5.5% of GS 16-18's having less than a baccalaureate degree, in comparison with 14.0% for the GS 13-15 group. A substantially higher percentage of both master's and doctor's degree holders are in the GS 16-18 category.

Comparison of Highest Level of Formal Education Achieved by Federal Scientific and Engineering Personnel in the Middle and Upper Grades

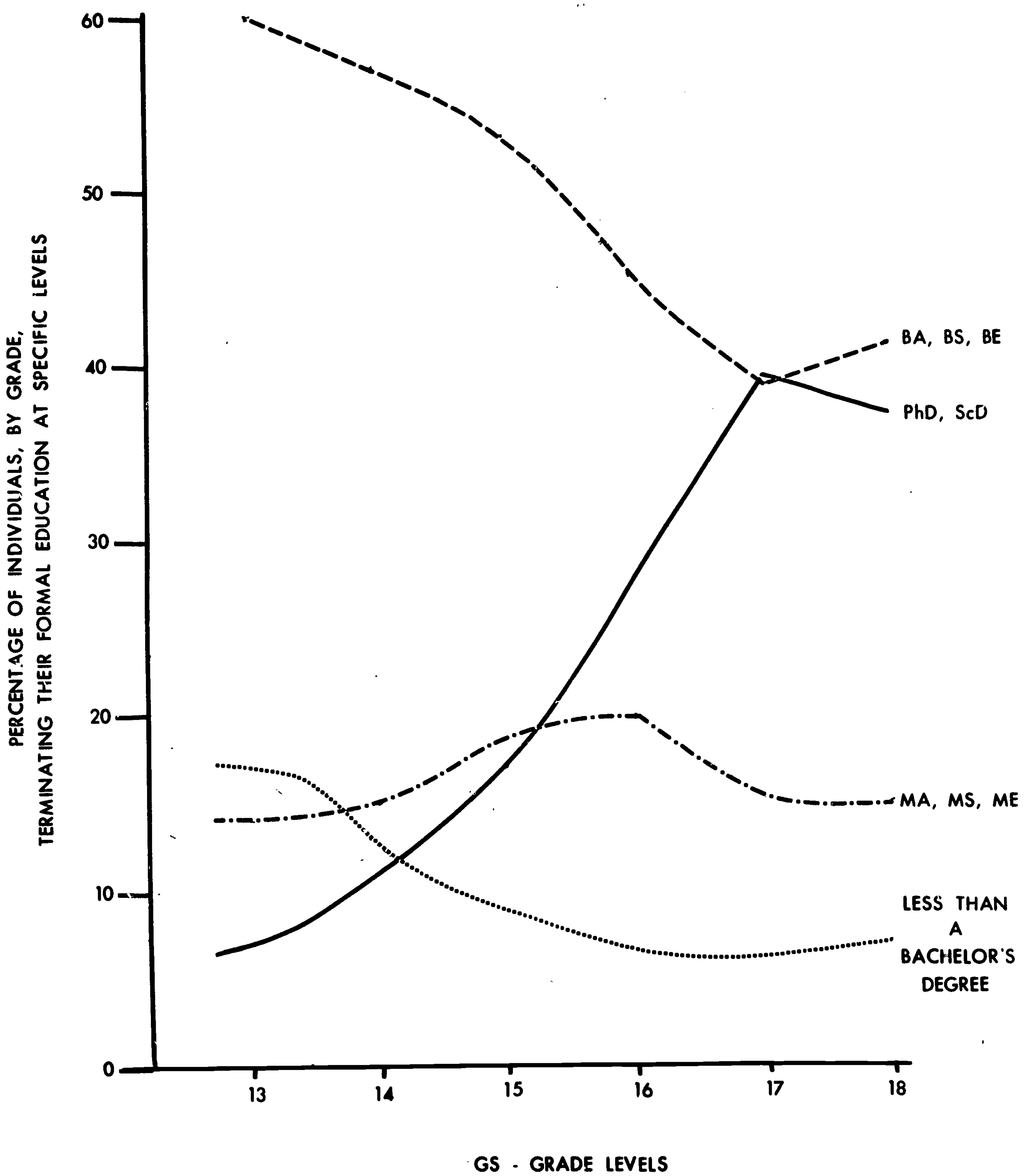
Level of education	Percent of GS 13-15 at this level	Percent of GS 16-18 at this level
No College	1.3	0.4
College, No Degree	12.7	5.1
BA/BS/BE	39.4	31.4
BA/BS/BE plus graduate work	19.3	10.9
MA/MS/ME	10.6	13.2
MA/MS/ME plus graduate work	5.6	3.8
MD	0.1	2.3
Ph.D./Sc.D.	10.9	28.9
Data Incomplete	0.0	4.0

When the total sample was broken down by individual grades and the relationship between terminal levels of education and GS grade was examined, several noteworthy trends appeared.

1. As the grade level rises from GS-13 to GS-16, there is a steady decrease in the percentage of individuals with less than a baccalaureate degree. At GS-16 this trend appears to stop and the percentage remains almost constant at 6% through GS-16, 17, and 18.
2. As the grade level climbs from GS-13 to GS-17, there is a steady increase in the percentage of individuals with an earned doctorate; and in the GS-13 to GS-15 range, the percentage increase in Ph.D. holders closely approximates the percentage decrease in individuals with less than the bachelor's degree.
3. Throughout the range from GS-13 to GS-18, with the single exception of GS-16, there is a steady decrease in the percentage of individuals possessing only the baccalaureate.
4. Throughout the range from GS-13 to GS-18, with the single exception of GS-16, the percentage of individuals who have terminated their formal education with a master's degree remains almost constant.

The full extent of these relationships is shown below.

RELATIONSHIP OF GS - GRADE AND TERMINAL LEVELS OF FORMAL EDUCATION FOR FEDERAL SCIENTISTS AND ENGINEERS



As shown below, age and grade data plotted as frequency polygons on common axis revealed that:

1. The age distribution at GS-14 and above is slightly skewed toward youth; and all of the individual grade polygons in grades GS-14 and above peak in the 46 to 50 year age group.
2. The GS-13 age distribution is skewed toward age, and peaks in the 56 to 60 year age group.

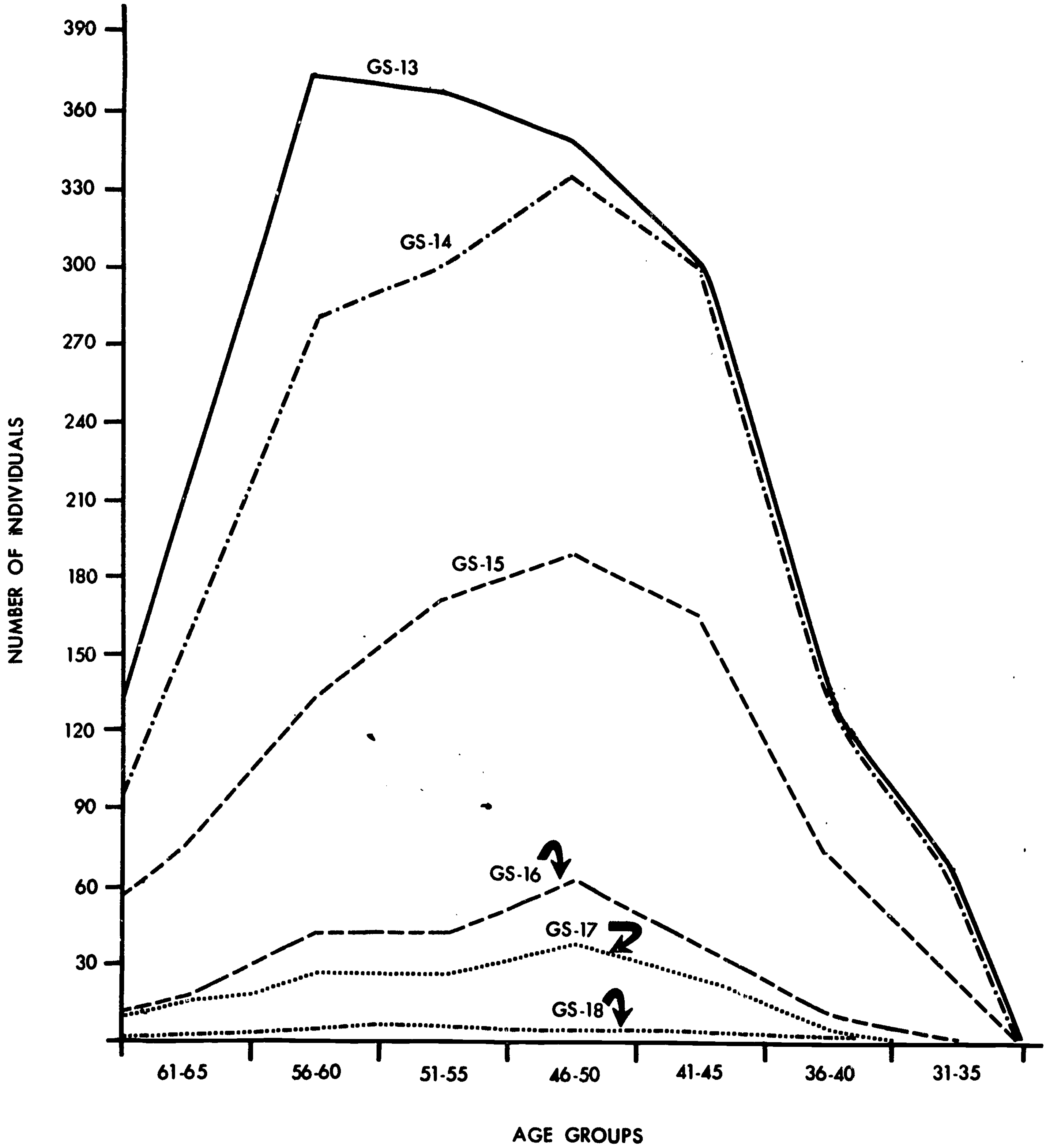
The Middle Level Group (GS 13-15)

Source data for the study of middle grade scientific and engineering personnel came from the U.S. Civil Service Commission's Roster of Scientists and Engineers in the Federal Service. Although this roster contains a great deal of information on each individual, and is maintained on magnetic tape, the size of the sample and the scope of the study restricted the number of information items that could be considered and analyzed. Accordingly, the study of this group focuses on factors of age, grade, area of specialization (educational major), and highest level of formal education attained.

When the educational backgrounds of the individuals in the middle level group were examined, a number of trends and relationships were revealed.

1. As the grade increases, individuals with educational backgrounds in certain disciplines (notably Aeronautical

NUMBER OF FEDERAL SCIENTISTS AND ENGINEERS
IN GRADES GS-13 THROUGH GS-18
BY AGE GROUPS



Engineering, Chemistry, and Physics) represent increasingly higher percentages of the total grade population.

2. As the grade increases, the percentage of the total grade population represented by Civil Engineers declines sharply.

The numerical extent of these shifts is shown below:

Percentage of Grade Population

GS Grade	Aeronautical Engineering	Chemistry	Civil Engineering	Physics
13	2.7	5.8	16.6	5.5
14	4.0	6.9	13.7	7.0
15	6.7	8.0	10.0	9.2

3. Among the middle grade scientists and engineers in the 15 most populous disciplines, there exists a broad spread of percentages of Ph.D. holders as a function of academic discipline. At GS-13, for example, 32.6% of all Geologists hold the doctorate whereas in four fields no Ph.D.'s were reported. Similarly, at GS-14, 86.3% of the individuals in the field of biochemistry held the Ph.D. while none were reported in two fields; and at GS-15, 87% of individuals in biochemistry held the Ph.D., while only 2% of the Civil Engineers reported Ph.D.'s. Comparisons with the total percentage of

professionals in each discipline in the national population have not been drawn.

A complete tabulation of the percentage of individuals within each of the fifteen most populous disciplines who held bachelor's, master's and doctor's degrees, by grade, is shown on the following page.

The High Level Group (GS 16-18)

Source data for the study of scientific and engineering personnel in the upper grades came from the U.S. Civil Service Commission's Career Executive Roster, an index containing detailed biographic information on approximately 1,700 Career Federal Executives in grades GS 16-18. Although the Roster provides coded information on up to two education and four experience fields for each individual, it does not make distinctions which permit separating practicing bench scientists and engineers from those individuals who have a scientific or engineering education but who are at present scientific or engineering administrators. Accordingly, information was drawn from the Roster regarding age, grade, length of service, fields of education (2) and career record (up to 4 items) of those individuals considered to be members of the scientific or engineering community. For purposes of this study, the scientific or engineering community was deemed to include individuals with training or experience in the following

Percentages of Federal Scientists and Engineers Holding Bachelor's, Master's, and Doctoral Degrees; by Academic Discipline and GS Grade

Grade	Highest Degree Held	Aeronautical Engineering	Architectural Engineering	Architecture	Biochemistry	Biological Sciences NEC*	Chemical Engineering	Chemistry	Civil Engineering	Economics	Electrical Engineering	Engineering NEC*	Forestry and Ranger Serv.	General Engineering	Geology	Industrial Engineering	Mathematics and Statistical Math	Mechanical Engineering	Physics
13	B	70.0	66.4	61.6	X	X	79.5	49.5	77.5	X	71.9	36.8	71.2	36.5	37.6	62.5	37.6	71.6	50.9
	M	21.6	1.0	.9	X	X	13.0	18.1	6.9	X	9.6	9.3	19.3	6.7	27.1	20.4	20.9	8.7	27.2
	PhD	--	--	--	X	X	2.2	26.0	.3	X	.02	1.9	3.9	--	32.6	.8	16.8	.4	13.4
14	B	72.7	X	X	2.5	30.8	71.0	39.4	78.2	X	75.4	36.0	66.5	35.6	28.8	57.6	42.0	74.4	43.8
	M	20.2	X	X	8.8	17.0	20.0	20.5	8.5	X	11.5	20.3	23.2	11.4	24.3	27.0	26.7	11.3	28.2
	PhD	.6	X	X	86.3	47.9	3.6	36.7	.4	X	1.0	1.8	5.4	--	43.1	--	10.4	.7	22.4
15	B	64.6	X	X	4.3	13.8	77.5	31.1	81.5	40.0	73.3	46.9	52.4	38.8	24.0	X	35.1	73.7	34.9
	M	27.3	X	X	8.7	15.5	12.3	15.7	9.3	38.4	15.4	26.6	34.9	13.0	14.7	X	34.7	16.0	24.3
	PhD	2.7	X	X	87.0	69.0	5.8	50.4	.2	20.0	2.2	4.1	7.9	2.4	58.6	X	17.6	1.8	36.1

X - Not included in the 15 most populous disciplines at this grade level.
-- - No PhD's reported for this discipline at this grade level.
* Not elsewhere classified.

fields:

Management of Research and Development Programs

Physical Sciences and Electronics

Engineering and Construction

Space Programs

Weapon System Planning, Acquisition, and Use

Nuclear Energy Programs

Medicine, Hospital, and Health Administration

Biological Sciences

Arms Control and Inspection

Patents

A preliminary screening of the data thus obtained revealed that the fields of Arms Control and Inspection, and Patents contained so few individuals as to be insignificant as groupings. Accordingly, although the individuals in these fields were included in statistical computations for the entire high-level group, they were not analyzed as separate occupational fields.

Both the education and experience of the members of the high-level group were examined as separate entities. In addition, relationships which exist among these and other factors were also studied, with particular attention being given to possible significant relationships among education, area of specialization, disciplinary trends, grade, and age.

The overall level of education of this group and the relationship between their respective ages and grades have already been discussed in the general findings.

When the career record entries of the entire high-level group were examined, a total of 2,218 career background items in 103 different fields were found. As noted previously, the source data was limited in that not more than four items of background information could be listed for each individual. Accordingly, this total represents 73.3% of the theoretical total number of experience items that could have been shown by a group this size, and averages just under three items per individual. Within the total sample, 394 individuals (52%) noted that they had had experience in the management of research and development programs. This item represented 17.8% of all the experience entries indicated. Additional information regarding other fields is shown on page 65.

A complementary analysis of the educational background of the high-level group showed wide differences in levels of education by occupational groupings. In the biological sciences, for example, 71.9% of the sample held the doctorate, while in the engineering/construction field only 7.0% held the Ph.D. A complete tabulation of the highest level of formal education attained by individuals in each of eight areas of specialization is shown on page 66.

In addition to the wide differences in levels of education by occupational groupings, one other item of significance emerged from this analysis. The master's degree does not appear to be widely regarded as a terminal degree. In only two cases

Career Backgrounds of High-Level Federal Scientists and Engineers (15 Most Common Fields)

Field	Number Reporting Experience in this Field	% of People	% of Total Experience
R & D Program Management	394	52	17.8
Engineering	167	22	7.5
Space Programs	130	17.2	5.9
Weapon System Planning, Acquisition and Use	115	15.2	5.2
Electronics	105	13.9	4.7
Management Improvement	88	11.6	4.0
Physics	83	11.0	3.7
Engineering and Construction	70	9.2	3.3
Nuclear Energy Programs	64	8.5	2.9
Physical Sciences and Mathematics	53	7.0	2.4
National Defense, Security, and Strategy	47	6.2	2.1
Education	46	6.1	2.1
Transportation (Aviation)	40	5.3	1.8
Chemistry	36	4.8	1.6
Meteorology	28	3.7	1.3

Note: Numerous individuals indicated experience in two or more of the fifteen fields shown above, and no attempt has been made to separate out individuals showing experience only in the fields listed. This information has been drawn from a sample of 757.

Comparison of Highest Educational Level of GS 16-18 Scientists and Engineers by Area of Specialization (Expressed as a percentage of total specialization sample)

	R & D Program Management	Physical Sciences/Electronics	Engineering/Construction	Space Programs	Weapon System Planning, Acquisition, and Use	Nuclear Energy Programs	Medicine, Hospital, and Health Administration	Biological Sciences
Sample Size	387	286	245	120	114	105	66	32
No College	.25	.7	.4	--	--	--	--	--
College, no degree	3.1	2.8	4.9	5.8	6.1	7.6	4.5	3.0
BA/BS/BE	25.6	20.6	51.8	34.1	36.0	30.5	12.1	3.0
Baccalaureate plus some graduate work	7.0	6.3	11.0	8.3	6.1	18.1	9.1	3.0
MA/MS/ME	12.9	12.9	15.1	12.5	21.0	11.4	9.1	--
Master's plus some graduate work	5.1	2.4	3.7	3.3	7.9	5.7	1.5	--
M.D.	2.0	1.0	--	1.6	--	1.9	21.2	18.7
PhD/ScD	40.8	51.0	7.0	30.8	18.4	23.8	40.9	71.9

(engineering/construction, and weapon system planning, acquisition, and use) did the percentage of individuals with a terminal MA exceed the percentage of those with a doctorate.

Managers of Research and Development Programs

Special attention has been given to R&D Managers, and they have been separately studied as a group. The first area analyzed with respect to this group was educational background. The disciplinary backgrounds of 377 individuals who provided appropriate source data reveal they were trained in a substantial number of different disciplines. Further differentiation indicated, however, that 73.4% of them had been primarily trained in only seven major areas. Those seven areas, and the number of individuals schooled in each, were:

Physics	64
Mathematics and Statistical Mathematics	58
Electrical Engineering	49
Chemistry	46
Aeronautical Engineering	24
Mechanical Engineering	24
Chemical Engineering	10

Information with respect to secondary fields of academic preparation was also available for a portion of the sample and was similarly analyzed. Of the 377,211 in the group, (56%) indicated two major subject matter areas in their educational background, and when secondary fields were tabulated, a similarly large number of different disciplines was represented. Slightly over 50% of the group showing two subject matter fields reported one of the following four areas as their field of secondary preparation:

Physics	54
Mathematics and Statistical Mathematics	21
Electrical Engineering	20
Mechanical Engineering	12

When the tabulations of primary and secondary disciplines were compared, it became apparent that the bulk of governmental managers of research and development programs, with training in more than a single discipline, have had academic training primarily in three closely related fields. Specifically, considering only the fields of Physics, Mathematics and Statistical Mathematics, and Electrical Engineering, the data available indicated that out of the sample of 211:

118 (55.9%) were either primarily or secondarily Physicists

79 (37.4%) were either primarily or secondarily mathematicians (including statistical mathematicians)

69 (32.7%) were either primarily or secondarily electrical engineers

In many other cases, even though a number of non-scientific or non-engineering disciplines were noted, the latter areas were coupled with either earlier or later training in a scientific or engineering area. The nature and extent of this combining of scientific and non-scientific training is shown below.

Combinations of Scientific and Non-Scientific Academic Preparation Reported by GS 16-18 Research and Development Program Managers with Training in More than a Single Discipline

Primary Discipline	Secondary Field
Physics	Economics, Education, English, History, Language and Literature (Modern), Philosophy
Chemistry	Business and Commerce, Education, Language and Literature (Classical), Public Administration
Mathematics and Statistical Mathematics	Business and Commerce, Economics, Education, English
Electrical Engineering	Business and Commerce, Education, Law
Civil Engineering	Architecture, Social Sciences Not Elsewhere Classified
Political Science	Engineering, Not Elsewhere Classified
Aeronautical Engineering	Education
Agricultural Engineering	Nutrition
Business and Commerce	Law
Chemical Engineering	Business and Commerce
Economics	Law
Education	Physics
Fine Arts, Not Elsewhere Classified	Mechanical Engineering
English	Mathematics and Statistical Mathematics

Geosciences, Not Elsewhere Classified	English
Marine Engineering	Law
Mechanical Engineering	Business and Commerce
Meteorology and Climatology	Philosophy
Philosophy	Meteorology and Climatology
Physical Sciences, Not Elsewhere Classified	Public Administration
Psychology	Anthropology, Archaeology and Ethnology

When the age distribution of R&D Program Managers was examined, it became apparent that the overall curve is skewed toward youth in the same manner as the GS 14-18 curves; and that 85% of the group fell into the 40 to 60 year age grouping.

The Research and Development Program Managers were also examined in terms of experience in more than one field. When this was done for eight of the most populous groupings, it became apparent that the only universal fields, that is, the only ones listed by at least one individual in each of the other seven, were the management of research and development programs and nuclear energy programs. The extent and nature of this experience in two or more fields is shown on the next page.

An analysis of the length of Federal Service of the members of the group revealed that half the group had between 16 and 25 years of service. Percentages within the 16-20 and 21-25 year

Extent to Which Managers of Federal Research and Development Programs Have Had Experience in More Than One Area of Specialization (8 Fields Considered)

	Management of Research and Development Program	Physical Sciences and Electronics	Engineering and Construction	Space Programs	Weapon System Planning, Acquisition, and Use	Nuclear Energy Programs	Medicine, Hospital, and Health Administration	Biological Sciences
Management of Research and Development Programs		184	92	75	66	54	22	22
Physical Sciences and Electronics	184		46	33	34	26	8	7
Engineering and Construction	92	46		36	32	23	1	0
Space Programs	75	33	36		34	2	5	5
Weapon System Planning, Acquisition, and Use	66	34	32	34		7	0	0
Nuclear Energy Programs	54	26	23	2	7		10	1
Medicine, Hospital, and Health Administration	22	8	1	5	0	10		15
Biological Sciences	22	7	0	5	0	1	15	X

service groups were as follows:

	Years of Service	
Grade	16-20	21-25
GS-16	25.3%	32.2%
GS-17	22.7%	35.6%
GS-18	25.0%	20.8%

Complete length of service data for the group, by grade, is shown on the following page.

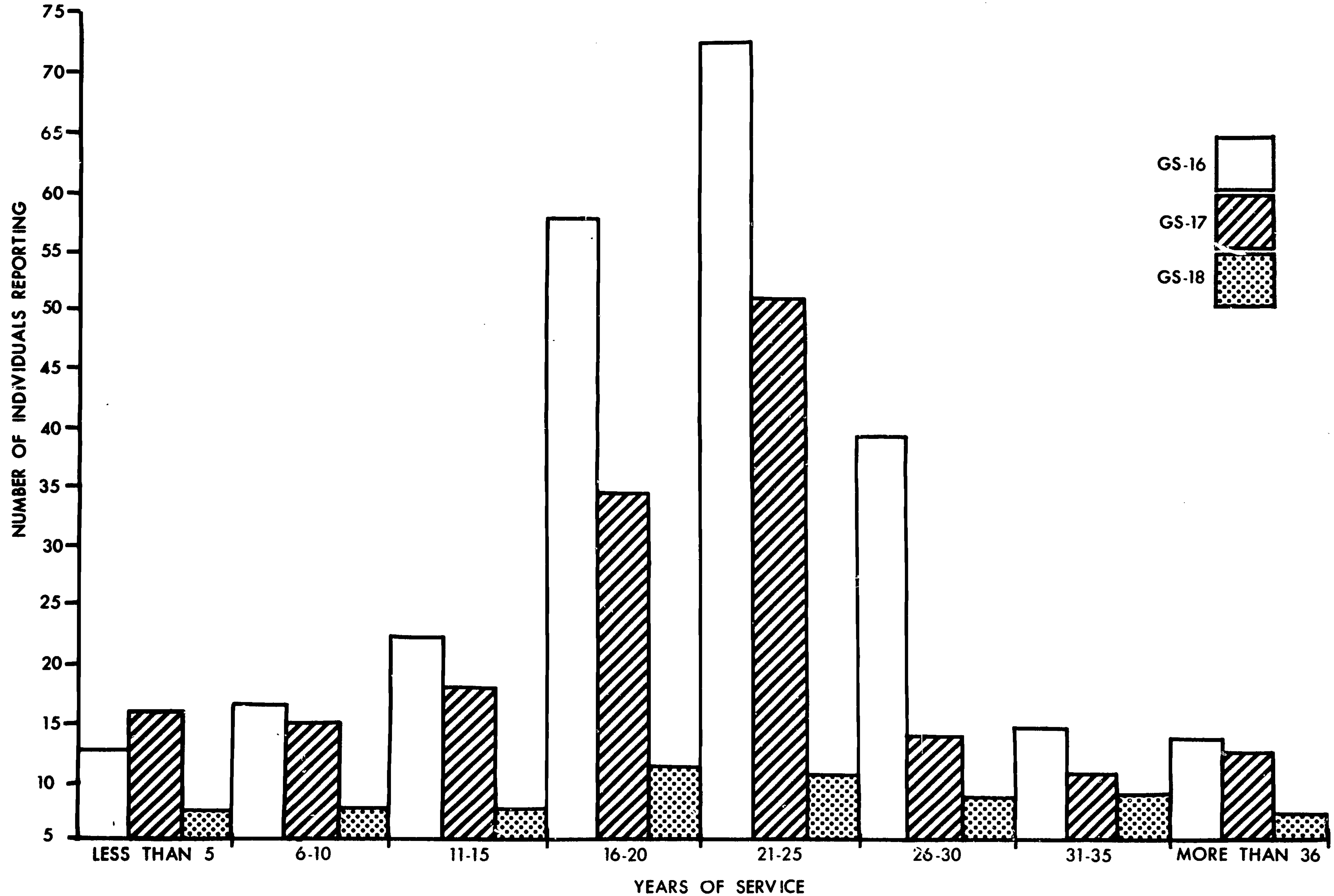
Conclusions

Based on data in this study, certain general conclusions follow:

1. Most senior scientists and engineers are in the 40 to 60 year age group. Age/grade relationships, as illustrated by appropriate functional charts, are skewed in the direction of youth. The one significant exception is at the GS-13 level, where the graph of age versus grade skews toward age in spite of the fact that this level has the largest number of individuals.
2. Federal scientists and engineers who pursue formal education beyond the bachelor's degree tend to continue on to the doctorate, and only relatively small percentages terminate their education with the master's degree.
3. Taken as a group, Federal scientists and engineers at

LENGTH OF SERVICE OF FEDERAL MANAGERS OF RESEARCH AND DEVELOPMENT PROGRAMS

(GRADES GS-16, 17&18)



grades GS 16-18 hold a much higher proportion of Ph.D.'s than their associates in grades GS 13-15. The percentage of Ph.D. holders varies widely with occupational categories, as might be anticipated from known curves of Ph.D's in the various disciplinary fields which are commonly represented in the general occupational categories.

3. The Federal Laboratory, Scientific and Technical Director

Approximately one hundred and seventy-five career employees qualify under the definition of laboratory, scientific or technical director applied in this study. In their hands rest responsibility for the implementation, design, administration, and conduct of over 95% of the total Federal in-house research, development, test, and evaluation (RDT & E) program. The Panel on Federal Laboratories of the President's Science Advisory Committee (Piori Panel) has identified over two hundred and fifty installations as falling within the loose confines of an RDT & E facility. To confine this sample, and for the identification of those individuals with major R&D administrative responsibilities, a number of basic factors was considered in the selection process. These factors were:

Only civilian careerists with duties as scientific, technical, deputy, associate, or full laboratory director; or agency R&D directors with administrative responsibilities (direct) over many minor installations were included.

Small installations, field stations, and similar facilities have been singly eliminated, although the senior agency official qualifying under the criterion above has been identified as "director." In each case, determination has been made by the agency of qualification standards applying at its own installations.

Many exclusively test facilities have been excluded.

Directors of extra-mural programs and contract operations which do not include significant in-house RDT & E capability have not been included.

National Security Agency and Central Intelligence Agency have not been included.

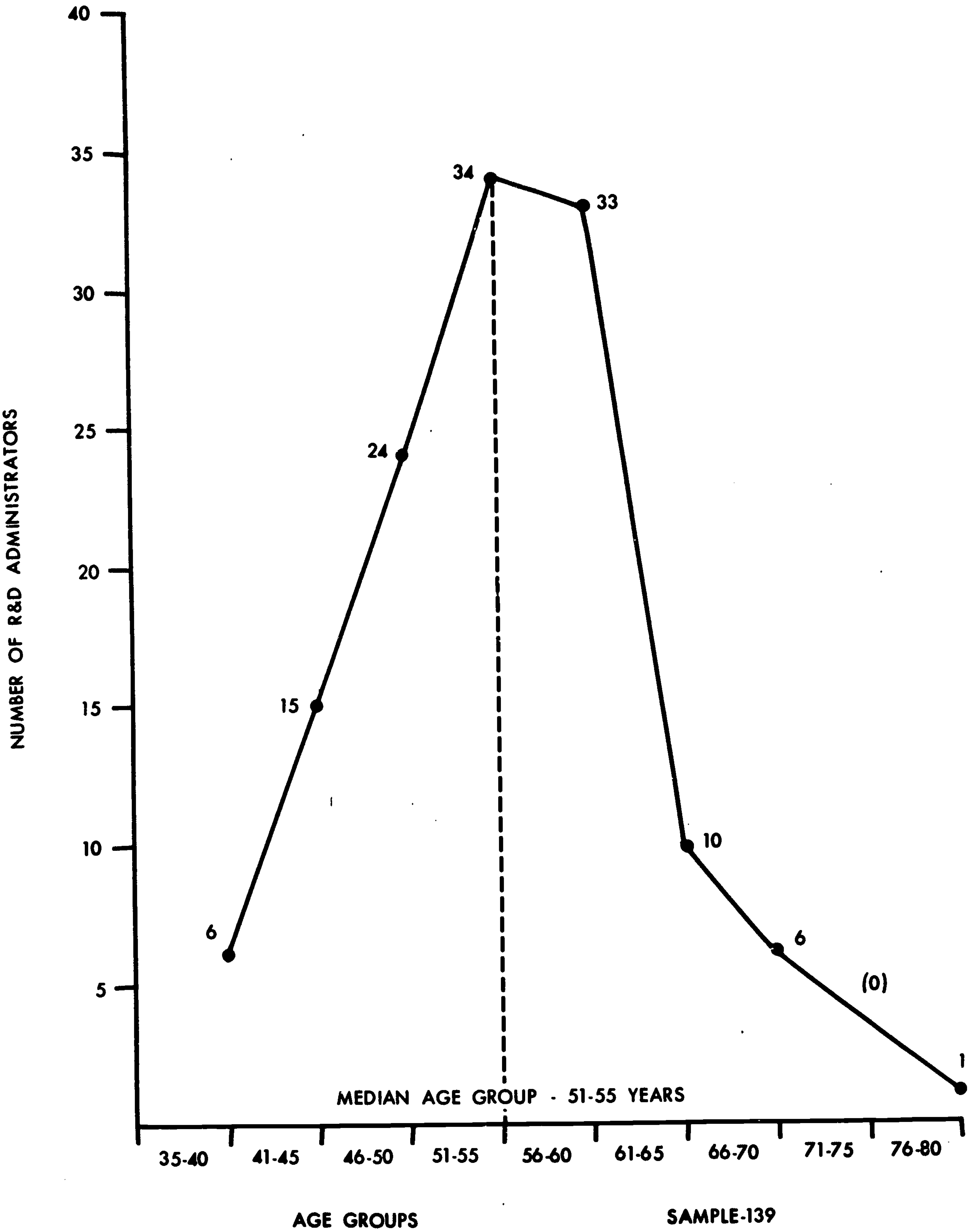
Data for each director has been drawn from complete resumes of background, educational, and professional experience submitted by agencies and updated as of February, 1965. The sample of one hundred and sixty-five represents 95% of all individuals who qualified under the above criteria. In each item analysis, specific information on the number of individuals from whose resumes material has been drawn is noted. Minor discrepancies in biographical reporting excluded an average 5% of the total sample from many item analyses. Correlation of material, and later random sample retrieval of previously unavailable data, indicates that this 5% may be expected to follow the pattern of the whole, thus not introducing appreciable distortion. In general, the sample follows many of the characteristics of the GS 16-18 group described in the last section of this paper. The term "Laboratory Directors", as used hereafter, will include scientific and technical directors and agency R & D officials.

Age and Educational Background

A number of basic descriptive factors deserves initial attention. The Age Distribution curve of laboratory directors ranges from 37 to 80 years, although the median age group approximates that of the senior federal career service-- 51-55 years. The proportion of directors falling below 45 years (21) and over 60 years (17) is roughly equal.

Laboratory directors' terminal educational experience stands at an overall level somewhat higher than most GS 16-18 RDT & E administrators. More than three-fifths (63.1%) hold a doctorate or equivalent doctoral-level professional degree (M.D., D.D.S., or D.V.M.). Only 13.9% indicate the master's degree as terminal, while 23% note their final educational experience as a bachelor's degree. Further examination of the distribution of degrees by field of study demonstrates (as expected because of the field of specialization) that most holders of terminal bachelor's and master's degrees are in various fields of engineering and/or the physical sciences. Biographical data submitted, which must be regarded as a relatively incomplete sample on this specific informational item, indicates that 14.9% engaged in postgraduate study beyond their terminal degree. Medical residencies and internships are included in the category of postgraduate study rather than professional experience, since the residency is comparable to an extended albeit clinical, educational experience.

AGE DISTRIBUTION



Only a small number (4.9%) noted secondary, organized advanced study other than university, such as the Industrial College of the Armed Forces, the National War College or various American or European centers for advanced work in scientific disciplines. [Total sample for data in this paragraph -- 165.]

Fields of Study for Degree(s)

A. Major Fields -- One field only indicated: Total -- 139

Engineering	41
Physical Sciences and Mathematics	47
Biological Sciences and Medicine (MD/DVM)	43
Behavioral Sciences	5
Social Sciences	3

B. Major Fields -- Two fields indicated: Total -- 22

Engineering and Physc. Scis./Math.	8
Engineering and Biol. Scis./Medic.	2
Physc. Scis./Math. and Biol. Scis.	9
Biol. Scis./Med. and Social Scis.	3

SAMPLE TOTAL: 161

Distribution of major fields of study for the terminal degree corresponds closely to the proportion of laboratory work assignments by field of each director. Majors in the physical sciences, mathematics, and engineering hold appointments in engineering development laboratories, various applied research and/or testing facilities or chemical installations. Medical and biological science majors are responsible for establishments specializing in basic research in agriculture or biomedical fields, or in military biological warfare and/or medical research centers. Several in the latter major study category administer Public Health Service facilities and laboratories, while directors in the social and behavioral sciences are in charge of centers for the study of human behavior, mental health, and/or Public Health Service laboratories. Thus the conclusion respecting major field of study must obviously remain that fields are appropriately fitted to the director's current assignment.

More interesting and revealing conclusions may be gleaned from the date of award of administrators' terminal degrees. Most federal laboratory directors completed their formal degree requirements twenty-five or more years ago (median period, 1936-40). The tabular data presented below does not, however, sufficiently delineate when administrators final full-time university work ended, since a considerable number of careerists receiving degrees later than 1940 did so through evening and part-time study. Examination of date-of-degree breakdown by individual, by degree, substantiates an approximate figure of 10% who in all probability were awarded the master's or doctorate upon completion of studies in the latter category. Several doctoral degree holders may have completed their dissertations long after their course work, as indicated by the time lag between completion of residential university work and award of the degree. A small proportion of laboratory directors may, therefore, have participated in university study during their initial exposure to federal or industrial laboratory work.

Date of Award of Terminal Degree

Year of Award	BA/BS/ BE	MA/MS/ MEng.	PhD/ScD/ MD/DVM	TOTAL	Percent
Before 1920			1	1	.7%
1921 - 25	2		2	4	2.1
1926 - 30	6	3	6	15	10.4
1931 - 35	8	3	15	26	18.0
1936 - 40	8	3	28	39	27.9
1941 - 45	3	3	10	16	11.1
1946 - 50	3	2	14	19	13.4
1951 - 55	1	3	8	12	8.3
1956 - 60		1	9	10	6.8
1961 - 65 (Feb.)		1	1	2	1.3
TOTALS	31	19	94	144	100.0%

An obvious conclusion, gleaned from the 83.6% who received their terminal degree prior to 1951, is that most Federal laboratory directors completed formal university training prior to contemporary radical revisions in teaching techniques and/or basic knowledge in their respective fields of concentration. All additional post-graduate and advanced study (completed by 19.8%), when further analyzed, reveals that over two-thirds of them received their terminal degrees prior to 1951. Biographical data available does not indicate as a specific item government in-service training which many administrators may have taken. Most interagency in-service training offered presently and in the past has been in fields of management skills, public policy, and administrative process. Few, if any, interagecy courses which might accurately be described as technical training for scientists and engineers were offered prior to 1960, and only a limited number are available today.

Career Professional Experience

Most Federal laboratory directors have been in government service virtually since award of their terminal degree. Government has been the first and only employer of 39.1% of senior administrators, while an additional 43.6% have worked for the government and one additional employer. Most individuals in the latter category have served with their non-government employer for five years or less. Over two-thirds of all Federal laboratory administrators have, for all practical purposes, worked only for the government and have been so employed since receipt of either their terminal degree or the degree last received while in full-time collegiate residence. Only 17.3% have worked for two employers in addition to the Federal government, and most directors in this category have less than seven years combined experience with both additional employers. Their median period of Federal assignment has been 11-15 years.

<u>Distribution of Total Professional Experience</u>
<u>(Federal and Private Sector)</u>

Sample total -- 156

A. FEDERAL GOVERNMENT ONLY -- 39.1% (61)

B. GOVERNMENT AND ONE ADDITIONAL AREA -- 43.6% (68)

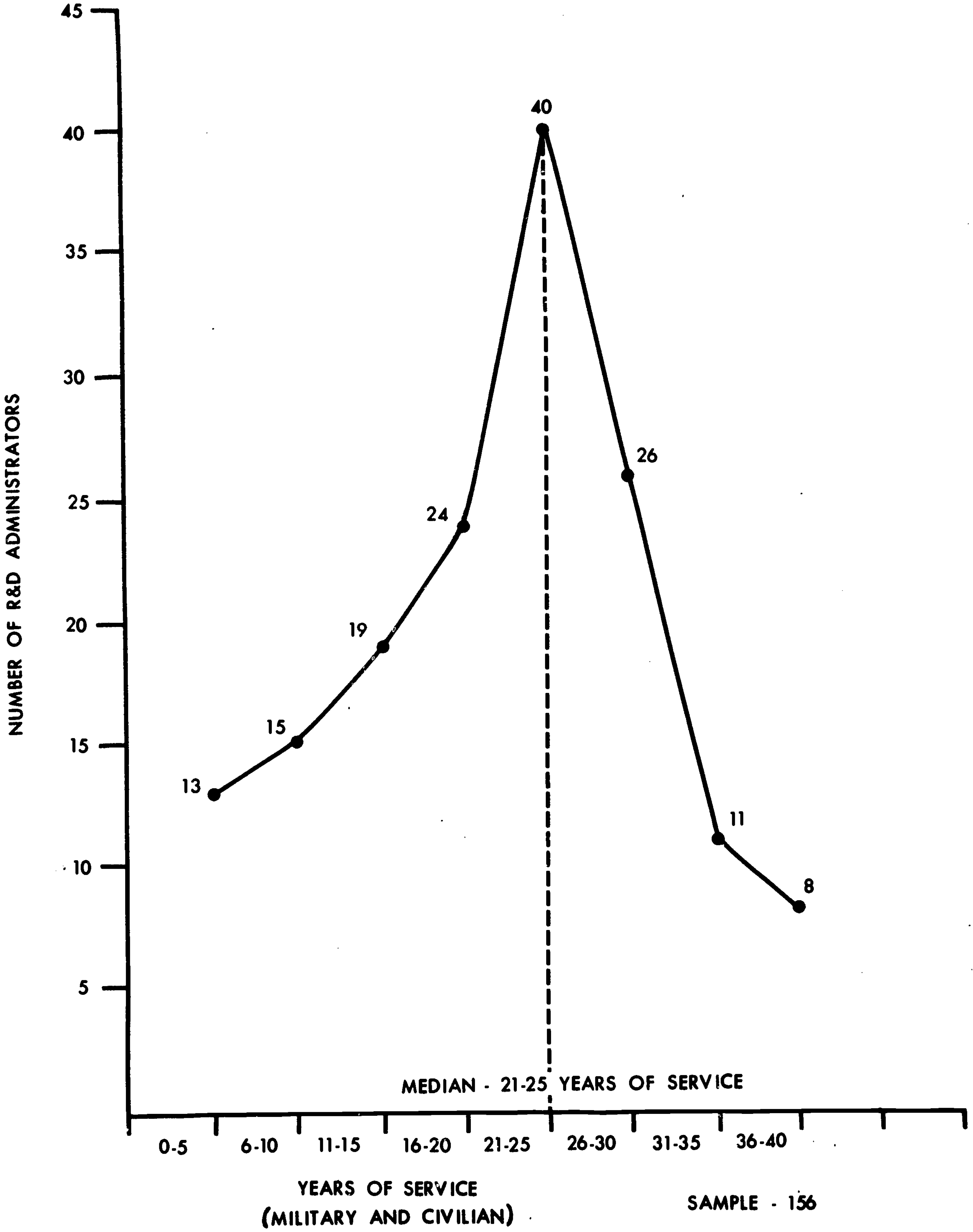
Years of Experience	Research Institute and/or Industry	Hospital and/or University
0 - 5	18	19
6 - 10	9	6
11 - 15	4	3
Over 16	5	4
Totals	36 (23.1%)	32 (20.5%)

C. GOVERNMENT AND TWO ADDITIONAL AREAS -- 17.3% (27)

Years of Experience	Research Institute and/or Industry	Hospital and/or University
0 - 5	17	12
6 - 10	6	4
11 - 15	2	4
Over 16	2	7
Totals	27	27

The graphic presentation of <u>Years of Federal Service</u> which follows coincides with the general curve for all GS 16-18 level RDT & E administrators presented in the last section. The median period of service is 21-25 years (54.4%) with 69.9% of all

YEARS OF FEDERAL SERVICE



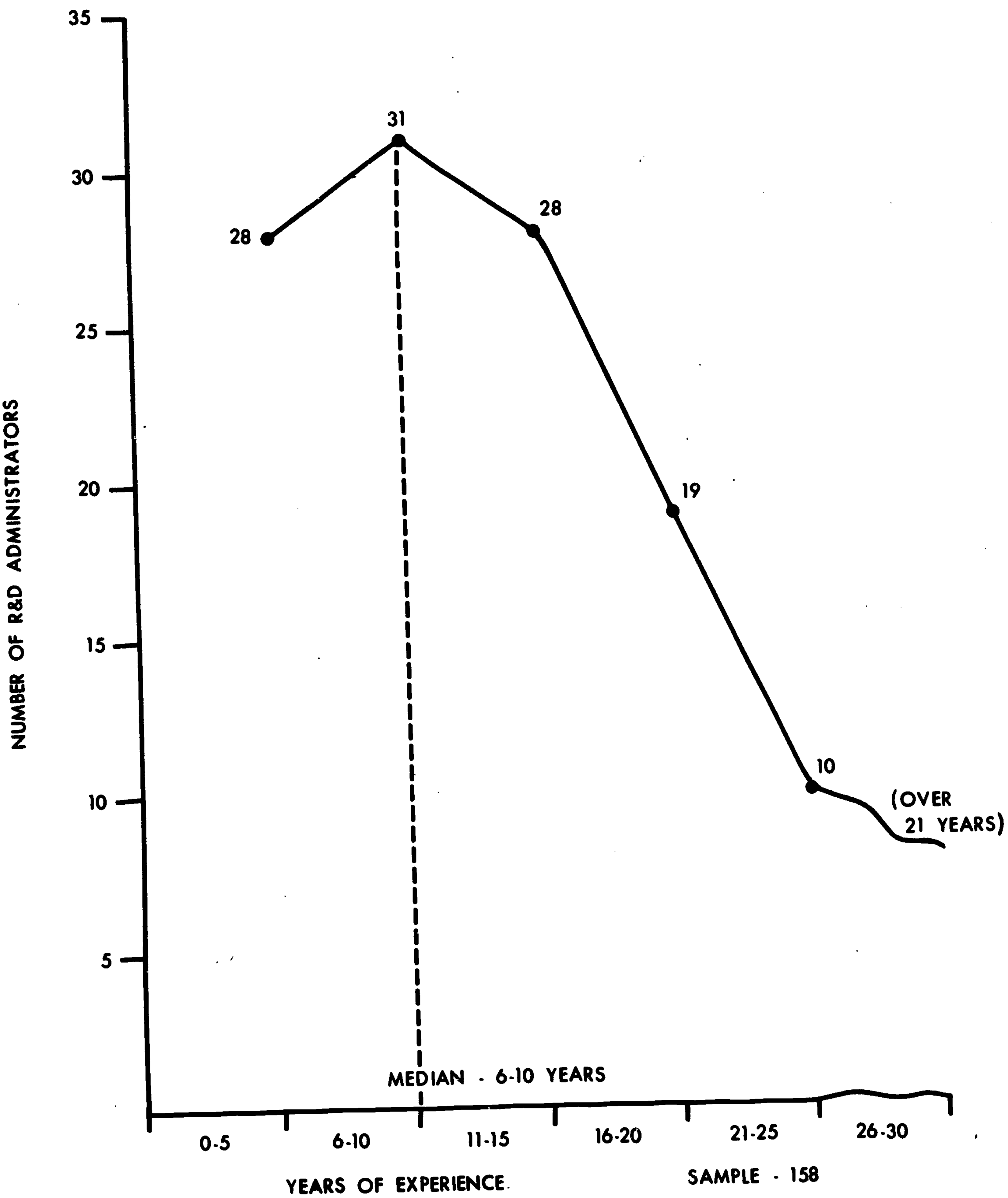
directors in service over fifteen years. Most of their service has been in a single federal agency (78.7%). Among those who worked at two (16.7%) or three (4.6%) agencies, the period of aggregate service for at least 85% of the group has been less than five years in the alternate agencies.

Professional Experience While in Federal Service

On the basis of biographical data submitted, a picture of laboratory directors' pattern of experience while in Federal service emerges. Of interest is the proportion of total service time in directors' past career patterns in what may be termed "bench" RDT & E assignments. This "experience" category included all positions held below full-time supervisory responsibilities requiring the incumbent to perform scientific or engineering tasks in research, development, test, or evaluation sectors.

Over one-quarter (26.5%) of directors reported no "bench" experience while on Federal assignments. Most of these were among administrators previously alluded to who had entered government after outside employment, and/or who had served with the government for ten years or less. The median period of "bench" assignment, indicated in this graph, was relatively short -- six to ten years. Most directors' careers are marked by a rapid rise or direct transition from "bench" to administrative or supervisory assignments early in their careers. Most directors

" BENCH " R&D EXPERIENCE (IN FEDERAL FACILITIES ONLY)



NO INDICATED "BENCH" EXPERIENCE

have also had over nine-tenths of their total Federal service in their present agency at the laboratory which they now direct. Both "bench" and administrative assignments have also usually been at their current laboratory. Career patterns thus clearly indicate that directors either are "grown" in the single laboratory situation, or enter on present, duties immediately following work at universities, hospitals or industry.

With reference to the experience spread while in administrative assignments, most directors (72.2%) have held but one general type of position including their present position. Of this group, the preponderance (79.7%) have been in the field of laboratory supervision and administration. The remainder have functioned as scientific or technical directors, a capacity which may or may not include specific administrative assignments depending upon the role assigned them by the principal administrator (in most cases cited, a military man). Less than thirty per cent (28.6%) have held two or more non-bench administrative assignments while in Federal service, and most of these assignments have combined laboratory supervision and/or administration and technical directorships. The small number representing agency administrative positions (seven individuals, or 6.8%) are, with but a single exception, now serving in agency roles which confer responsibility over a number of small facilities or laboratories which qualify them under the purview of this study.

The short tenure in their immediate position of 62.5% of present laboratory directors -- five years or less -- is somewhat misleading. As the preceding data indicates, many have served prior to the present assignment as assistant or associate, scientific or technical director. For purposes of this study, "present position" was interpreted to mean just that. The total experiential spread is accurately portrayed in the table which follows, and graphically underscores the basic commitment to supervisory and administrative roles which the future laboratory director makes early in his career.

Distribution of Non-Bench Administrative Assignments
While in Federal Service (Non-Military Only)

A. ONE POSITION ONLY (INCLUDING PRESENT POSITION) Total--109 (72.2%)

Years	ADMINISTRATIVE Laboratory	POSITION Agency	SCIENTIFIC DIRECTOR	TECHNICAL DIRECTOR
1- 5	16	1	6	7
6-10	25		4	2
11-15	24		2	1
16-20	14			
21-25	6			1
over 26	2			

B. TWO POSITIONS (INCLUDING PRESENT POSITION) Total--38

Years	ADMINISTRATIVE Laboratory	POSITION Agency	SCIENTIFIC DIRECTOR	TECHNICAL DIRECTOR
1- 5	16	4	2	15
6-10	7		4	12
11-15	10		1	1
over 16	4			

C. THREE POSITIONS (INCLUDING PRESENT POSITION) Total--4

Years	ADMINISTRATIVE Laboratory	POSITION Agency	SCIENTIFIC DIRECTOR	TECHNICAL DIRECTOR
1- 5	3	2	1	2
6-10	1		1	2

SAMPLE TOTAL: 151

D. YEARS OF EXPERIENCE IN PRESENT POSITION--Sample: 152

0- 5	85	11-15	13	over 21	3
6-10	44	16-20	7		

Awards and Honors

Information furnished in biographic resumes permitted a fairly complete summation of major awards conferred upon Federal laboratory administrators during their government and private careers. The definitions of "Major Award" applied limited consideration to awards or honors conferred by the government at agency or Presidential level for significant administrative or technical accomplishments, and by professional societies, foundations, universities, and other types of professional or educational societies at national level.

Major Honors Awarded Federal R & D Administrators

Sample total -- 158
Number accorded Honors -- 50

A. Awards by Either Government or Professional Organizations: (37)

	One	Two	Three	Over 3
Professional	6	3	2	
Government	15	8	2	1

B. Awards by Both Government and Professional Organizations: (13)

	One	Two	Three	Over 3
Professional	7	2	2	
Government	4	3	2	4

Honorary degrees were not included in this summary. The majority of awards conferred by government were for administrative achievements, while those of professional and technical societies were for contributions to scientific or engineering knowledge. A number of awards in the latter category were for significant applications of knowledge for the production of military or civilian "hardware."

A Comparative Profile of the Federal Laboratory Director

In common with his university or industrial counterpart, the Federal laboratory director has had long service in his present laboratory environment and with his present employer.* He is somewhat older and better educated than the average industrial facility director, and younger and less well educated than university counterparts. (Education in this context applies to terminal degree by field of specialty, thus comparing engineering laboratory directors with other engineering directors, and biologists with biologists.) He has had somewhat more "bench" experience than his industrial and much less than his university counterparts.** He has "come up through the ranks" in his own laboratory environment, and in all probability will remain in his present position until retirement if the laboratory or facility is in the

* Interpreted in the case of industrial or university directors as industry or universities in the generic sense.

** For more data, albeit fragmentary, on the industrial and university laboratory director, refer to such publications as Toward Better Utilization of Scientific and Engineering Talent, N.A.S., 1964; Hagstrom, The Scientific Community, Basic Books, 1964.

engineering or physical sciences. If it is in the biological sciences, he may go on to a university or to industry after several years additional experience in his present position. He has probably come from one of the latter environments, for most biomedical laboratory directors have had lengthy experience in other occupational categories prior to Federal service. The Federal laboratory director has had little technical training, offered either by universities or government, since completing his terminal degree. The probability that he will have more training before retirement is quite small.

Appendix

List of Participants
University-Federal Agency Conference

Bloomington, Indiana
November 7-10, 1965

Dr. Allen V. Astin
Director
National Bureau of Standards

Mr. Robert Barlow
Special Assistant to the Director
Office of Science & Technology
Executive Office of the President

Dr. G. W. Bergren
Assistant Dean
University Extension
Purdue University

Dr. Lloyd V. Berkner
Chairman, Board of Trustees
Graduate Research Center of
the Southwest

Dr. William B. Boyd
Associate Dean
College of Arts and Sciences
Ohio State University

Dr. Samuel E. Braden
Vice-President and Dean for
Undergraduate Development
Indiana University

Dr. George E. Briggs
Associate to the Vice-President
for Research
Ohio State University

Dr. Lynton K. Caldwell
Professor of Government
Indiana University

Mr. Raymond E. Carroll
Assistant to Dean
College of Engineering
University of Michigan

Mr. Joseph A. Connor
Director, Chicago Region
U.S. Civil Service Commission

Dr. John A. D. Cooper
Dean of Sciences
Northwestern University

Dr. Bruce Davidson
Associate Dean
College of Engineering
University of Wisconsin

Honorable Alexander H. Flax
Assistant Secretary for
Research and Development
Department of the Air Force

Dr. Norman R. Gay, Dean
College of Engineering
University of Notre Dame

Mr. Edward Glass
Assistant Director for
Laboratory Management
Defense Research and Engineering
Department of Defense

Dr. John Hicks
Executive Assistant to the
President
Purdue University

Dr. Albert G. Hill
Professor of Physics
Massachusetts Institute of
Technology

Honorable J. Herbert Holloman
Assistant Secretary for Science
and Technology
Department of Commerce

Dr. Boyd Keenan
Head, Department of Political Science
Purdue University

Dr. Keith R. Kelson
Director Division of Pre-College Education in Science
National Science Foundation

Dr. Walter H. C. Laves
Chairman
Department of Government
Indiana University

Mr. Harold H. Leich
Chief, Policy Development Division
United States Civil Service Commission

Honorable John W. Macy, Jr.
Chairman
United States Civil Service Commission

Mr. J. Kenneth Mulligan
Director
Office of Career Development
United States Civil Service Commission

Dr. Raymond L. Randall
Institute of Public Administration
Indiana University

Mr. Franklin J. Ross
Deputy for Requirements to the Assistant Secretary for Research and Development
Department of the Air Force

Dr. Juergen Schmandt
Assistant Director
Program on Technology and Society
Harvard University

Dr. Norman R. Scott, Associate Dean
College of Engineering
University of Michigan

Dr. Chalmers Sherwin
Deputy Director for Research and Technology
Defense Research and Engineering
Department of Defense

Mr. Carl F. Stover
Executive Director
National Institute of Public Affairs

Dr. William G. Torpey,
Manpower Specialist
Office of Emergency Planning
Executive Office of the President

Dr. J. L. Waling
Associate Dean
Graduate School
Purdue University

Dr. R. T. Watson
President
Industrial Laboratories Division
International Telephone and Telegraph Corporation

Dr. Ernst Weber
President
Polytechnic Institute of Brooklyn and
Chairman, Joint Advisory Committee on Continuing Engineering Studies

Chancellor Herman B Wells
President
Indiana University Foundation

Dr. F. Joachim Weyl
Deputy Chief and Chief Scientist
Office of Naval Research
Department of the Navy

Dr. York Y. Willbern
Director
Institute of Public Administration
Indiana University