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Professional Personnel Policies and Practices of R&D Organizations

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PROFESSIONAL PERSONNEL POLICIES AND PRACTICES OF R&D ORGANIZATIONS

Introduction

From the date of its establishment in 1952 through 1968 the University of California, Lawrence Livermore Laboratory (LLL) experienced steady growth—passing the 5000 employment level in 1962 and reaching peak employment of about 6000 in 1968. In 1969 a decrease in program funding required management to reduce employment by about 400, which was more than could be achieved by attrition alone. To meet the required reduction in force (RIF), the involuntary termination of 219 employees, of whom 104 were in professional categories, was carried out during the spring of 1970. A smaller RIF was completed in 1971 directed toward a manpower level of 5185 employees allowing for some hiring to optimize the distribution of skills required for our continuing program.

After a history of continual growth over a 16-year period, adjusting to the need for even a fairly minor reduction in force has not been easy. Criteria for the selection of those employees to be laid off and acceptable procedures for terminating them (some with service exceeding 10 years) had to be formulated and then implemented on a relatively short time scale. As a result of the experience of the past two years, LLL must be prepared for the eventuality that employment will remain essentially constant for several years to come.

In the context of this new employment plateau the Laboratory Director, Michael M. May, appointed us a three-man group* to study policies and practices affecting professional personnel and to make recommendations of methods for maintaining the vitality and creativity of the staff under conditions of essentially static employment. He suggested that we visit a number of other organizations engaged primarily in research and development (R&D) to learn what policies and practices are currently in use and what alternatives are considered more effective in this period of diminishing government funding.

In preparation for this study we discussed among ourselves and with concerned members of LLL management what topics to emphasize. The result of these discussions was a list of questions dealing with specific features of the management of professional personnel which we believed would be important in determining the future vitality and

*The three-man study group included individuals of different backgrounds at Livermore. C. M. Van Atta, until the fall of 1970, was Associate Director and Head of the Controlled Thermonuclear Research program, W. D. Decker was Head of the Mechanical Engineering Department and T. Wilson has been a Personnel Representative and currently is on the staff of the Salary and Wage Department.

creativity of the staff. By "vitality" we mean the intellectual and physical vigor, and by "creativity" we mean the imaginative and innovative skill, with which R&D tasks are initiated, pursued and brought to successful conclusions. The topics covered in this study therefore do not include all aspects of the employment of professional personnel.

We did not presume to judge the relative effectiveness of the various organizations we visited in maintaining the vitality and creativity of their staffs, but we did note that more ideas on the subject were generated in those organizations in which top management was devoting significant time and effort to the problem. We have very little to say about special training of employees for management positions or the technique of sensitivity training, not because we regard these topics as unimportant but because they lie somewhat beyond the scope of our study. Many fringe benefits, such as group insurance of various types and vacation privileges, are not discussed in any detail in the belief that such items are of only peripheral significance to the objectives of our study.

The topics we have included may be summarized as follows:

- Conditions of employment.
- Procedures for evaluating performance and selecting employees for advancement, termination and layoffs.
- Recognition and cultivation of employees of exceptional abilities.
- Management of professional salaries.
- Motivation and maintenance of competence through educational and retraining programs and rotation of assignments.
- Effects of growth rate, turnover rate and selection of new employees on the average age of the staff.
- Problems of an aging staff, current retirement systems and alternatives favoring early retirement.
- The threat of limitations on the options of management by new Federal laws and the formation of professional unions.

In discussing these subjects we have not only reported on current personnel policies and practices together with alternatives under consideration at the various organizations we visited, but we have editorialized and expressed opinions regarding the efficacy of specific measures. The results of our study are described in this report. Specific recommendations to our management will be the topic of a separate internal report.

During our investigation of professional personnel policies and practices we visited the organizations listed below and wish to express our sincere appreciation for the hospitality and help we were accorded. The individuals with whom we had discussions are listed in the Acknowledgments at the end of the report.

Applied Physics Laboratory, Johns Hopkins University

Argonne National Laboratory

Battelle Memorial Institute — Columbus

Bell Laboratories

Brookhaven National Laboratory

General Electric Company, Research and Development Center

Jet Propulsion Laboratory, California Institute of Technology

Lockheed Missiles and Space Company

Los Alamos Scientific Laboratory, University of California

Naval Ordnance Laboratory

North American Rockwell Corporation Power Systems Divisions, Atomics International and Rocketdyne

Oak Ridge National Laboratory

RAND Corporation

Sandia Laboratories

Standard Oil Company of California, Chevron Research Company, Engineering Department

The Aerospace Corporation

TRW, Inc.—Systems Group

Methods of Acquiring a Vital Staff

CONDITIONS OF EMPLOYMENT— INDEFINITE VERSUS TERM

By far the predominant condition of employment for professional personnel has been for an indefinite period; i.e., for as long as the job exists and performance is satisfactory. Only in the past year or two have many organizations considered term employment, the principal feature of which is that the period of employment is limited to a specified term, such as two or four years, at the end of which the employee is either promoted to a new status or automatically terminated. Interest in term employment has grown because employees and supervisors have in the past tended to equate indefinite employment with permanence. When staffs began to decline, employees discovered jobs were not permanent, and supervisors found themselves ill-prepared for the new situation since they had failed in their job of evaluating the relative worth of employees.

Brookhaven is the only organization we visited that has consistently used term employment. It has been used as the basis of employment of the Scientific Staff and is complemented by promotion or granting of tenure when an employee completes his term employment and is favorably recommended by a review board.

Argonne uses term employment for some of the scientists engaged in high energy physics, and is studying the possibility of term employment of scientists generally. APL has adopted this procedure on a trial basis since our visit. LASL is experimenting with term employment in P Division. ORNL has used a postdoctoral program as a form of term employment for half of their recent scientific hires. Postdoctoral programs at LASL, LLL and ORNL are said to serve some of the purposes of term employment, particularly when hiring has shrunk very low and postdoctoral appointees become a significant fraction of the new employees. A postdoctoral appointment is not the same as term employment. It does however provide some of the advantages of term hiring, and this feature has led to an increased appreciation of the technique.

Term employment seemed to evoke greatest interest in organizations that need a basic research capability in science. Engineering and applied science laboratories showed little interest. At LLL and at the NASA Ames Research

Center the potential use of term employment appeals primarily to leaders of a few divisions that are largely research oriented.

Laboratories with corporate sponsorship seemed least interested in term employment. They tended to stress probation periods of 6 to 12 months and a rigorous culling out process by the line organizations as a more effective means of preventing the continued employment of unsatisfactory employees. However, supervisors in nearly every organization we visited lamented their failure to carry out the culling process adequately during growth periods in the past decade or so. The fault was not with the method but with the management. There was clearly underway or planned a stiffening in the "probationary" review and acceptance by management of the responsibility for careful periodic evaluation of new employees. In most organizations we visited, future employees hired with no stated limitations will be critically evaluated and released within five years if they fall short of expectations.

Term Employment at Brookhaven*

Term appointments and tenure have been practiced at the Brookhaven National Laboratory (BNL) since 1948. Because of its uniqueness among the laboratories we visited, this feature of Brookhaven operation deserves a complete description.

All members of the Scientific Staff, which totals about 450, are assigned titles and are initially employed on a limited term basis as follows:

Assistant Scientist - Appointments are made for terms of one or two years, and service at this rank is limited to two years.

Associate Scientist - Appointments are made for terms of one, two or three years, and service at this rank is limited to three years.

Scientist - Appointments are made for terms of two, three or four years, and service at this rank is limited to four years. The combined duration of term appointments as Associate Scientist and Scientist may not exceed five years, and that for all three ranks may not exceed six years.

Senior Scientist - This designation is honorary and is conferred in recognition of outstanding contributions to the Laboratory's program.

The conditions of term employment at Brookhaven are that all term appointments end on June 30 of the appropriate year, with the result that the lengths of initial appointments will vary somewhat from the nominal one, two, three or four years. Extension of the term of appointment or promotion to higher rank is effective as of July 1, the day following completion of the current term appointment. An employee is notified not later than February 1 preceding the expiration of his current term appointment of his future status at the Laboratory or termination on the coming June 30.

A term appointment or any renewal or extension thereof shall not be revoked prior to the stated expiration date except for enforcement of AEC contractual provisions, or by financial exigency, or for disability, or for adequate cause. Termination for cause may be effected only

*Parts of this section are either quoted or paraphrased from material provided by R. C. Anderson.

after a hearing before a committee appointed by the Director and including at least one representative of the BNL Council.* Termination because of financial exigency can occur only after consultation with the Council and after every effort has been made to continue the appointment in some other appropriate department of the Laboratory. Such terminations may not occur during the first year of a term appointment and must in any case be preceded by a two-month notice.

Continuing appointments at Brookhaven are the means of providing the necessary continuity in various research programs, in the design, construction and operation of major facilities and in high-level professional services. A continuing appointment may be made at any rank from Assistant Scientist to Senior Scientist and is not subject to a specific time limitation, as is the case of a term appointment. A person on a continuing appointment is involved in work that requires several years for completion. When this work is completed the Laboratory has no special responsibility to him as far as further employment is concerned.

To be considered for a continuing appointment the candidate must exhibit a high degree of skill and competence in some departmental program or function; e.g., the direct implementation of research carried out by academic visitors and other members of the staff or advanced training in new techniques for the execution of research projects.

A continuing appointment will not be terminated except for enforcement of AEC contractual provisions, by reason of financial exigency or major change of program requirements, for disability or for adequate cause. In the case of financial exigency or major change of program requirements, every effort will be made to continue the appointment in an appropriate department of the Laboratory. Termination for cause requires a hearing before a committee appointed by the Director and including at least one member of the BNL Council. Termination for reasons of financial exigency or major program change requires consultation with the BNL Council. At least four months' notice is given, and such a termination will not occur during an employee's first year of employment.

Tenure appointments at Brookhaven are made only by action of the Board of Trustees of Associated Universities, Inc. (AUI) and constitute recognition of independent achievement of a high order in the performance of original research or of other intellectually creative activity appropriate to the Laboratory. Recognition may be based upon (1) significant contributions to knowledge related to the purposes of the Laboratory, (2) continuing contributions of outstanding significance to the productive use of the Laboratory's facilities, or (3) outstanding and creative contributions to the design, development and improvement of those facilities.

A tenure appointment constitutes a commitment of permanent employment by AUI until the appointee's retirement, except as noted below. Tenure appointments are intended to afford appointees the maximum practicable freedom to

*The BNL Council consists of 15 members of the tenured staff representing the various divisions of the Laboratory.

direct their own efforts and to provide a sufficient degree of economic security to attract persons of ability.

A tenure appointment can be terminated only by action of the Board of Trustees of AUI and only for reasons of financial exigency or on demonstration, resulting from due process, of adequate cause. Involuntary termination by the Trustees shall occur only upon the recommendation of the Laboratory Director after a hearing by the BNL Council. In the case of involuntary termination for reason of financial exigency, the Laboratory undertakes to give adequate advance notice with regard to the academic year and in any case with a minimum of six months' notice.

A tenure appointment may carry the title of Scientist or Senior Scientist. One feature of the tenure appointment which is regarded as significant is the procedure by which the merit of the candidate is judged to be adequate for being so recognized. The candidate is recommended for tenure by the upper echelons of management in the Laboratory, not only on the basis of internal appraisal of his work, but also by appraisals of recognized scientists outside the Laboratory. For several years the "rule of thumb" regarding the proportion of Scientific Staff in tenure status was one-third. At present there are about 155 tenured staff members in a Scientific Staff of 450. BNL has 900 professional employees (engineers and scientists) and a total employment of about 3000.

Term appointments and tenure have not been utilized for engineers or scientists who operate in a support role. In actual practice it is rare for an engineer to be in a research role at Brookhaven where he can qualify for tenure. This accounts for the program applying to less than half of the professional staff. Tenure appointments were first made in 1948 and have averaged 10 per year in recent years, but far fewer are expected in the future. A graph showing the number elevated to tenure appointments each year is shown in Figure 1. It appears that 155 of the approximately 175 tenure appointees designated since 1948 are still at BNL. It is estimated that 10-20% of the term appointees achieve a tenured status.

Term employment and tenure need not be linked together as they are at Brookhaven. Although tenure at BNL is intended to be equivalent to tenure at a university, it is not significantly more secure than the Senior Staff designation at the Lawrence Berkeley Laboratory. Both groups are essentially assured that they will be the last in line for termination in any RIF due to financial exigency. On the other hand, neither group has any assurances of permanence in the event that a really severe

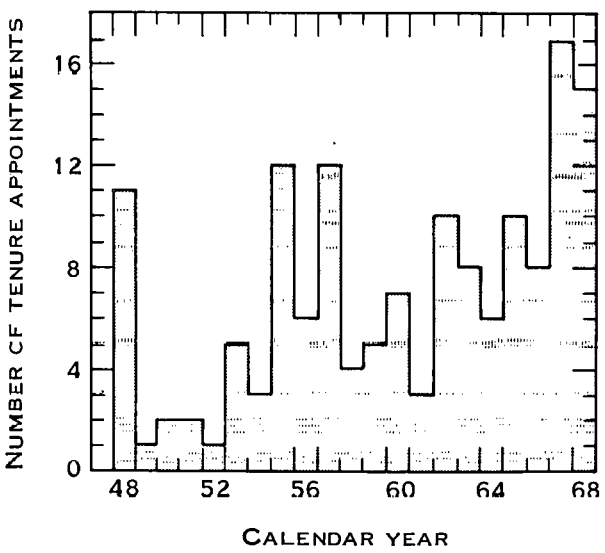

Figure 1. Scientific Staff tenure appointments at Brookhaven National Laboratory.

RIF should become necessary. Neither AUI nor UC has assumed any obligation for continued employment of these groups should Laboratory funding collapse.

There seems to be no advantage to LLL in adopting the concept of tenure as it is practiced at Brookhaven. If a sequence of ranks with limited terms of employment were adopted, the final step at LLL could hardly be more than promotion into an indefinite employment status with no stated term of employment. If an employee were to pass successfully through a sequence of promotions involving 6 to 10 years of service, the Laboratory would have used the employee's most vigorous years and could not then without compelling cause terminate his employment before he would become eligible for retirement. Tenure is not only inconsistent with the dependence of the Laboratory on AEC funding, but seems an unnecessary embellishment even though a sequence of ranks with a limited time of employment were adopted.

The sequence of ranks for the Scientific Staff might have the very desirable effect of insuring that those promoted from rank to rank and finally to a more permanent basis would undergo a more objective and critical review than would otherwise be applied. At each step the sponsor of a candidate for promotion has a much more concrete step to justify than one who merely confirms that an employee should continue in his indefinite employment role because he is a satisfactory employee. A promotion committee must be convinced that the past achievements and the future prospects of the employee justify the proposed advancement. Many will fail to make the grade and be terminated at the end of the current term. The proportion of those who are allowed to make the grade can be administratively controlled to make sure that only those of outstanding merit are promoted to the next higher rank.

The GS ranking system of Federal Civil Service organizations is similar to the BNL sequence of ranks and provides an instrument to make promotions that are based upon merit. The essential element in each case is the periodic review of performance by a critical personnel review board.

The Prevalence of Informal Tenure

Every organization, be it supported by industry or government, recognizes an informal tenure. Long term employees are much more secure than new employees, say those with service under five years, from termination for cause or in a layoff. In this day and age employers are very conscious of their images, and even though times are hard they are reluctant to be callous for fear of affecting their competitive positions when stability and normal hiring return. Individual supervisors making recommendations for layoff tend to protect long-service employees no matter how much they are urged by higher levels of management to release those with obsolete skills or of less value to the organization. In layoffs based on performance or value to the organization it is clear that long-service employees are sometimes retained despite their lack of merit. While a few long-term employees are released, a degree of protection and permanence is afforded them. One of the implications of indefinite employment has been that it will endure as long as funding is available and performance is satisfactory.

Hans Mark, Director of the NASA Ames Research Center, informs us that in a reduction in force the managements of civil service organizations are required to lay off a certain number of long-term employees. However, in the absence of a reduction in force or a defined budgetary reduction in a specified category of work, considerable ingenuity on the part of management is required to effect the involuntary termination or retirement of a long-term employee in a civil service organization.

Most organizations accept an increasing obligation to provide continuity of employment the longer a man is in their employ. We have found that this protective attitude will prevail, however, only if the employee makes a reasonably successful effort to retain his competence, to maintain his productivity, and to adapt to the changing needs of his employer. If he fails in his part of the bargain, he must expect to have his continued employment questioned. An employee who loses sight of his obligation is vulnerable at the time of a layoff in spite of his seniority.

Summary

The managements of most laboratories would not change from indefinite to term employment because they fear that the threat of not surviving beyond the term might drive some good applicants away. R. C. Anderson, however, firmly believes that well qualified applicants have not been discouraged from applying at Brookhaven because of the practice of term appointments for the scientific staff, but on the contrary have accepted term appointments as an effective means of maintaining high quality. Essentially all academic appointments are made for a specified term, and continued employment at universities depends upon advancements in rank until tenure is granted.

At ORNL our informants expressed the opinion that many applicants accepted postdoctoral appointments only when indefinite employment was unavailable. Their experience indicated that the best applicants held out for indefinite employment and that mediocre applicants used the postdoctoral route as a means of getting on the payroll. Extrapolating their experience with postdoctoral appointments to what might occur if all employment of scientific staff were based on term appointments has influenced ORNL management to favor indefinite employment.

The object of term employment is to gain a sizable throughput of young employees from which the best can be chosen for retention. It would seem prudent to offer only one type of employment for each job classification. If management offered either term or indefinite employment for a given position, term employment would probably lose its effectiveness. The mechanics of promotion by concurrence of an independent committee forces the supervisor to make a positive, documented recommendation based upon the merit of the employee. He must further support that recommendation before a committee charged with responsibility for maintaining the professional competence of the staff. Failure on the part of the supervisor to act would automatically deny promotion and result in the termination of an employee at the end of his current term. This procedure is almost the inverse of present LLL practice, by which failure of the supervisor to act results in retention

of employees who should be terminated. Further, if management wishes to limit the number of employees who attain indefinite employment status, the selection committee can serve that function.

In a less formal manner, the same level of selectivity can be achieved without resorting to term employment if supervisors can be made to follow up their evaluation with tough decisions to terminate unsatisfactory employees rather than default. J. A. Hornbeck of Sandia places great stress on the importance of annual merit reviews by the line organization as the most effective means of weeding out poor performers early. In this case the line organization makes the evaluation, comes to a decision, and carries out the appropriate action. If supervision is accountable to higher levels of management for the fate of new employees during their first five years on a name-by-name basis, the selection process can be just as valid as that made with the aid of an independent committee. Most laboratories have chosen indefinite rather than term employment knowing that they already have the tools at hand to evaluate new employees fully. All that is required is a management resolve and the clear delegation of responsibility to supervisors to insure that the intention is carried out.

The line organization can be augmented by an independent review committee to insure adherence to a desired standard in the evaluation of recent employees. Although such a committee may seem to be an unnecessary embellishment, it would reinforce the weakest points in the supervisor's review process, namely, conducting an objective evaluation and then making a decision whether to continue employment or recommend termination. An independent committee can thus provide management all of the assurances inherent in the term-employment method while preserving the practice of indefinite employment.

EMPLOYEE TURNOVER RATE

Influx of New Employees Needed

Each R&D organization needs an answer to the question, "What influx of new employees is required to stay vital?" There is no universal answer to this question, but there is one uniquely suitable for each organization. The input of new employees needed depends upon two factors; (1) the ratio of research to development, and (2) the extent of efforts to stimulate, motivate and utilize existing staff. Most laboratories both cultivate the existing staff and add new hires to gain vitality, but the proportions vary.

The organizations we visited had been living in an expanding technical economy, and most of them had experienced a reasonably continuous growth for nearly two decades. These conditions encouraged mobility of employees because jobs were plentiful. During this period the combination of attrition and growth typically generated enough hiring opportunities so that the question of providing a sufficient input of new employees rarely arose. More often there were complaints of too much hiring—too many new hands to train.

A deep concern was expressed at many of these organizations whether enough new employees could be added in the future to stay competitive. Supervisors of scientific groups fear that no hiring will result in a loss of vigor, a lack of new

ideas, and a decline of creativity. Engineering groups generally worry about losing pace with new technology as it develops.

Early in the study two questions seemed to us to be important:

(1) What rate of hiring had each organization been accustomed to in the past and was it sufficient?

(2) What fraction of the new employees should be recent graduates and what fraction should be experienced?

In order to answer the first question we gathered turnover data for the past 10 years from most of the organizations visited. Some could not readily recover the data we requested, and some of the data we did receive had limited accuracy. Table 1

Table 1. Professional personnel turnover in R&D organizations (5 and 10 year averages).

Organization	Annual percentage of professional staff[a] Hired and transferred in	Terminated and transferred out
5-year averages through 1970		
Aerospace Corporation	7.1	12.1
Oak Ridge National Laboratory	8.9	10.2
Lockheed Missiles & Space Company	9.8	13.2
Bell Laboratories	11.0	9.1
Standard Oil Company of California,[b] Engineering Department	19.8	16.8
10-year averages through 1970		
Argonne National Laboratory	6.3	6.2
Los Alamos Scientific Laboratory	7.5	4.1
Naval Ordnance Laboratory	8.4	7.1
Chevron Research Company[b]	9.2	10.8
Sandia Laboratories	9.7	7.6
Applied Physics Laboratory	9.8	6.7
Lawrence Livermore Laboratory	9.9	7.5
Battelle Memorial Institute - Columbus	11.1	10.0
RAND Corporation	13.2	13.6
Jet Propulsion Laboratory	17.8	10.5

[a]Includes all full-time, regular, technical, professional employees who were added to the staff by any means and those who left for any reason including layoff. The percentages were calculated for each year separately and then averaged. Some figures are based on calendar and some on fiscal years.

[b]The Engineering Department of Standard Oil has a specific responsibility for hiring and training promising young engineers for transfer into other company departments. Chevron Research Company also shares this responsibility. Without intracompany transfers included these figures become:

	Hired	Terminated
Engineering Department	12.2	6.7
Chevron Research Company	7.9	7.2

shows the technical professional employee turnover data supplied by the 15 organizations which responded. The hiring and termination percentages are not precise but are accurate enough to represent the range of turnover experienced.

Turnover rates had a greater range than we expected. In no case did our interviews reveal concern over the past turnover rate, so it is possible that features unique to each organization accounted for the large differences. Growth of an organization did not consistently result in a high turnover rate. Everyone interviewed expected a low turnover rate to continue until scientific and engineering employment returns to normal. If the normal mobility of professional employees is stifled by declining budgets, many organizations are expected to be reduced to a hiring rate near zero. Hence there was a sincere interest in establishing a "rock bottom" hiring rate essential to maintain a healthy organization.

An analysis of the turnover histories led us to a few conclusions. Barring sharp pulses of growth and decline, the annual hiring rate of professionals has varied from 5 to 15% of the staff with about 9.5% being average. Since the growth portion of hiring was nominally between 0 and 5% during the period we studied, the influx of new employees resulting from attrition averaged about 7%. This conclusion is drawn from a small amount of data with wide dispersion, and its limitation is recognized. In addition, however, at each organization we asked how much influx of new employees would be acceptable as a minimum. The most common answer was 6 to 8%.

New hires in the aerospace industry were older on the average (33 and above) than in strictly R&D laboratories. The youngest average hiring age at 26 was maintained by Bell Laboratories. Since they hire a large number of advanced degree professionals it is clear that their hiring consists predominantly of new graduates. This practice contributes to their remarkably low average age of 35.8 years for professionals in 1970, which is noteworthy for an organization established in its present form 47 years ago.

In past years supervisors frequently declined taking new graduates and instead hired experienced employees to minimize training during hectic work schedules. This practice was particularly prevalent in the aerospace industry and was necessary to respond to contract awards. The penalty was a higher salary cost in succeeding proposals which affected adversely the winning of new contracts and resulted in an accumulation of predominantly older and more expensive staffs. The emphasis has shifted everywhere so that in the future a firm base of new graduates has priority over the hiring of experienced professionals. Whether that resolve will hold up when the technical economy resumes its growth is a moot question.

We formed the opinion that a minimum of about 3% addition of new graduates each year with total employment of 6 to 8% was necessary to maintain vitality. Although many organizations hire nearly all their new employees as recent graduates, the mission of the organization determines the optimum distribution in age and experience for new employees.

Speculation on the Future

Many supervisors interviewed professed not to know what they would do if hiring went to zero. Some indicated, however, that their organizations could tolerate one to two years of no hiring, but then they would have to take steps to hire regardless of the state of their budgets.

Only Bell Laboratories had significant experience with a period of no hiring. During the depression Bell Laboratories went five years without hiring any professionals with the result that R&D output was adversely affected for several years. As a result the present management would be reluctant to exceed one or two years of no hiring in any future crisis.

A Textbook Solution

What might happen if several years pass and no hiring has been done? Or worse yet, what if budgets were to continue to decline? No laboratory has a firm plan to embark upon. First, it is likely that efforts would become frantic to stimulate the remaining staff with education, scientific conferences, and rotation of assignments. These efforts would be interim in nature, but if well done would delay the need for a more serious step. The second step might well be a corrective layoff designed to decrease the average age of the staff. If an organization should develop anything like a 10-year age disadvantage, it would probably no longer be an effective competitor. A

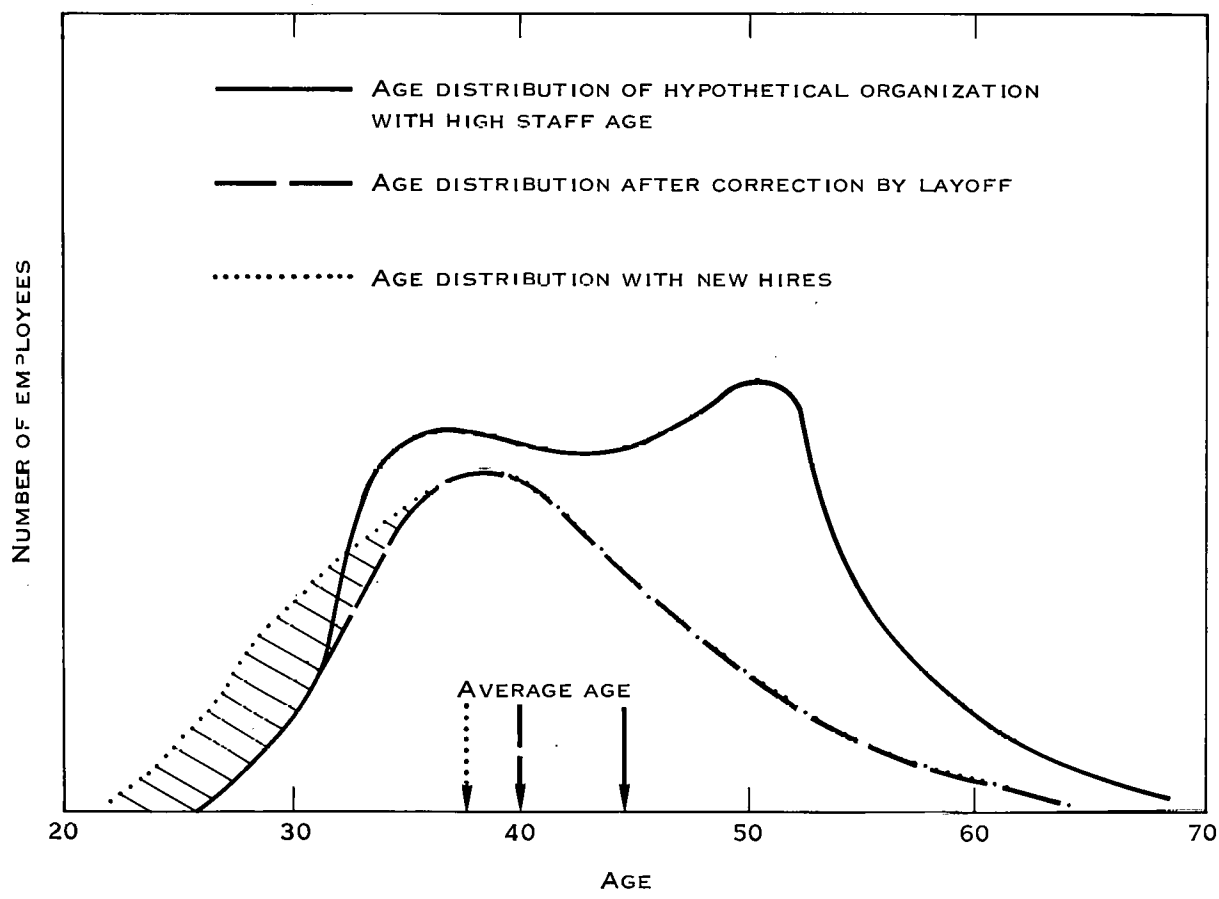

Figure 2. Textbook solution to aging staff problem.

laboratory director would run a high risk if he should delay too long to act once the average age of his staff starts to rise rapidly.

Unfortunately, drastic courses of action sometimes have tragic consequences. It may be fairer to the majority of employees in the long run, however, to create tragedy for a few than to preside over the demise of an entire organization. Such a demise might occur if management should fail to take a sufficiently drastic course of action.

Faced with the crisis of severe budget decline, a laboratory director would probably choose to save his top people and take such action as necessary to maintain a selected staff age distribution. But high rank alone may not insure that an employee would avoid layoff, particularly when high rank has been earned for supervisory responsibility primarily. The maintenance of a chosen age distribution will become an urgent priority. Each director will have to work toward the age distribution which in his judgment is best for his laboratory.

Figure 2 shows a hypothetical age distribution of the staff of an aging organization before and after drastic action to maintain vitality in response to a severe budgetary decline.

None of the organizations visited has taken such drastic action to reduce significantly the average age of its staff because of concern that the net effect might well be destruction of the morale of the staff. But the shattering impact on morale comes primarily from having any layoff. We doubt whether the effect on morale depends significantly on the criteria for selection of those included in a major layoff. If a laboratory can survive the fact of a major layoff, the staff will probably accept any rational layoff list.

A Likely Solution

What will probably happen if several years pass with no hiring is much less drastic. Social pressures and compassion will prevail. Laboratory directors will do everything possible to invigorate the remaining staff as it gets older, and they will have some success. They will insist on a few new graduates each year, an irreducible minimum partly gained by contrived layoffs. The implications of the Federal laws pertaining to discrimination on the basis of age may seriously limit the options of management in hiring, terminating and retiring practices. Until the implications of these statutes are better understood, radical changes in practices affecting the average age of professional staffs will have to be approached with great care. An increasing staff age will probably have to be accepted and accommodated as a fact of life. An older staff may not be as creative, but it will probably compensate to some degree for any lack of creativity by high quality of execution and a strong esprit de corps.

Calculating the Aging Rate of an Organization

We can predict by the use of a simple formula the aging rate of an organization in a situation of zero growth.

Let

$$a_0 = \frac{N(1 - r)a_r + Nr\,a_L}{N} \qquad (1)$$

$$a_0 = (1 - r)a_r + ra_L \qquad (2)$$

where

a_0 = average age of N employees at the start of the year.

a_L = average age at the start of the year of Nr employees who leave during the year.

a_r = average age at the start of the year of N(1 - r) employees who remain.

N = number of employees at the start of the year.

r = fraction of employees who leave during the year.

After one year the age of the employees who remained is $(a_r + 1)$ and the Nr employees have been replaced by employees of average age ϵ at the end of the year. Then

$$a_1 = \frac{N(1 - r)(a_r + 1) + Nr\epsilon}{N} \qquad (3)$$

$$a_1 = (1 - r)(a_r + 1) + r\epsilon \qquad (4)$$

where

a_1 = average age of N employees at end of year.

ϵ = average age of new employees hired during the year.

For the average age of the organization to remain constant

$$a_0 = a_1 \quad \text{or} \quad \Delta\bar{a} = 0 \qquad (5)$$

Equating:

$$(1 - r)a_r + ra_L = (1 - r)(a_r + 1) + r\epsilon$$

$$\epsilon = a_L - \frac{1}{r} + 1 \qquad (6)$$

Equation (6) enables us to determine the required average age of new hires to maintain a constant average age of the organization with a given rate of hiring or

$$r = \frac{1}{a_L - \epsilon + 1} \qquad (7)$$

which gives the turnover rate required to maintain a constant average age. For example,

Assume: $a_L = 40$ (age of leaving employees)

$\epsilon = 28$ (age of new hires)

then $r = \frac{1}{40 - 28 + 1} = 7.7\%$ required turnover rate.

To predict the age increase for a given set of conditions we substitute equation (2) into equation (4) such that

$$a_1 = (1 - r)\left[\frac{a_0 - ra_L}{1 - r} + 1\right] + r\epsilon \qquad (8)$$

As an example let us assume we have an organization with the following conditions. (This example approximates LLL's 1971 situation.)

$a_0 = 39$ (beginning of year average age)

$r = 3\%$ (turnover of stable staff)

$a_L = 36$ (age of leaving employees)

$\epsilon = 28$ (age of new hires)

Then from equation (8) the average age of the organization at the end of the year would be

$$a_1 = (1 - 0.03)\left[\frac{39 - (0.03)36}{(1 - 0.03)} + 1\right] + 0.03(28) = 39.7 \text{ years}$$

The fraction of the staff that doesn't turn over each year gets one year older and has a major impact on the aging rate of an organization.

In its hiring process, management can choose the age of new hires and predetermine the effect of their age distribution on the average age of the total staff. The turnover rate and the average age of terminees, however, are not completely under the control of management. These

two factors significantly affect the organization's aging rate and should not be underestimated. For example, the institution of a very favorable early retirement program will result in the voluntary early retirement of some employees and reduce the average age of the group. If a laboratory rigorously culls out employees who don't meet its standards, a higher turnover rate and an older termination age may also result which in turn again slows the aging rate.

We can derive equations for growth and decline conditions, but the arithmetic gets a little more involved. We doubt that any laboratory management would rely on a formula to assure good work by its staff. The attempt is rather to show the interaction of factors so that they can be included in the planning for a professional staff.

Summary

- Although engineering staffs and scientific staffs have different needs, they have a comparable need for an influx of new employees to maintain a level of vitality.
- Aside from growth, normal attrition has supplied R&D organizations with about 7% new professionals (both new graduates and experienced hires) per year in the past decade.
- The minimum required input of new graduates is about 3% (at a time when other new hires could be zero) to maintain vitality.
- Organizations could exist for one or two years with no hiring and not suffer irreparably in vitality.
- Should an economic decline further decrease R&D staffs it is most likely that managements will accept an increasing staff age, that they will hire very few new graduates each year, and that they will lose some vitality rather than break the spirit of the organization by decimating a long term staff.

HIRING THROUGH RESEARCH GROUPS

When hiring is at a minimum it is helpful to be able to hire into that part of the organization where new ideas and technology can have the greatest impact. This requires that openings in other parts of the organization be filled by transferring people out of the area where innovation is most needed so that nearly all new hires will be in that crucial area.

We found this technique in use in six places. It was very enthusiastically supported and was sometimes called the "suction pump" effect. The details of operation varied, but in each case the result was the same; a healthy throughput of new employees was occurring where it was needed most.

It is a fact that in the continuum between basic and applied research (and development) there is an increasing dependence on experience as the work becomes more applied. Conversely, basic research requires more creativity and more new ideas such as are likely to come from new graduates. Consequently, the effects of no hiring are more quickly felt in, and more damaging to, the capability of doing good basic research.

In a strictly engineering organization there is a similar continuum extending from basic research through developmental work and to production engineering. In an industrial organization we find that such a

continuum may extend from research through engineering into management of company operations.

Figure 3 is a graphic representation of the work continuum in various organizations. In organizations using the "suction pump," openings in the work continuum are filled with people working at the left of those openings whenever possible. Positions at the left end of the continuum are always filled by new hires. This results in maximizing the hiring where new ideas and new technology are most needed.

In studying the Standard Oil Company of California complex we found that Chevron Research and the Corporation's engineering department represented the most technical end of their work and the place that most needed an influx of new employees. Company policy favors filling management positions with technical people. When management opportunities arise in the many operating companies or in the corporate structure, it is desirable to consider transfers from the technical organizations. These transfers are considered promotions. Those employees who have demonstrated adequate qualifications have the opportunity to accept such transfers. In most industrial organizations, selected professional employees are encouraged to prepare for administrative responsibilities by taking management courses and by participating in seminars dealing with company policies and management problems. Of course when the technical employee is first hired, one factor that is considered is his suitability for promotion to management. The employee is aware of this consideration. These transfers can move out enough

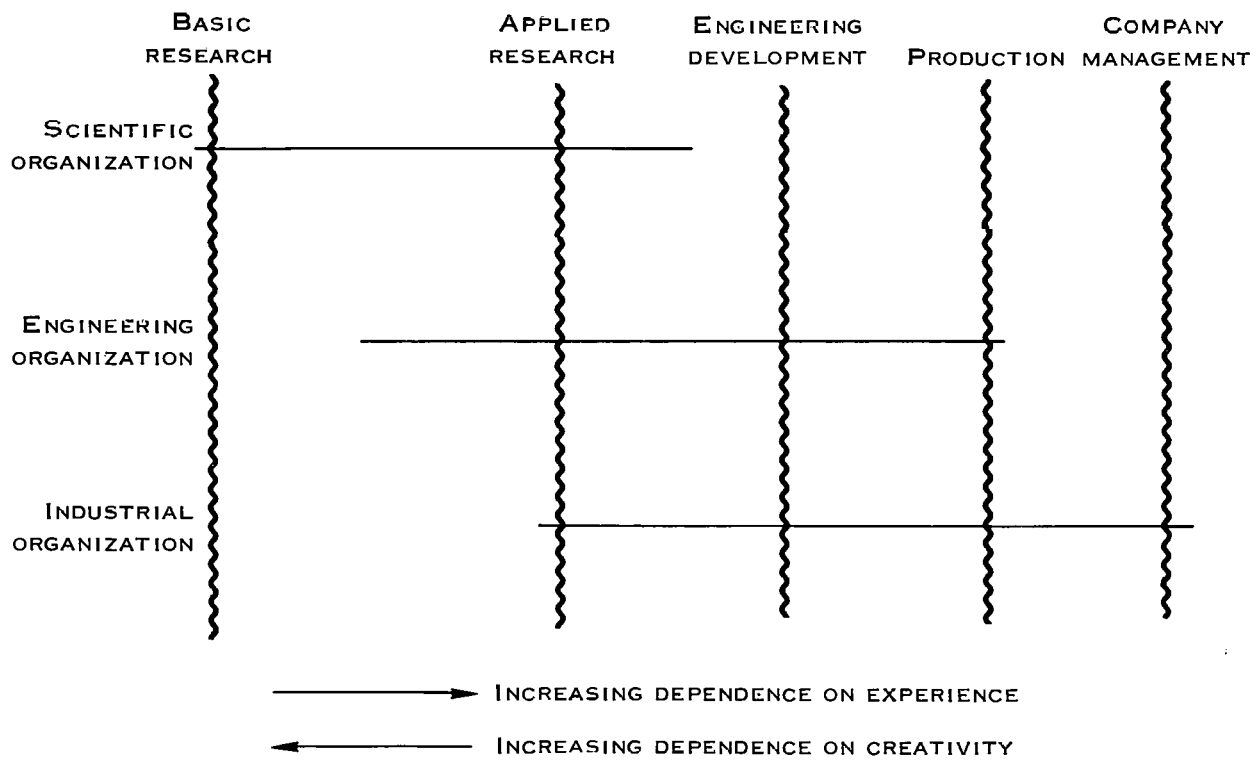

Figure 3. The work continuum from basic research to production.

people to significantly increase normal attrition. A certain number of employees remain in the technical organizations, either declining transfers or failing to measure up in management potential.

At The Aerospace Corporation we found that employees in the engineering and scientific divisions came to be regarded as highly desirable transfers into project engineering functions after they had obtained substantial experience. Many research types enjoyed the opportunity of transfer (and often promotion) after a number of years in scientific research. Such transfers must be sufficiently inviting to appeal to the professional or the program will not work.

Sandia and Bell Laboratories both state that members of their research groups become attractive "catches" for their own developmental areas. Although the majority of new development personnel is employed directly from outside, a significant number is transferred from the research department. When this occurs a new employee can be hired into the research area.

The General Electric Research and Development Center utilizes the "suction pump" technique in transferring R&D employees to other branches of the General Electric Company. Openings are aggressively sought and candidates for transfer are carefully selected. It is considered an important supplement to normal attrition from the research staff.

Jet Propulsion Laboratory currently directs a considerable proportion of new hires into its R&D area and fills most project management jobs from within.

Although the organization of the Lawrence Livermore Laboratory is not structured to encourage transfers of this nature, a significant number have occurred. Perhaps the "suction pump" technique could be applied more deliberately. Each division leader and department head could evaluate his own requirements to determine how great a spread of capabilities is required to do his work. If the division or department continuum is broad enough, then hiring at the more basic end of the continuum may enhance the value of the few new employees that can be hired.

The technique can be applied in the Mechanical and Electronics Engineering Departments where the work continuum extends from engineering R&D to semi-production engineering and management. The departments can adopt the practice of limited hiring of Ph.D. engineers to fill the needs for new specialties or increased competence. Ph.D. engineers, for example, who started in analytical groups or as thermal or controls specialists have broadened their range of competence sufficiently in 5 to 10 years to be able to fill project engineer openings or management openings as they become available. Engineers have a sufficiently general background to absorb the experience appropriate to make them attractive replacements for more hardware oriented work. The system is already working in that the departments are filling by transfer most positions on the more applied end of the continuum. The impact of the few new hires is concentrated in those areas which have greatest need of new ideas and technology.

Can the scientific division leaders find a reasonably broad continuum in their own groups? Some are more likely to succeed than others. Certainly the family of scientific divisions, if looked at as an entity, presents a very reasonable continuum from basic research to applied R&D. A larger flow of scientists from basic to applied work could occur than does now. Transfers of this type should be made only with willing employees who are fully informed and ready to accept a job in another group. Some groups by the nature of their interests could not contribute much to the "suction pump" effect. But there have been enough transfers among groups in the past to indicate that such a program could be expanded at LLL.

Hiring through research groups could help to maximize our benefits from a limited hiring program. A concerted effort would be required to avoid hiring replacements for the more applied work. This technique has proved to be valuable for each of the six organizations that have used it, and they will continue to benefit from it.

POSTDOCTORAL PROGRAMS

In the course of our discussions about hiring, the use of postdoctoral appointments in scientific groups was mentioned a number of times. At least 6 of the 18 laboratories have postdoctoral programs. While nothing precludes the use of such programs by engineering departments or applied research groups, postdoctoral appointments are of interest primarily in basic research groups dominated by physicists or chemists.

The postdoctoral appointment provides an opportunity for a recent Ph.D. to continue research under a senior scientist in a working climate. The appointments are for one to two years and are usually at a pay rate below that of regular employment. The real stars of such programs are often invited to join the permanent staff.

The number of postdoctoral positions available in organizations varied from 6 to 60. Where the program is an adjunct to regular employment and has the attributes of a fringe benefit, both to supervision and to the employee, it is favorably regarded. When the main avenue for new employment is through postdoctoral appointments the reaction is very mixed. A frequent complaint is that many postdoctoral appointments are accepted because the applicants could not get permanent employment. Conversely, the best applicants hold out for regular employment and avoid the postdoctoral route.

Sandia management believes that postdoctoral programs should not play a part in the culling of new employees but should be directed to other ends. They tend to attract, and often are designed for, recruits who are less than excellent. The term of employment is usually too short for a new man to demonstrate competence and creativity. Taking advantage of the fact that a period of difficult scientific employment will attract better candidates to a postdoctoral program would be inappropriate in the opinion of J. A. Hornbeck, since that practice would erode the distinction between the regular and postdoctoral programs. This difficulty would be further increased by the present lack of opportunities for the postdoctoral employee when his appointment is finished.

Another complaint is that the postdoctoral program perpetuates the faculty-student relationship into the working world. Some exploitation of this arrangement exists in laboratories (as it does in universities) leading to what is called a "slavery" relationship. There is some feeling that such an arrangement is inappropriate except in a situation in which the reward is not so much monetary as it is an opportunity for advanced training under the guidance of an outstanding scholar.

The management at the General Electric Research and Development Center considered and then rejected a postdoctoral program. They chose to acquire all professionals as regular employees with an opportunity to evaluate them rigorously in their early years.

A sampling of opinion at Lawrence Livermore Laboratory at the division leader level indicated little interest in enlarging the postdoctoral program and no great enthusiasm for the concept.

In a declining economy when placement is difficult for new Ph.D.'s, the postdoctoral program may attract better people than in times of ample employment, and it is a very inviting technique for sifting potential employees. In any case the postdoctoral appointment appears to serve some of the purposes of term employment and as such has heightened the interest in term employment as a method of acquiring future staff.

Techniques for Maintaining Vitality in the Existing Staff

We encountered a number of techniques for stimulating and directing the efforts of a professional staff that is faced with the threat of stagnation—particularly a staff in a repressive economy in which growth and hiring have virtually stopped. Many of these techniques are merely ideas and have not yet been implemented, but the fact that they appealed to the managements of several organizations, or in some cases had actually been instituted, makes them worthy of discussion.

Of the many ideas to be discussed, four generated the most interest and were judged to have the broadest impact.

- Rotation of assignments. (See page 19.)
- Continuing education and retraining. (See page 21.)
- Effective evaluation of employee performance. (See page 25.)
- Improved early retirement benefits. (See Retirement Systems, page 49.)

ROTATION OF ASSIGNMENTS

At eight of the organizations the topic of assignment rotation as a means of stimulation of a scientific or technical staff came up in the course of our discussions. The idea may have had appeal in other organizations or may actually have been in use without our discovering it. Because this topic was discussed time and time again, we became more convinced that it is a practical tool for keeping a laboratory dynamic.

At Jet Propulsion Laboratory we learned from Fred H. Felberg that it was the intent of management to change assignments frequently enough to keep

the organization churning to a certain extent. As Assistant Director for Plans and Programs he believes that JPL needs to do more churning in the future because "everyone tends to get comfortable where they are when growth stops or declines." It was his thought that changes made for changes sake may well turn out to be beneficial to the health of an R&D organization.

J. P. Nash, Vice President of Lockheed Missiles and Space Company at Sunnyvale, maintains a program of assignment rotation for his engineers, but he admitted that it is difficult to keep his groups interested in rotation when established teams are functioning well. It is his belief that conscious rotation efforts are necessary to build and maintain a viable professional staff.

The attitude at Sandia is that a certain amount of rotation in assignments can be healthy if directed toward placing men in positions where they can contribute and grow. However, rotation as an end in itself is not favored since it implies that management is interchangeable, which is only partly true in an organization in which strong technical control is an important aspect of management.

The actions instigated by Sherwood L. Fawcett, President of the Battelle Memorial Institute, in revitalizing the organizations in the Battelle family demonstrated the need for dedication at the highest executive level to accomplish changes that are instinctively resisted at the working level. With Dr. Fawcett's encouragement, Roger Merrill, upon taking office as Director of Battelle - Columbus, reshuffled the Laboratory structure as one of his first orders of business. They recognized that they were operating with an organization designed fifteen years ago. The nature of their work had changed and a growing awkwardness of operation became apparent. They made a bold step rather than relying on changes to evolve. Merrill reduced the number of departments from seven to five. Three of the five department managers currently are new in their jobs. The Battelle management has been encouraged to look at other levels that are subject to stagnation or suffering from entrenchment. To keep the program of rotation going, Sherwood Fawcett has initiated a requirement to identify candidates for management jobs with the objective of limiting incumbency to five years at higher levels. Department managers are extending the program deep into their organizations. Many of the job changes to be made will be lateral—not promotions. "The objective is to develop an organization that can adapt easily to changing conditions—one in which the staff accepts change as a way of life and is challenged rather than threatened by new assignments."

Strong group leaders often employ the rotation policy in their groups to keep enthusiasm high and to encourage creativity. At some laboratories the group structures were so autonomous and different in character that mobility throughout the organization was very slight. In those cases assignment rotation could only become policy at the group level, but it was interesting that the practice thrived in some of those groups and that the group leaders attested strongly to its value.

We tested the sentiments of a segment of LLL's middle management about the value of rotating assignments. All 21

respondents favored the idea in principle and suggested that a time limit of 2 to 5 years in an assignment might be appropriate. The opinion expressed was that to operate successfully the policy not only must have top management support and direction but must operate Laboratory-wide and be carefully administered. (Dr. May's announcement of his resignation as LLL Director is a demonstration of his strong personal conviction that the Director should limit his tenure to five or six years.)

We did not find any adverse results from deliberate plans of rotation at LLL or at any organization we studied. There appear to have been no bad effects from LLL having had 5 different directors in its existence of 19 years. At the project level, even where dramatic changes in personnel have occurred, the most usual result is for a new man to build upon the achievements of his predecessor and for neither to suffer in the comparison.

The greatest reluctance comes from incumbents themselves who tend to argue for the status quo until a "better offer" is made. What the long term incumbent can rarely see is that his greatest opportunity for new achievement lies in a new assignment—even a lateral move. Department heads are frequently unwilling to disturb a satisfactory operation because of the liability of a new man who requires training, indoctrination and testing in the particular job situation. The selection of individuals in a program of rotation is obviously important, but upon thorough evaluation there is always more than one man who can do any job. The potential benefit to be accrued by rotating the assignments of employees at all levels of a laboratory is worth careful consideration.

CONTINUING EDUCATION AND RETRAINING

Current Practices in Continuing Education

The importance of retraining and continuing education as a tool for keeping the laboratories dynamic was supported everywhere we visited. There was a variety of opinion regarding how best to implement significantly different programs than now exist.

Currently educational benefits are provided by organizations largely as additional fringe benefits. Educational opportunities were emphasized as a part of recruiting programs in the past when it was recognized that the very best applicants wanted to extend their education and would accept employment only where such opportunities existed. In general, strongly motivated young employees make good use of fee-reimbursed programs to further their education. Since the programs were usually limited to a small fraction of the staff, there was little appreciation of the potential impact of continuing education if applied to a total staff. There is a stirring now in many organizations. While fee-reimbursed programs and short-course support continue to dominate the offerings, there is a growing involvement and interest in utilizing a new type of educational format to increase the technical capabilities of an organization. This new approach is of crucial interest when other avenues of strengthening the technical stature of the staff are diminished.

Continuing education programs are not supplanting the traditional educational

support programs but are growing as a complement to them. Retraining is the first step in the effort, which emphasizes reestablishing skills that have deteriorated since graduation. Usually a reeducation is required in courses up to the employee's degree level. Continuing education then follows, which extends the employee's capabilities to a new level but in a style that matches the needs of a practicing professional. In some broadly based organizations, research departments can be excellent sources of instructors for scientifically oriented courses.

Degree programs and regular university courses are currently not providing real continuing education. The opportunity to take the same courses as today's 20-year olds is not very appealing to a 40-year old professional who has some previous training and considerable experience. Today's professional is looking for a condensed version of his academic training that is closely coupled to the real world of his work. Unless that requirement is met there is little motivation for continuing education in the ranks of practicing professionals.

There appears to be dramatic potential for revitalization when management recognizes that a significant upgrading of a large fraction of the staff will supply much of the stimulation and new technology that previously came on board as a matter of course in a growing economy.

The interest in continuing education is much greater in organizations dominated by engineers. Particularly in scientific research, continuing education seems of least value since it is in this area that the very technology is being created which the rest of the world wants to keep up with. Even scientific staffs are finding, however, that maintenance of fundamental skills not only improves research capabilities but makes reassignment more feasible when current work is terminated. Flexibility is a trait of growing importance among today's scientists and engineers. The LLL middle management survey, which covered a broad range of scientific and engineering interests, revealed that they would ".... place greater emphasis on continuing education" to compensate for the inability to hire new employees.

Convenience to the employee has been found to be crucial in sustaining educational programs. It is very hard to sustain the interest of older employees in off-site after-hours courses except on an occasional basis. If attendance has been made extremely convenient, the employee realizes that management has set a high value on his participation. Applied Physics Laboratory and Los Alamos Scientific Laboratory have on-site programs for degree work which have enhanced participation.

An outstanding example of the utilization of the talents of a major research laboratory for educational purposes is that represented by the Department of Applied Science at Livermore. Largely in response to the urgent request of the management of LLL, the Department of Applied Science was established within the College of Engineering at UC Davis in 1963. The department is housed partly in a small classroom facility built adjacent to LLL at University of California expense and partly on the Davis campus. The department offers a number of undergraduate courses and grants degrees of M.S. and Ph.D. in Engineering-Applied Science.

Four areas of specialization for the Ph.D. degree are offered at Livermore:

Applied Mathematics and Computer Science

Nuclear Science and Technology

Materials Science

Plasma Physics and Hydrodynamics

Students may complete all requirements for the M.S. and Ph.D. degrees either at Davis or Livermore, or they may divide their programs between the two sites.

Student registration at Livermore is typically slightly over 100—about half being LLL employees and a few Sandia-Livermore employees. LLL employees may take up to 6 units per quarter on approval by an administrative committee without reduction of pay but may be cut to 80 percent or less of full time pay to accommodate time off for greater concentration on academic programs with supervisory approval. On completion of all course work required by the Department of Applied Science, an LLL employee may embark on Ph.D. thesis research using Laboratory facilities—provided the thesis problem is one of interest in some component of the Laboratory's program. The thesis director is a member of the academic department and is chairman of the student's thesis committee. The student meanwhile remains an employee of LLL and subject to supervision within the Laboratory structure. Since starting to grant degrees in 1967, 32 Ph.D. degrees have been granted, of which 9 were to Laboratory employees, and 21 M.S. degrees, of which 5 were to Laboratory employees. Many Laboratory employees take specific courses of special interest to them at the Department of Applied Science without any intention of completing work for a graduate degree. The Laboratory also offers graduate fellowships to promising students who are employed half time during the academic year and full time during the summer months. There are 17 such fellowships at the present time.

The teaching staff at the Livermore branch of the Department of Applied Science is made up of several full time faculty members, some faculty members who are employed half time by LLL and several LLL employees employed as lecturers part time by the Department. The association with the Department of Applied Science therefore provides teaching opportunities for qualified Laboratory employees as well as means of academic advancement for employees seeking additional training. LLL employees participating in the program confirm that teaching a graduate course is the most effective way of restoring mastery over subject matter in basic science. The academic program of the Department of Applied Science provides scientific personnel an opportunity for maintenance of fundamental skills equivalent to that provided engineers by continuing education.

Where the work of a laboratory is basic rather than applied research, it is doubtful that improving continuing education opportunities would be an appropriate tool for keeping the organization vital. Some kinds of work and some types of technology will not necessarily be fortified by this technique.

Continuing Education at Bell Laboratories

At the Bell Laboratories there is a continuing education program that is well

suited to any organization wanting to remain competitive and vital. It is worth describing in detail. There are other large modern in-house programs in the United States that we did not study. The philosophy of the Engineering Departments at LLL dovetails remarkably well with that of the Bell Labs in regard to the role of continuing education.

Bell Labs started in-house continuing education courses in 1962 at one or two sites, and in 1969 they instituted their current company-wide program. E. D. Reed, chairman of the program, said that the mission of a continuing education program, aimed at mature professionals spanning a wide range of ages, is different from that of a graduate school and must be designed accordingly. Like LLL they found no university willing to tailor a program to the needs of a practicing engineer or scientist who does not need another degree. Bell Labs offers classes during working hours as a part of the job. Employees are urged to participate but not required to. Homework is done on the employee's own time. Most of the instructors are employees. The Bell Labs management is convinced that continuing education is required to combat obsolescence and in time will attempt to measure the usefulness of the program. Success of the program is measured at present in terms of participation and drop-out rate. However, work performance—not course participation—yields promotions and raises. Correlation between performance and course participation may eventually provide a measure of usefulness of the program.

The courses at Bell Labs are of semester length with one 2-hour class per week. Classes are held at 12 sites with approximately 3000 participants. The program offered 120 courses this year, up from 100 last year. The courses are directed toward Bell Labs' interests in telecommunications but run the gamut from basic mathematics to graduate level physics. There are three levels of courses. The first is review to reestablish skills, usually up to the B.S. level. The second level is interdisciplinary to give employees familiarity in another subject area but not expertise. The third level courses are in depth and attempt to produce experts

The program has the complete backing of management. It is directed by a high level technical committee headed by E. D. Reed. The committee selects the instructors and designates the courses to be taught—based on their own judgment and a survey of employee interests. Students must complete 80% of the homework and take a final examination for successful completion.

Initially Bell Labs experienced a high withdrawal rate. Students tended to drop out if the course content or the instructor did not suit them. A pre-course meeting seemed to remove that problem. An inadequate review of mathematics plagued the older students, so that an enlarged mathematics course was introduced and appears to have solved the problem. A certain number drop out due to work load or travel commitments. Two visits to LLL have encouraged the Bell Labs people to consider videotaping the classes to provide a makeup option to students who travel or miss classes for any reason. (Videotape makeup is an absolute necessity for LLL's traveling engineers and

has resulted in minimal dropouts. A good tape can be used to teach future courses with considerable success, we find.)

The participation at Bell Labs is fairly uniform in all age groups up to age 55. Above that age there is a declining participation. A third of Bell Labs' Ph.D.s are taking the courses. The research division with mostly "scientific" employees was slow to take part, but by the third semester 20% were enrolled. The courses are aimed primarily at the development area, so they would not appeal strongly to those in basic research. It is not surprising that this group would participate less actively since their work in basic research has a high academic content. However, those participating must be improving peripheral skills which they feel they need. The program has been very effective in easing the transition of employees from military work at Whippany into commercial work at the other sites. There is a high participation of these employees including a majority of the Ph.D.s.

The Bell Labs' management has determined that the stimulation and restored confidence resulting from two hours a week in these courses easily makes up for the working hours lost. An unscheduled benefit was the enhancement of each instructor's expertise in the field he had to teach. At Bell Labs, management is sensitive to the fact that stagnation is always a problem, so they would have this program no matter what the hiring rate or the state of the national economy.

Costs of Continuing Education

Among the greatest deterrents to shifting from the traditional education support programs to in-house continuing education programs is the cost. Most organizations find that the cost of intensive participation in university operated programs is truly prohibitive. In-house continuing education may be a better bargain if management realistically assigns the actual costs of such a program. Bell Laboratories accepts the expense as part of the cost of doing business. The cost in lost effort is mostly a paper cost since the weekly output of employees does not seem to drop measurably when they are enrolled. The strengthening of the special expertise of instructors partially repays for their involvement. The administrative costs are somewhat increased with larger participation. If classrooms must be constructed or a television system is installed, a capital investment is required. At most the initial capital costs should not exceed a few hundred thousand dollars. The real cost of effort devoted to the program is at most a few tens of thousands of dollars per year. For many organizations the continuing education route may actually be the cheapest, fastest and most direct way to maintain a vital staff.

EFFECTIVE EVALUATION OF EMPLOYEE PERFORMANCE

Identification and Cultivation of Exceptional Talent

We have been reminded by H. M. Mark of the Ames Research Center that the presence of a few individuals of exceptional talent has to a very large degree been responsible for the success (and even the existence) of outstanding R&D organizations. It is sometimes assumed that individuals of truly exceptional talent will make their own opportunities and thus

rise within the organizational structure. This assumption is indeed valid for some gifted people—particularly those with outgoing personalities and a knack for good interpersonal relations. Those gifted people who do not happen to have these qualities are not so easily recognized. Some are unconventional in behavior as well as in their approach to technical problems. Exceptional individuals do not respond well to routine assignments and should not be forced to conform to a prescribed work pattern. They may be relegated to inappropriate assignments, become discouraged and leave the organization.

One of the major responsibilities of supervisors is to seek out exceptional talent, make sure that highly gifted people are challenged by assignments demanding major departures from routine solutions, and reward outstanding achievement by commensurate salary raises, promotions and opportunities for further achievement. One test of the integrity of a supervisor is whether he will feel threatened by the presence in his group of an exceptionally gifted person and take defensive action or whether he will respond to the challenge and assist the gifted person by making sure that his capabilities are communicated to higher management. The ultimate result of appropriate action on the part of the supervisor may well be that sometime in the future his former gifted subordinate may rise to a higher status in the organization than himself, or even become his boss. If he is realistic and psychologically well adjusted, the supervisor will take pride in his correct appraisal of outstanding talent and the benefit to the organization resulting from his supportive action. It follows that a mature and perceptive management will recognize and appreciate the role of the supervisor in developing exceptional talent.

Highly talented individuals do not necessarily make good supervisors and in many cases do not want to assume supervisory responsibilities. A talented but strongly egocentric person may deprecate the contributions of his subordinates and inhibit their opportunities for initiative action. In such cases the objective of management should be to provide a high degree of freedom of action for the gifted individual with opportunities for him to apply his ingenuity and test his concepts without being burdened with supervisory responsibilities.

Most of the research oriented organizations we visited recognize two channels for advancement in status and salary—the line supervision route and the role of the highly talented individual research worker. The directors of LLL have all tended to reward about equally those who assume major administrative responsibility and those who make major contributions as individual research workers. Gifted members of the staff can best be encouraged by informal direct communication with top management outside the defined channel of the line organization. Such informality can at times be disconcerting to those in the line organization who have been bypassed, but the direct communication between a perceptive director and a highly gifted research worker can enliven the spirit of both and produce response within the organization far more effectively than the slow osmosis of information up through the supervisory structure.

Past Evaluation Methods

"If there is any general weakness in management, it is the hesitancy to appraise objectively individual performance and the guts to inform the employee of his weak areas." An employee relations manager associated with Atomics International and Rocketdyne thus summarized the company's difficulties in maintaining a dynamic staff in a layoff period. These divisions of North American Rockwell Corporation suffered severe cutbacks, and the resulting large layoffs exposed them to every problem conceivable.

Evaluations have often been misdirected in the past. A written appraisal designed to develop and encourage the employee usually contained little or no derogatory information. Such appraisals do not serve management's needs of knowing the staff capabilities and of identifying the top and the bottom performers. However, when a ranking process was used in conjunction with the appraisal program the employee evaluation system could really identify the poorest performers and detect a decline in performance. The majority of the organizations had, at the most, a written appraisal system and were clearly concerned with the problem of detecting poor performers. Most of them were looking for more effective techniques, and many, like LLL, are shifting their practices to include a ranking process.

Appraisals and ranking provide an annual technique of assessment. To use them effectively the manager must apply standards that demand good performance. An employee should be more than satisfactory in the eyes of a manager; he must instead be "excellent enough" to contribute to the improvement of the organization's capabilities. In the long run, many employees who are just "satisfactory" become problems instead of contributors.

Eight organizations had evaluation programs that were geared to detect decline in performance—APL, Argonne, Chevron Research, Standard Oil Engineering, Bell Laboratories, Sandia, General Electric R&D Center, and Battelle - Columbus. These organizations did not have equal success in acting on the information when it became available. A management resolve and follow-up are the key to success but often fade under programmatic pressure.

New Evaluation Programs

Battelle - Columbus had initiated three specific programs of evaluation over and above the annual evaluation. They were the "over 65 club," the "Reverse Peter Principle," and the "Career Development Planning Program."

The "over 65 club" is made up of older, obsolete employees whose age plus years of service exceeds 65. These are men who were competent in earlier times and at younger ages but who no longer meet the needs of Battelle. A typical member either has not kept up with advances in modern science or is an expert in a field which is no longer supported at Battelle. One example is the case of a classical mathematician aged 54 with 23 years of service, who was great 20 years ago. But with the advent of computers his traditional mathematics approach is decreasingly valuable. He is being retrained as a mathematician utilizing computers. If this training fails to improve his value he will be urged to become a teacher.

About 60 professionals have been identified who should have been retrained or released years ago when it was first apparent that they were becoming obsolete. A program for the improvement of each individual is being developed, utilizing help from management and from the Personnel Department. The investigation and interviewing takes three to four days for each person, and each case is different. Counseling, reassignment, and retraining are the treatments used in each case. Some of them are sponsored for up to a year in school with the understanding that they will terminate at that time. BMI has set aside $500,000 in trust funds this year to pay the costs of reeducation.

The "Reverse Peter Principle" is applied to those employees who were promoted beyond their level of competence. In these cases both Battelle - Columbus and the individual have acted in good faith. Unfortunately the man wasn't competent for the job and no corrective steps were taken. Battelle does not want to terminate these employees but is determined to correct the problem. As an alternative to termination the employee is offered a job at his current level of competence—a demotion. Where required his pay may be cut. Some older engineers who had gravitated away from engineering have been transferred to non-technical staff positions. Since November 1970, about 35 to 40 actions have been taken. The effect is no doubt traumatic for the employee but it is believed to be salutary for the organization. The employee has a good base from which to advance in a new activity or to seek another job if he chooses not to stay.

A career development planning program has been developed to assist each employee in planning his future career, either within Battelle or ultimately perhaps in some outside organization. The planning program has four major ingredients:

(1) Each staff member is asked to describe his ultimate career objectives. This process includes a formal self-appraisal and an analysis of the educational and on-the-job training steps the individual thinks he needs to achieve his ultimate career goal.

(2) The staff member's immediate supervisor performs a similar function for that individual. He describes the type of career he thinks the individual is capable of achieving within Battelle. This process includes a performance evaluation and a description of the educational and on-the-job training steps required of the individual if he is to achieve the described career objectives.

(3) The supervisor counsels with the individual staff member and together they compare career objectives and plans. If in reasonable agreement, they proceed together to prepare a career development plan for the staff member.

(4) If the staff member's career objectives and the supervisor's appraisal are not in reasonable agreement, this discrepancy needs to be understood early in the individual's career so that he can plan, with his supervisor, to develop a career along less ambitious lines or to seek employment outside of Battelle at the appropriate time. This procedure becomes especially critical as the staff member approaches the age of 40. Battelle seeks through this program to

assist each individual to grow to the limits of his capabilities regardless of whether he can find suitable career opportunities within the organization.

Evaluations by a Key Staff Man

A few organizations rely on the judgment of a key staff man as a substitute for written evaluations. Such reviews and judgment can be quite thorough and effective. They have the fault of not recording the evaluation process in the employee's file, and in addition there is a good chance the employee will not be aware of his evaluation. This informal technique lacks the thoroughness and reliability that is needed when budgets decline and employees must be selected for layoff based on their performance.

Enlarged Role of Personnel Departments

In several of the organizations visited the role of personnel departments has been enlarged to deal more effectively with the management of professional employees in periods of regressive budgets. One function is that of communicating to professional employees the fact that they are now in a competitive situation in which not only increases in salary, but even continued employment, depend upon the maintenance of an acceptable performance record. Another function is educational; of those employees who become surplus for one division of the organization, some with appropriate retraining can successfully be transferred to another division and thus avoid the need for termination. Others who cannot be reabsorbed in this fashion can be retrained for the purpose of qualifying them for employment elsewhere. As a part of the retraining process, aptitude testing to assess the alternatives for the employee's future career can be helpful. One result of an active program designed to assist the employee, whose performance has fallen off, is to strengthen the resolve of supervisors to be more objective in their appraisals of performance.

Summary

There appears to be a trend toward the adoption of evaluation techniques that better identify poor and outstanding performers. Ranking processes are increasingly used to aid in that evaluation. When employees are identified as poor performers, supervision and the Personnel Department work closely together to aid in the employee's development or his termination, whichever is appropriate.

The evaluation process and the resulting personnel actions usually require strong leadership at the highest level of management. The policy changes that provide effective evaluation do not originate at the working level. There is an increasing acceptance by top management of its role in maintaining an effective evaluation program.

LEAVE PROGRAMS

There was surprisingly little discussion of the role of leaves in maintaining a dynamic organization. Where it was discussed in any depth it related to the academic sabbatical leave.

Most organizations have a procedure to accommodate the employee who wishes to spend a year teaching, to accept a fellowship leave, or to take leave for a

Washington appointment. Characteristically such a leave does not cost the organization anything, may be advantageous to the organization, and rarely is expected to benefit more than the individual employee. Such leaves are infrequent enough to avoid any strain on the organization.

The academic sabbatical is practiced at Brookhaven. The research staffs at ORNL and Argonne have been urging their directors to obtain authorization for sabbatical leave programs. Chauncey Starr, Dean, School of Engineering and Applied Science at UCLA, recommends a generous sabbatical program to keep the staff dynamic. At no other organization we visited were paid sabbaticals discussed, and we concluded that the program was currently limited to Brookhaven.

Brookhaven has a 6-month program at full pay and a 12-month program at half pay. It is presently seeking approval for a full year's leave at full pay. The privilege is limited to the tenured staff of about 150. Experience has shown that less than half of the eligible employees apply for sabbaticals, and that the number on leave at any one time averages about 10. R. C. Anderson, Assistant Director for Scientific Personnel, believes that an enlarged program would be healthy for Brookhaven.

At the Lawrence Laboratories (Berkeley and Livermore) and at Los Alamos there are provisions for Professional Research and Teaching Leave, under which a highly qualified employee may receive up to two-thirds of his current salary for a leave period up to one year. "The employee must be one of outstanding professional ability with a firm plan of study, teaching or research which is clearly relevant to the interests of the Laboratory and to his competence," according to the Supervisor's Handbook of LLL. Leaves of this type are highly restricted and limited in number. Los Alamos granted 40 such leaves during the past 5 years with average length of leave of 8-1/2 months. At LLL the number granted during the same period was 15.

At LLL we queried division leaders about their interest in increasing the leave program to help improve their staff. Most of them felt there was no significant benefit in expanding leave programs as a means of stimulating their groups. In our discussions on the question of leaves, some division leaders expressed the belief that the employee who would contribute most as a result of a leave would be the least likely to request it. The division leaders are also inclined to favor programs that involve a large fraction of the staff rather than a very few.

The leave privilege, including the sabbatical, is no doubt a valuable management tool. However, for a leave program to be effective management must exercise care in the selection of the participants to assure that the maximum value accrues to the organization.

DIVERSIFICATION ACTIVITIES AT THE LABORATORIES

Concern with a Loss of Mission

Alvin Weinberg, Director of the Oak Ridge National Laboratory, offered the opinion that the problem of aging staffs would not be a worry if the more serious problem of "mission" for the laboratories were addressed. Many of the current concerns about a vigorous young staff grew as the "mission" began to fade. He added that the whole country should be oriented

to a new "mission" to keep our technological resources vital and dynamic.

The loss of a sense of "mission" was apparent in many places.

- NASA has reduced its space exploration program significantly. JPL, AI-Rocketdyne, Lockheed, and TRW were waiting for a re-direction to be defined.
- The AEC has reduced its reactor development program in favor of industry. The decision to narrow down the work to essentially one approach to the breeder reactor has affected the staffs at Argonne, AI, ORNL, LASL and Brookhaven.
- The AEC weapons program lacks clear future goals affecting LASL, LLL, Sandia and Battelle.
- The de-emphasis of research in high energy physics is causing reduced budgets at Brookhaven and LBL.
- The general decline in immediate DOD needs creates uncertainty in the future level of effort at NOL and Battelle.
- While DOD R&D programs remain very active, the general uncertainty of the nation's political and social climate tends to prevent long range development plans from firming up.
- The general anti-technology emotions that have been growing within the nation create some uncertainty about what kind of future work society and industry will really need from its "laboratories."

Some officials observed that so much attention is spent on declining "missions" that the importance of the remaining task is underestimated. At Sandia, John Hornbeck said that it was of paramount importance for the management of the corporation to maintain excitement and interest in the work at hand. It is too easy to become disenchanted and to forget that the "missions" remaining at the laboratories are still very important and deserve the highest effort and skill.

A Growing Interest in Diversification

Concurrent with the fading "missions" that concern the laboratories has been the growth in diversification of work. The two events have not always been related.

There is a growing feeling that the many R&D laboratories in the country should be regarded as national resources, and as such their strength should be preserved for future needs. Much of the strong interest in diversification of work has sprung from the working level professional. Some of this interest is probably self-preservation at work as employees realize that opportunities for mobility have decreased in the current recession. There has also been a strong desire to respond to the persistent social pressures against the war in Vietnam, against increasing the nuclear stockpile, for bettering the environment, and for an improved technological conscience. Management and employees have usually agreed that diversification might provide the means to hold together an experienced staff that could be called upon should a national need suddenly occur.

The discussion and acitivity directed toward diversification was most pronounced in AEC supported laboratories. Following closely behind were the NASA and DOD sponsored organizations. Thus far, however, the agencies of government, from which funds must eventually come to meet these aspirations for diversification, are lacking in funds and experience in the management of large-scale technical programs. Laboratories with industrial

sponsorship were primarily responsive to corporate needs, and diversification was not an issue with them.

- At ORNL the prime reason for diversifying is to protect the staff. The acquisition of additional contracts is encouraged up to a level that still would avoid a job shop climate. Nearly 15% of their work is non-AEC and includes such customers as NIH, NASA, HUD, and NSF. As diversification increased they were cautioned by the AEC not to come to them if they suffered budget cuts from their non-AEC sources. It actually has turned out that the AEC work was reduced (mostly reactor R&D) while the other agencies have increased theirs.

- The Aerospace Corporation has used some of their fee money to develop new program areas. They are permitted to add contracts from other agencies up to 20% of Air Force funds. At present these outside activities include (1) problems associated with short-haul air transportation for seven western states, (2) problems of space transportation for NASA, and (3) communications and transportation systems for the city of Los Angeles.

- At Argonne, Robert Duffield, the Director, stated a strong desire on his part and by the scientific staff to greatly expand their non-AEC work. Argonne has a Center for Environmental Studies funded at the $2.5 M level by non-AEC agencies. Initially most of the work at the Center is for HEW in pollution studies.

- RAND is expanding its work in the non-defense area. At present, non-defense programs account for about 25% of their total effort and are on the increase. (The recent separation of the Physics Department from RAND into a new corporation carried away a sector that was 100% DOD supported. The remainder of RAND had therefore greatly increased the fraction of non-defense work by the separation.) In the mid-60's, RAND management was convinced of the necessity of getting involved in new fields of research. This trend has helped alleviate the effect of decreasing DOD support. With the change in emphasis there has been greater employment of social scientists. RAND is expected to become more involved in teaching — particularly in fields in which it has concepts for new approaches. In some respects RAND is becoming more like SRI in its range of interests and activities. The present range of involvement includes: (1) New York City problems, (2) health care, (3) communication policy relative to T.V. and radio broadcasting, and (4) educational policies and objectives.

- Lockheed Missiles and Space Company at Sunnyvale receives its major support from NASA and DOD. The company management is interested in a modest amount of diversification but does not see a large shift of effort into other fields.

- TRW is eager to apply its technological capabilities and methods in new fields and has accordingly set up the Civil Systems Division. FY '71 funding of $10 M was obtained from sources other than DOD or NASA.

- APL, originally funded entirely by the Navy, has had an expanding program of space research funded by NASA for the past ten years. Since 1965, it has joined with The Johns Hopkins Medical Institutions in growing collaborative grant programs to bring the benefits of missile and space

technology to medical problems in many areas. More recently it has taken on tasks with agencies of the Department of Transportation (Urban Mass Transit Authority and the Federal Aviation Administration) to apply its competence on problems in these areas. These programs have all been aimed at applying the technologies and methods developed in its defense work to civilian problems rather than at diversification. For the budget year ended September 30, 1971, approximately 18% of the APL effort was in these non-defense areas.

- At Battelle - Columbus the work normally has been divided into 45% industrial and 55% government. Contracts with industry have been increasing but insufficiently to overcome the decline in AEC, DOD, and NASA funds.

- There is strong pressure from within NOL to diversify into non-DOD work, and the management is attempting to move in that direction. Management and staff feel that NOL and similar laboratories ought to be made national laboratories, and that such an act would broaden their base. They have very little non-DOD work so far.

- The Lawrence Laboratories at Berkeley and Livermore have recently embarked on efforts to obtain environmentally oriented contracts from non-DOD and non-AEC agencies. The management has stipulated that the number of contracts must not become so great that there is interference with the primary obligation of these Laboratories to the AEC.

SALARY MANAGEMENT

Salary as a Factor in Maintaining a Dynamic Organization

Salary and raise practices are analyzed frequently and thoroughly by experts in that field, and reliable comparisons of salary practices at various laboratories are made. Although we gathered some numerical information it is too sketchy to be presented as a complete picture of comparative practices. Our interest was confined to salary and raise practices as a factor in maintaining a dynamic R&D organization, and our report will emphasize that interest.

Recognition that salaries must be adequate and competitive is universal. Management rather carefully selects a salary maturity curve that reflects geographic location and the market demand. To aid in selecting a maturity curve there is strong reliance on salary surveys that include organizations with comparable work and which compete for the same talent. There is little hesitation in shifting from reliance on one survey to another whenever improved data can be obtained.

A few organizations have followed the practice of exceeding survey data by a significant amount in setting salary levels. These practices are justified as necessary to attract outstanding talent or to insure a superior performance. There was no evidence apparent to us that the desired result was obtained. Other factors in addition to salary have a strong effect on the motivation and performance of professional scientists and engineers. The evolution of highly paid staffs had become

a great concern to several organizations because of the resulting difficulty in competing for contracts in a declining economy. The high operating costs and occasional external criticism had resulted in serious examination of past salary practices.

The managements of many organizations tend to believe that they have a good image, and in many cases that salary practices are a factor in that image. Despite considerable unemployment in technical fields, it was considered most important to have a reputation for good salaries in order to remain competitive for recruiting new employees of high caliber.

There is a trend away from lockstep salary progress along a single salary maturity curve. Professional employees as well as their supervisors are emphasizing that performance and pay should go hand in hand. The most valuable employees are expected to get the best pay. There was a tendency in many organizations in the past for all employees to get about the same raise and thus remain in a tightly clustered band about the salary maturity curve. Some scientists may have been two or three times as valuable as others in their same age group, but rarely did as much as a factor difference of two exist in salary. It is now becoming more acceptable to have a wide dispersion in salaries with the recognition that those at the bottom and top will be performing vital and necessary jobs, but that their value to the organization may vary greatly and salaries should vary accordingly.

Several managers expressed the opinion that among the worst practices of the past 15 years had been that of giving everyone a raise each year and of giving raises that tended to be about the same amount for everyone. This practice has resulted in a situation in which staff members of ordinary value are paid within a few percent of the top performers and has made it difficult to select professionals rationally for layoff when the salary record appears to indicate little about the relative value of employees.

The modern administration of professional salaries frequently relates salaries to a set of maturity curves each representing the average or target salary as a function of age (or number of years since an academic degree) for a particular rank in merit or performance. The curves may be drawn to correlate with ranking in quartiles, quintiles, octiles, etc., so that an employee's salary may be compared with that for his merit ranking and adjustments made in the salary raises to bring his salary in line with his rank. A typical set of maturity curves is shown in Figure 4 for use with a quartile ranking system. These curves are changed each year in response to the market conditions for professionals, cost of living index, and alterations in the salary policy of the organization. Note that the salaries for the employees of highest merit ranking continue to increase with age, whereas those corresponding to lower merit ranking flatten out after age 40 (about 18 years after the B.S. degree). For this latter group, salary raises would be small or even zero and would consist mainly of cost-of-living increases, whereas the salaries of those in the top octile are dominated by merit raises.

There is a general interest in introducing more spread in professional salaries, and the most common tool has been the use of some method of forced

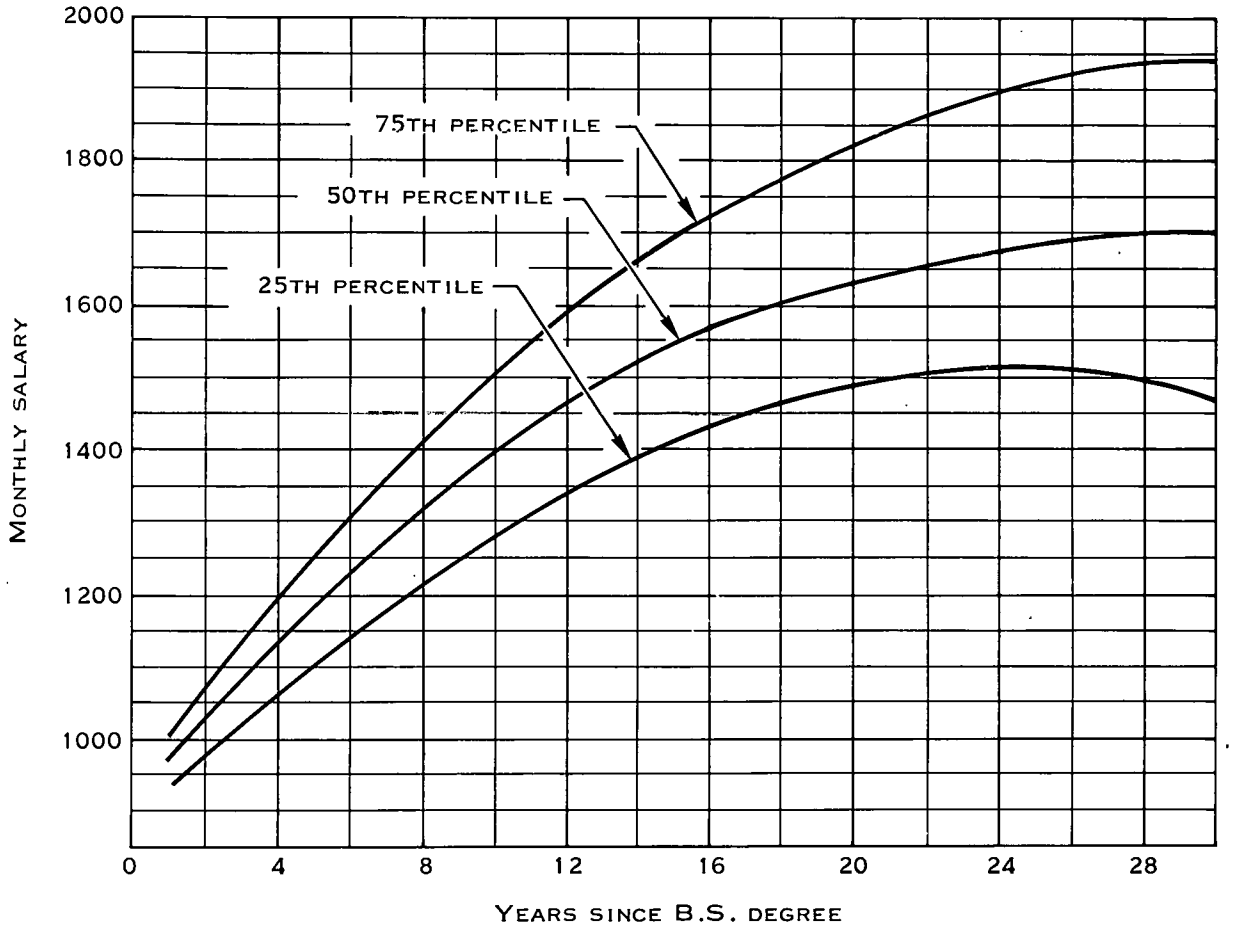

Figure 4. Typical salary maturity curves.

ranking. The ranking processes vary in formality and rigidity. There is a tendency to rank small groups numerically and large groupings by quartiles, quintiles, octiles, etc. The methods vary, but all of them seem to lend confidence to the salary setting process. By the time the ranking of employees is completed in an organization, a great deal of discussion has occurred which quantifies the difference in value of employees. This discussion builds the rationale for the rank position of an employee and provides the basis for a performance interview between the employee and his supervisor.

While in most organizations supervisors do not tell the employee his rank position, there is a growing trend to emphasize to the employee a tight relationship between performance and salary. This relationship frequently has not been made clear to the employee in the past. Performance interviews often studiously avoided relating the salary level to performance level in any objective way. Instead there was an emphasis on how well the employee did his assigned tasks with an avoidance of defining how important those tasks were to the organization. Because of the inadequacy of the interviews, many

professionals have been misled in their own assessment of their importance to the organization.

There is a desire to shift emphasis from giving the annual raise to adjusting the salary level. The term "raise administration" in contrast to "salary administration" was frequently mentioned. "Raise administration" was the easy way out for a busy supervisor in the past. He rewarded value and annual performance by giving a raise that was above or below average as appropriate. This technique presumed that every employee was at the appropriate salary level initially. It also presumed little change in relative value to an organization over a period of time. The introduction of ranking practices into the salary review process has made it much easier to give raises that result in an appropriate salary and in the long run to preserve the desired relationship between performance and salary.

"Raise administration" was also used in an attempt to give each employee an adjustment for the increase in the cost of living. Unfortunately the changes in the cost of living frequently required nearly all the raise fund and little remained for recognition of merit. In many cases employees received cost-of-living raises when their relative value to the organization decreased.

There is a growing recognition that professional salaries should not necessarily increase relentlessly with age. It is unlikely that mere age and time in an organization will ever again result in high salaries. A stronger adherence to the practice of only paying high salaries for high performance will result in early topping out of many employees, and in some few cases it will result in an actual reduction in salary. The effect of a salary reduction may be achieved by withholding raises to reduce the real dollar value of an employee's salary in an inflating economy.

Reappraisal of Methods of Compensation

Some past practices in salary administration are being reexamined for their impact on operating costs and their effect in achieving management's goals.

Fringe benefits are a cost additive to salary proportional to the number of employees. The wisdom of past actions in granting extensive fringe benefits is frequently assessed. The cost of fringe benefits, particularly the cost of insurance, increases independently of company action and is therefore beyond cost control. Employees who are covered 100%, together with their families, no longer exert a restraining influence on increases in cost of insured services. Hindsight indicates that it might have been wiser to provide only a contribution toward fringe benefits so that as the cost of medical service, dental service, visual care, etc., escalated, the employee would share that cost instead of it being borne entirely by the company. An appreciation of the growing dollar cost of fringe benefits is lost on the employee when he receives fully paid insurance coverage from his employer. It is hard at this late stage for employee organizations to accept the concept that the escalating costs of fringe benefits are the same as increased wages in their effect on operating costs. With the achievement of the unions in getting 100% coverage in many forms of insurance as a fringe

benefit, it was inevitable that the same benefits would become available to professionals. It is also unrealistic to expect any backing off from benefits already granted. There is, however, a current move toward combining fringe benefits and raises into one package so that the employee is fully aware of his total gain in effective wages and is also aware that the costs of benefits and salaries represent the real cost of an employee in the budget of the employer. Some organizations go into salary negotiations with a "cafeteria" approach; i.e., the employee can select a combination of wage increase and fringe benefits that does not exceed a fixed total amount. The bookkeeping aspects of the "cafeteria" approach appear formidable, but the introduction of this concept demonstrates the changing emphasis on fringe benefits.

Fringe benefits were intended to help the recruiting of professionals. In retrospect it was observed by some managers that the fringe benefit package was of greatest importance to the average applicant and rarely was a significant factor in acquiring outstanding employees. To satisfy most applicants, fringe benefits and salaries must be adequate, but they are overshadowed in importance by other factors such as the type of work offered, the reputation of the organization and opportunities for increased responsibility.

Organizations that offered fringe benefits with obligations that extended beyond termination of employment have found an unusual burden to bear if they have laid off large numbers of employees. In the aerospace industries some companies offered life insurance, medical insurance, etc., that covered the employee until retirement once he was vested. Where large layoffs occurred a company could be providing some fringe benefits to more ex-employees than to current employees. Such long-term costs have been hard to absorb, particularly for companies that must remain competitive. In retrospect, companies caught in this situation need not have incurred the continuing liability, but could have written convertibility into the insurance policies at their inception.

The raise approval process in organizations varied. In some the final review is performed by the director and his immediate associates. In others a committee of senior professionals perform the review. In still others the review is performed by a salary and wage group who call unusual requests to the director's attention. There seemed to be a desire in several organizations to relieve top management of the bulk of the review process and reserve only the top salaries for their approval. Salary review committees appointed by the director to act in his behalf appeared to be an acceptable substitute for the tedious involvement of the director himself. It appears that the director can achieve his salary objectives through such a committee collaborating with a salary and wage group. An increasing reliance on the advice and research of a salary and wage group has become essential for most organizations.

Reliance on the subjective judgment of a supervisor or of a staff assistant in setting raises and salaries is decreasing in favor of utilizing the supervisory chain in a ranking process that is more likely to quantify relative values objectively. The technique of using ranking in

establishing raises has been discussed earlier in this section.

A stretchout of review periods is replacing the annual review of all professionals as the salary level increases. The review periods can be less frequent with advancing age, but increased age usually is consistent with increased salary level so the criterion is about the same. Two years is usually the maximum period between salary reviews, but the actual granting of raises may be even less frequent in some organizations for senior professionals. Depending upon the salary level the review period can be set at 15, 18, or 21 months. Organizations choose the stretchout period to suit their needs for regulating higher paid employees. This technique can achieve a broad spread among the top salaries in an orderly way. In organizations where stretchout periods were optional and ill-defined, the practice was followed infrequently and non-uniformly.

Limiting Raises in a Tight Economy

At least six of the organizations studied had taken some steps to limit professional raises in 1970 or 1971 to less than that indicated by their salary survey information. No organization proposed to reduce salaries, to eliminate raises altogether, or to reduce the workweek for professionals. There has been a limited use of the "furlough," which is a temporary layoff of less than three months, to tide the organization over until adequate funds are again available. This practice can forestall the loss of critical skills and postpone or avoid permanent layoffs when used in a timely fashion, but it is sometimes a prelude to permanent layoff if funding does not arrive.

At least nine of the organizations had considered the advisability of foregoing or limiting salary raises for professionals and had decided against it. Their reasons were: (a) the inevitability of union pay increases that would alter adversely the relationship between the relative pay of the professionals and the non-professionals; (b) the value of the professional staff had not declined relative to other categories of employees; (c) the current unemployment of scientists and engineers is testimony more to the numbers required rather than to any change in value to an organization; (d) the "image" of the organization as a good employer might be affected, and management did not wish to lose their competitive position when hiring returns to normal.

The organizations that limited raises responded to a need to lower costs or a need to reserve funds to hire a few new employees. One year's experience of limiting raises is not going to change greatly the competitive position of any of the organizations we studied. We see it as a token much overshadowed by other uncertainties in each organization's budget. Some organizations may continue to limit raises as a corrective action to bring staff salaries more in line with their competition as shown in the annual salary surveys.

There is a great willingness for unemployed scientists and engineers to work for much less than current salaries. Applicants have made specific offers to work at two-thirds or one-half the rate they used to earn. New graduates of acceptable competence are willing to accept employment at markedly reduced salaries. The existence of this body of employable

professionals willing to work for less has caused some reassessment of appropriate salary levels. Currently the availability of competent professionals at low salary represents too small a fraction of the professional work force to cause more than serious soul searching and occasional re-evaluation of salary costs. Should any significant numbers of engineers and scientists enter the profession at low salaries, salary surveys would be affected and in turn the current salary trends might change. In that event, organizations would probably follow the indicators and respond to the marketplace by limiting raises accordingly.

LAYOFFS

Background

At the time of our visits to R&D organizations late in 1970 and early in 1971, some of them had gone through their first experience of major layoffs during the preceding year. Some approximate statistics showing the reduction in total employment for organizations that experienced layoffs are given in Table 2. The percentage of professional personnel laid off was generally somewhat smaller than the figures shown for total personnel. Whereas most of the reductions in employment are dominated by the layoffs, normal attrition and some rehiring are also included.

Table 2. Examples of reductions in total employment.

Organization	Approximate number of employees: Recent peak (year)		End of 1970	Percent reduction
North American Rockwell Corporation				
Power Systems Divisions				
Atomics International	3,500		1,100	
Rocketdyne	20,000		3,200	
Support Group	—		1,100	77
Totals	23,500	(1966)	5,400	
Lockheed Missiles & Space Systems, Inc.	30,704	(1963)	20,662	33
TRW, Inc. - Systems Group	16,300	(1970)	12,500	23
Aerospace Corporation	4,343	(1964)	3,332	23
Jet Propulsion Laboratory	4,408	(1967)	4,231	4.0
Battelle Memorial Institute - Columbus	3,000	(1967)	2,577	14
RAND Corporation	1,262	(1969)	1,158	8.2
Naval Ordnance Laboratory	3,158	(1962)	2,806	11
Argonne National Laboratory	5,169	(1968)	4,597	11
Brookhaven National Laboratory	3,450	(1968)	3,000	15
Lawrence Livermore Laboratory	5,877	(1969)	5,489	6.7
Los Alamos Scientific Laboratory	4,634	(1969)	4,308	7.1
Oak Ridge National Laboratory	5,067	(1968)	4,636	8.5
Sandia Laboratories	8,158	(1968)	7,557	7.4

Until about 1968, the aerospace industry, under the impact of NASA and DOD procurement, had expanded steadily for about 10 years—competing furiously for scientific and engineering personnel. In this environment professional employees were in a continual musical chairs game of moving from one organization to another with salaries escalating as the game was played. On the average, professional employees changed employment four times by the time they reached the age of 40 years, and as a consequence many were not vested in any retirement system. The game of musical chairs and escalating salaries was brought to a dramatic conclusion with traumatic overtones by the precipitous cut-backs and consequent layoffs in 1969 and 1970.

One of the common reactions of employees laid off in the recent reductions in force was the question, "Why me?" Hiring practices and the procedures of annual appraisal had not prepared professional employees for the eventuality that they might be chosen for layoff. When major reductions in force became necessary, many who had taken for granted the continued availability of employment were shocked into the realization that employment at ever increasing salaries was not necessarily permanently available. Even those who were retained were deeply affected, and the morale of the remaining staff in many instances was reduced to a low ebb. The subsequent high unemployment rate among previously highly paid scientists and engineers has proved to be not only a tragic experience for those thrown out of work but also a very sobering experience for those who were retained (or in a few instances rehired).

Layoff Selection and Procedure

Most of the organizations included in this study have some form of merit ranking system, which was an important factor in the selection of professional personnel included in reductions in force. However, without exception, considerations other than ranking were also important. In many organizations professional employees of age 50 and above, particularly those of 20 years or more service, were protected as being essentially unemployable in the present market but not yet eligible for retirement. In several instances employees who were not yet fully vested in the retirement system, but would be in 1 or 2 years, were excluded from the RIF; e.g., in those cases in which an employee becomes fully vested on completion of 10 years of service, employees with 8 but less than 10 years of service were given this consideration.

In most organizations seniority is an important factor, at least to the extent that, other factors being equal, the employee of least seniority was included in the RIF. Organizations that had major layoffs found that if seniority were strictly followed, a significant increase in average salary of the remaining staff occurred. The competitive position of an organization bidding for new contracts can be seriously impaired by an overly strict adherence to seniority as the basis of selection of those to be laid off.

Another very important consideration in all cases was identification of skills needed for the continuing program. Because of the many conditions other than merit ranking that must be considered, those employees who are terminated in a

RIF are not simply taken from the bottom of the merit ranking, but are selected from a list containing at least twice as many names as the number to be laid off. In a 10% RIF most will come out of the fourth (bottom) quartile, but some will also come out of the third quartile.

Selection for layoff becomes increasingly difficult as the percentage of personnel to be laid off increases. As is evident from Table 2, we encountered some extreme examples, such as that of the Power Systems Divisions of North American Rockwell. According to the Manager of Compensation and Employee Relations, the divisions made the mistake of adhering to a strict seniority system in the earlier layoffs (1966-67) and failed to keep all levels of management fully aware of long range objectives. This procedure created excessive deficiencies in certain essential categories of professional personnel and could have seriously affected the ability of the organization to function creatively and attract new work assignments. These early errors were corrected by establishing communication with all levels of management and by abandoning seniority as a basis for retention of personnel. Newly hired professional employees of less than 1 year of service and employees in the top 35% in merit ranking without regard to seniority were exempt from layoff as well as those having the specialized skills needed to meet the future objectives of the divisions. As a result of the revised layoff rules, together with some hiring to correct deficiencies created in the early phase, the management believes that the competence of the organization has been preserved and probably improved. However, the average age of the staff and consequently the hard core cost have increased somewhat so that other adjustments may be necessary to remain competitive. We were told that the morale of the staff had been badly affected during the layoff operation, which is not surprising considering the high proportion of employees involved, but the spirit of the organization had recovered remarkably by the time of our visit.

A serious burden on the continuing operation of these divisions is the cost of insurance and other fringe benefits for which the company remains obligated for those terminated in the RIF. Another serious concern is a movement toward the organization of a union of professional personnel, which would seriously limit the options available to management in responding to the necessity of any future reduction in force. The pressure for professional unions is greatest in the aerospace industry of Southern California, and the strongest selling point in favor of organizing is the achievement of portability of retirement rights (see Retirement Systems, page 49).

Layoffs have also occurred as a result of changes in an organization's mission, as has been the case with the Jet Propulsion Laboratory of the California Institute of Technology and The Aerospace Corporation. In the case of JPL, retraining and reassignment of affected personnel reduces the number that need to be terminated. Recently Mr. W. H. Padgam, Assistant Director, Personnel Administration and Supporting Services, has introduced a computerized system for recording and retrieving the capabilities of each JPL employee as an aid in reassignment, advancement or other personnel actions.

The staff at Battelle Memorial Institute, Columbus, has been decreasing for three years, and a further decrease is expected during 1971. The resulting reduction in total staff is expected to be from 3000 to 2475, most of which was achieved through attrition. One major layoff of about 100 employees was required. Selection is mainly on the basis of performance rating; but, in addition, efforts are made to retrain those considered for layoff either for the purpose of reassignment within Battelle or as an aid to those who are laid off in finding new employment.

There has been a great variation in the matter of severance pay for those laid off in reductions in force. In some cases only the three weeks, five weeks, or other normal notice period for termination is covered in termination pay. More generally, however, the practice is to give employees terminated in a RIF severance pay proportional to the period of service—such as 1 week's pay for each year of service up to 26 weeks' pay, as has been the case at LLL. Los Alamos Scientific Laboratory was permitted to be somewhat more generous, giving 1 week's pay per year of service up to 10 years plus 2 weeks' pay per year of service beyond 10 years up to a limit of 52 weeks of severance pay. At Sandia Laboratories the severance pay formula was 1 week's pay per year of service through 7 years, plus 2 weeks' pay per year of service from 8 through 14 years, plus 3 weeks' pay per year of service from 15 through 20 years, with a maximum of 39 weeks except for laid-off employees under 60 whose pension is actuarily reduced. Such an employee receives 3 weeks' pay for each year beyond the 20th, so that with 25 years completed he could receive 54 weeks of severance pay. As at LLL this past year, in which 111 out of a total RIF of 194 were volunteers, reasonably generous severance pay is a great help to management in reaching the quota in the case of a relatively minor reduction in force.

At LLL, as in past years, employees who are laid off may take advantage of the grievance procedure under the rules of the University of California. However, with the change in status of the Laboratory, the Director is now at the same administrative level as the Chancellor of a University campus and therefore reports directly to the President of the (statewide) University. The grievance procedure is now centered within the Laboratory except for final appeal to the President of the University. Previously the Berkeley Chancellor was a step in the LLL grievance sequence. (LASL had previously been allowed to follow the grievance procedure that LLL has now been accorded.)

In only one other organization did we find a more protective grievance procedure, and that was the Naval Ordnance Laboratory, which in common with all Civil Service organizations makes the layoff of an unwanted employee difficult unless the supervisor is able to have the job category abolished. However, in periods of contracting budgets, abolishing some job categories is an accepted practice. Management is then in a position to put pressure on an employee to terminate or retire. A further complication results from the fact that an employee, whose job category has been abolished, can displace or "bump" another employee with less tenure in a similar category. A

recent interpretation of the rules by the Civil Service Commission has made bumping more difficult by requiring that the person demanding reassignment on this basis prove competence to meet the requirements of the job he is seeking. Since proving competence under these circumstances is difficult, abolishing the job of an unwanted employee has become a fairly effective means of ensuring his termination or retirement.

In some other organizations visited we did find less formal in-house grievance procedures in operation. TRW, Lockheed-Sunnyvale and Chevron Research are examples. In many other cases an employee is merely encouraged to appeal informally up the line to the director or president of the organization if he feels he has received unfair treatment. Informal appeals of this type usually do not result in a reversal of supervisory decisions, but in a few instances such reversals have occurred. The availability of an informal grievance procedure has two salutary effects: (1) supervisors are more careful in preparing convincing documentation for their personnel actions, and (2) employees gain a degree of satisfaction from having an accepted channel of communication to top management for registering their complaints.

AGE AS A FEATURE OF THE PROFESSIONAL STAFF

Average Age

The average age of professional personnel of the R&D organizations we visited varied from 35.8 years for the Bell Laboratories to 42.8 years for Oak Ridge National Laboratory. The average ages of professional personnel at some time during 1970 for all the organizations visited are given in Table 3, in which some of the figures are only approximate.

A number of factors influence the average age of the professional personnel in an organization. Some of these factors are: the growth and turnover rates in the organization, the attitude of management regarding productivity versus age, the character of work being done, and recruiting and retirement practices. What constitutes an optimum age distribution for the scientists and engineers of an R&D organization is a more pertinent question, and one on which there is a wide variation of opinion. Part of this variation is entirely understandable in terms of the character of work for which the organization is responsible. Thus we found that some organizations in the aerospace industry, such as the Jet Propulsion Laboratory and The Aerospace Corporation, had to provide effective management of large projects, each of which involved a number of subcontractors. For this type of responsibility men with relatively broad experience and the ability to work effectively with representatives of subcontractors are needed. These requirements have typically been met by hiring older men in their late forties or early fifties. All agree that for the generation of new concepts and introduction of new elements of technology, recent graduates from universities with superior graduate schools are generally more effective. But in most R&D organizations there is a spectrum of needs to be met ranging from basic research through direct supervision to management and from conception to execution of ideas. The more successful organizations of this description, such as

Table 3. Average ages of professional personnel of R&D organizations visited.

Organization	Average age
Bell Laboratories	35.8
TRW, Inc. - Systems Group	37.8
Standard Oil Company of California, Engineering Department	38.0
Battelle Memorial Institute	38.5
Sandia Laboratories	38.6
Lawrence Livermore Laboratory	38.7
Jet Propulsion Laboratory	39.0
Ames Research Center, Moffett Field	39.0
Rocketdyne, North American Rockwell	39.0
RAND Corporation	39.1
Applied Physics Laboratory	39.4
General Electric Company, Research and Development Center	40.3
Brookhaven National Laboratory	40.7
Atomics International, North American Rockwell	41.0
Lockheed Missiles and Space Company	41.4
Chevron Research Company, Standard Oil Company of California	41.5
Los Alamos Scientific Laboratory	41.5
Naval Ordnance Laboratory	41.5
The Aerospace Corporation	41.6
Argonne National Laboratory	42.0
Oak Ridge National Laboratory	42.8

Bell Laboratories, hire predominately new graduates from the best universities, weed out those who fail to meet reasonable standards of productivity during the first three to five years of employment and thus maintain an influx of young graduates. How much influx can be maintained depends partly upon the opportunities for mature staff members to transfer from R&D into management positions in operation or production divisions of the company. This avenue of attrition is an important mechanism for maintaining a relatively low average age in such well established organizations as the General Electric Research and Development Center and the Engineering Department of Standard Oil Company of California.

For those organizations, such as the Lawrence Livermore Laboratory, which do not have convenient opportunities for promotion outside the R&D field, an accumulation of older staff members tends progressively to limit the influx of new employees and block the opportunities of younger employees for upward mobility. Unless measures are taken to avoid this trend, the average age of the laboratory staff will increase at the rate of nearly 1 year/year, and stagnation will set in due to lack of mobility and influx. Bell Laboratories, rather surprisingly, has

had very little success in placing older professional employees in management positions in Western Electric Company (Bell Systems manufacturing subsidiary) or the telephone operating companies. Until about two years ago the average age of Bell Laboratories' professional personnel had been slowly decreasing due to three factors: the practice of hiring graduates as they leave the universities at the B.S., M.S., and Ph.D. levels, critical weeding out at 2 years and 5 years after employment, and a steady growth of about 5%/year, resulting from hiring at the rate of 12%/year and terminations at the rate of 7%/year. Without the growth factor, maintenance of a low average age is much more difficult as has been discussed under Employee Turnover Rate, page 9.

Age Distribution

The history of R&D organizations sometimes results in rather surprising

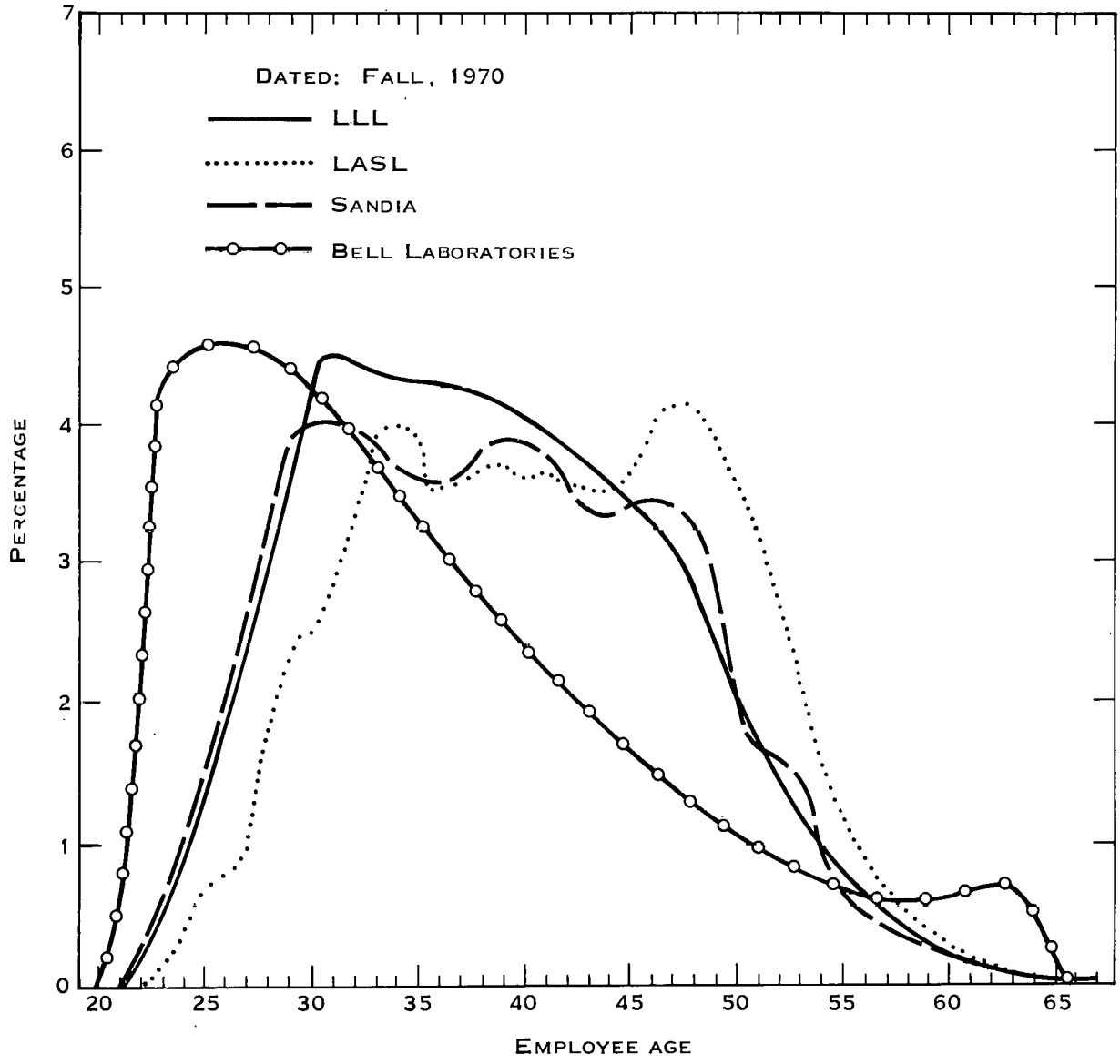

Figure 5. Examples of professional employee age distributions for R&D organizations.

age distributions. RAND Corporation at the time of our visit had a distinctly bi-modal distribution with a peak centering at about age 31, a dip at about age 38 and a second peak at about age 44.

Age distributions for professional personnel of LLL, LASL, Sandia and Bell Laboratories are shown in Figure 5. The LASL curve is very similar to that of LLL except that it is shifted upwards in age by about three years, while the Sandia distribution is almost identical to that of LLL. The distribution curve for the Bell Laboratories with its peak in the low 20's and then falling off with age (except for a slight hump between ages 55 and 65) is exceptional and reflects the emphasis on employment directly out of the universities.

There seems to be nothing unhealthy about the LLL age distribution as it is today. The problem of an excess of professional employees falling in the retirement age bracket (55 to 65) 10 years hence would appear to be a valid concern unless something is done each year to weed out employees of poor performance more diligently than in the past. If a critical review of performance were carried out each year and unsatisfactory employees replaced by new employees with an average age of about 30, the age distribution could perhaps be prevented from simply moving up the age scale at the rate of 1 year/year and could eventually be stabilized at an average age not much greater than it is at present. As is stated elsewhere in this report, personnel actions will have to be carefully considered to avoid antisocial consequences destructive of morale and illegal procedures in violation of Federal laws against discrimination on the basis of age.

Productivity Versus Age

Management attitudes toward aging as a factor influencing the usefulness of professional employees have proved to be varied. Some supervisors, particularly those in the more basic research activities, seem to put great emphasis upon the necessity of maintaining a low average age; however, we have found this emphasis on youth the exception rather than the rule.

In a survey of the opinions of middle management at the Lawrence Livermore Laboratory on practices affecting professional personnel one question asked was whether there is evidence of decreasing performance, productivity and creativity with increasing age. Most respondents stated that they saw no evidence of a pronounced and predictable decrease in productivity with increasing age. A few expressed the belief that there is some evidence of a minor decline in productivity and creativity with age, while others were of the opinion that scientists show more evidence of declining effectiveness than engineers.

In the conclusion to a study of performance as a function of age, A. J. Bernstein, Manager of Professional Personnel at the General Electric Research and Development Center, contends that there is no significant relationship between age and value to the Company. A slight falling off of productivity as measured by patents and publications is counterbalanced by other factors such as judgment, contacts in the Company and influence on other technical employees, which also benefit the Company. Dr. Bernstein firmly believes from his study of the subject that an aging poor performer has in almost all cases been a poor performer from early

in his career and should have been redirected or terminated years earlier by proper action of his supervisor.

There is considerable evidence in support of the belief that, given a stimulating environment conducive to productive effort including opportunities for educational renewal and a diversity of work experience, well motivated scientists and engineers maintain productivity up to the normal retirement age of 65 years and beyond unless failing health becomes an obstacle. However, marginal performers with advancing age are prone to stagnate and become an increasing source of concern to management. There are those who had adequate skills at one time but have allowed them to become obsolete. Finally, supervisors left too long in middle management roles block the avenues for upward mobility of younger employees.

To provide management with a mechanism to deal effectively with the wide range of conditions attending advancing age, considerable flexibility in the age of retirement of professional personnel is needed. Whereas some organizations are moving toward an earlier mandatory retirement age of 62, 60 or even 55 years, the wide variation of effectiveness of individuals with advancing age suggests that provisions for graceful retirement with adequate pensions from age 55 to 67 would be preferable. This topic is discussed in some detail under Retirement Systems, page 49, but as one means of providing openings for new employees, and thus maintaining a relatively low average age, early retirement provisions would be most helpful particularly in a no-growth situation.

A survey of the literature on aging was made which included numerous studies and reports completed in recent years on the subject of productivity and creativity versus chronological age. Conclusions stated in these sources as they may relate to the LLL professional staff in its particular research and development setting have been summarized below. The similarity of conclusions expressed by many of the authors of the material reviewed lends a degree of validity to the following summary remarks:

- In scientific research activities, creative contributions of major significance most generally occur before the age of 40. In developmental scientific activities the majority of more significant contributions occur before the age of 50.
- During a mid-career period, which encompasses the 40's and early 50's, there may be a tendency to "coast." Performance may decline because of a relaxation of zeal or motivation after having achieved. The employee may develop a cautious approach to his work which inhibits inquisitiveness and risk taking.
- After the age of 50 productivity tends to climb. Contributions made during this late period are usually more "productive" than "creative," i.e. a pulling together of one's life work, guidance of younger professional employees, etc. The older employee is generally secure in his position, has fewer family pressures, and is willing to take risks again.
- Engineers tend to improve with age if the work depends on the breadth and depth of the technical experience and not so much on creativeness. However, in a field in which there are rapid changes

improvement may depend more upon learning new technology than upon on-the-job experience.

- Studies reveal that intellectual capability declines little with age within the normal range for retirement.
- The most crucial determinants of productivity and creativity are motivation and opportunity. Those with high motivation and good opportunity for research tend to produce effectively throughout their careers.
- Outstanding performers are those who are highly motivated and evidence a large measure of self-confidence in their work. These people generally do not experience a mid-career sag, provided the working environment is reasonably favorable.
- There is strong evidence that management should stress continuing education, assignment rotation and the like for both engineers and scientists. These "maintenance of vitality measures" should begin to be applied 5 to 10 years after the start of an employee's professional career and continue throughout his working life. These measures minimize the effects of immersion in a specialized area that can fall out of favor causing the value of the professional employee to decline when other technical capabilities become more important.
- Older scientists continue to be useful to the organization in many ways despite their drop in strictly creative scientific achievement. Although they tend to produce a lesser amount of major creative work than their younger counterparts, they do continue to produce over the span of their careers. When the working environment is otherwise favorable, only two conditions can effectively keep older employees from performing worthwhile creative tasks; negative attitudes and failure to try.
- Since a number of different research studies similarly suggest that there is a tendency for a decline in performance during the 40's, it would seem appropriate to consider the advantages of conducting a "mid-career" review with each employee. This may be the most important time for management to assist the employee with a planned program of renewal through continuing education, sabbatical leaves, assignment rotation and other revitalization techniques including, perhaps, a thorough discussion of the appropriateness of a career change.

A relatively large body of selected literature was studied in preparation for the discussion and documentation of this subject. Only a limited amount of the literature reviewed appears as referenced material since much of the data studied were not related to professional employees in strictly R&D activities.

Source Material

Bercnson, C., "Should Old Engineers Just Fade Away?", Chemical Engineering, September 12 (1966).

Lehman, H., Age and Achievement, Princeton University Press, Princeton, New Jersey (1953).

Oberg, W., "Age and Achievement and the Technical Man," Personnel Psychology, V. 13, p. 245-49 (1960).

Pelz, D. C. and Andrews, F. M., Scientists in Organizations, John Wiley & Sons, Inc. (1966).

Raudsepp, E., "Those Older Men are Valuable," Hydrocarbon Processing, July (1969).

Schaie, K. W., "Rigidity-Flexibility and Intelligence: A Cross-Sectional Study of

the Adult Life Span from 20 to 70 Years," Psychological Monographs, No. 9 (Whole No.462), LXXII (1958).

Taylor, J.W., "Age and Creativity," Management Review, February (1969).

Terman, L., Lecture at U. C. - Berkeley (1954).

Yang, C., "Yang on Yang," Newsweek, January 22 (1962).

"Selection on the Basis of Individual Capacity," Labour Gazette, p. 644-45, September (1970).

RETIREMENT SYSTEMS

Introduction

Early retirement has been considered, and in many organizations used, as one element in personnel policy to improve the quality of the professional staff. There are several reasons for considering involuntary and encouraging voluntary early retirement. Some of these are:

- Obsolescence due to failure to keep up with advancing knowledge or technology.
- Positions of administrative responsibility held too long by aging incumbents who block the progress of younger employees.
- Need of openings for employment of applicants who are especially talented or have specialized knowledge.

The two retirement systems (UCRS and PERS)* under which LLL operates permit retirement at age 55 and require retirement not later than age 67. However, the annuity versus age drops off so rapidly for retirement before age 65 on UCRS and before age 63 on the recently revised PERS schedule that early retirement is an unattractive option. This feature of these systems arises from the fact that they are both actuarial in structure over the steeply rising portion of the curves, the form of which can be very simply derived. An employee puts into the reserve an amount proportional to his salary, and this amount is duplicated (approximately) by the University, so at the time of retirement the accumulated reserve (plus interest) is proportional to r(R - S), where r is a rate factor, R is the age at retirement and S is the age at the time of employment. This sum of money will be paid out as an annuity for a period of years equal (on the average) to the employee's life expectancy E at the time of retirement. E can be found in standard tables of vital statistics. The annuity A, therefore is given by

$$A = r(R - S)/E$$

If we put numbers into this formula we obtain curves which are very nearly proportional to the steeply rising portions of the annuity-factor curves for UCRS and PERS. The above simplified formula understates the annuity somewhat because it does not include interest paid on the remaining principal during the pay-out period. It is surprising that despite this omission and that death, disability, and survivor benefits are also covered by these systems, the annuity versus retirement age curves fit the simply derived formula as closely as they do.

When the employer provides a substantial portion of the retirement fund there is no obligation to the employees

*Those employed beginning October 1, 1961, are members of UCRS, the University of California Retirement System under the Board of Regents of the University; those employed prior to that date are members of PERS, the Public (California State) Employees' Retirement System controlled by the California Legislature.

that the retirement annuities follow an ideal actuarial schedule. Even the UCRS and PERS schedules break away from the ideal actuarial form, characterized by curves of ever increasing slope, to straight lines at age 65 and 63 respectively. These departures tacitly recognize that there are considerations other than that of matching the ideal actuarial curve. One can argue with considerable validity that on retirement the employee should receive an annuity which is at least as large as an actuarial return on his own contribution (plus interest) to the plan. No such argument need be applied to the portion of the retirement annuity that results from the employer's contribution.

Several proposals have been made for the modification of UCRS to make early retirement more palatable. As an example, D. E. Feller of the University of California School of Law at Berkeley proposes augmenting the present retirement system with a special fund which would strongly encourage retirement at age 62 by making the annuity factor essentially constant from age 62 on. He would add to the present retirement factors the increments given in Table 4. For an employee, entering the system at age 32 and retiring at age 62, the total retirement factor would then be 75.9%, and would remain the same until age 67. For other ages of entry into the system the retirement factor would vary slightly from age 62 to age 67, but would be relatively flat. He also points out that treated as a separate fund, the increment of cost would be largely, if not entirely, made up by the reduced salaries paid young replacements. Professor Feller suggests that an appropriate procedure for providing the early retirement benefits would be for the Board of Regents to set up a fund entirely separate from the Retirement System out of which the supplemental annuity based upon the added factors in the above table would be paid and charged as an item in operating cost. By following this procedure the early retirement cost could be more readily identified and compared with savings in salary effected by the employment of young replacements for those retired under the early retirement scheme. A frequent criticism of Prof. Feller's and similar schemes is that the added funds are spent in rewarding the less able members of the staff.

Whether a modification of UCRS as radical as that proposed by Professor

Table 4. Modified annuity factors for UCRS as proposed by D. E. Feller. (Example shown is for employees who started at age 32.)

Retirement age	Added factor (%)	Present factor (%)	Total factor (%)	Retirement pay (%)	
				Present	Proposed
62	0.68	1.85	2.53	55.5	75.9
63	0.50	1.95	2.45	60.6	75.9
64	0.31	2.06	2.37	65.9	75.9
65	0.13	2.17	2.30	71.6	75.9
66	0.06	2.17	2.23	73.8	75.9
67	0	2.17	2.17	75.9	75.9

Feller will be adopted by the Board of Regents seems doubtful. However, some modification of UCRS more favorable to early retirement seems inevitable within a year or two. Opinions within the faculty and the University administration favor such action. When action is taken, the change in UCRS may very well be somewhat more drastic than that recently adopted for PERS.

Comparison of Retirement Systems

Retirement plans which are entirely or mostly financed by the employer may be structured to encourage early retirement and have no resemblance to the actuarial form. However, many of the retirement plans we have seen, for which the increase in annuity is small with increasing age, do not really provide much incentive for early retirement because the annuity is too small in any case. A few examples will illustrate the range of benefits offered.

Standard Oil Company of California (including Chevron Research) pays the entire cost of the retirement plan, but employees may provide themselves with additional pensions by contributing 2% of their salaries. Mandatory retirement age is 65, at which age an employee receives his maximum retirement income, calculated as follows:

(1) For service to July 1, 1971, the greater of:
   (a) 1.4% of his maximum 5 years' average salary in excess of $600 multiplied by his years of service, up to 40 years.

or (b) 1-1/3% of his career earnings in excess of $600 per year, plus 2/3% of his maximum 5 years' average salary in excess of $600 multiplied by his years of service, up to 40 years.

(2) For service after June 30, 1971: 1.55% of his maximum 5 years' average salary multipled by his years of service, minus 1.25% of his social security benefit multiplied by his years of service after June 30, 1971.

The maximum retirement annuity for the assumptions outlined in Table 7 is 62% of the applicable salary. Retirement is possible any time after 25 years of service. But the annuity is then reduced from the maximum retirement income at the rate of 7% per year from 62 to 55 if the employee has at least 35 years of service, otherwise at the rate of 3% per year from 65 to 60, then 7% per year from 60 to 55. Thus, an employee retiring at age 55 receives 50% of the retirement income of an employee with the same period of service retiring at age 65—or about 31% of his applicable salary. Although not quite as steep a dependence on age of retirement as the UCRS-PERS systems, Standard Oil offers no great incentive for early retirement, although the company has induced a few employees to retire early by special severance pay.

As part of its retirement income package, Standard Oil Company of California offers a profit sharing plan, which is invested in company stock, to those employees with five or more years of service. The company has paid approximately $1.50 for each $1 contributed by eligible employees. The amount which the company contributes to the plan each quarter is determined by the company's profits during the previous quarter. For those employees who take full advantage of this plan (97% of

all eligible employees), the total retirement income at age 65 from this plan, together with their annuity plan income and social security, is as follows:

Top Management—70-75% of maximum 5 years' average salary

Middle Management—75-80% of maximum five years' average salary

Union Employee—80-85% of maximum 5 years' average salary

Sandia presents an interesting case because management has initiated a significant change in the retirement schedule to encourage early retirement and has additional changes under consideration. In addition to their contributions to social security, employees contribute 2% of their first $4500 and 5% of salary above $4500 annually. The basic fixed annuity is computed by the following formula based upon the career average salary.

Annuity = (0.01 × $3000 + 0.02
× amount over $3000)*
× (years of participation in the plan)

An employee may elect to have 25 or 50% of his accrued annuity derived from this formula converted to a variable annuity, the value of which fluctuates with the value of a diversified equity portfolio. Although it recognizes the significantly increased expense involved, management also has under consideration applying the same formula to the "high 3" or "high 5" average salary, which would yield a much more attractive pension than the career average salary. The mandatory retirement age is 65, for which the formula applies directly. Employees may retire at their option as early as age 60, but they can retire earlier down to age 55 only with management approval. Until recently, for retirement in advance of age 65, the annuity was reduced by an actuarial factor, which was 0.67 for retirement at age 60 and 0.49 for retirement at age 55. This actuarial reduction resulted in the same rapid reduction of annuity with decreasing retirement age as is typical of the UCRS and PERS systems in use at LLL, so that early retirement was most unattractive. To eliminate the steep dependence on retirement age, Sandia management has taken two steps. About three years ago Sandia obtained AEC approval for improving annuities for those retiring in the age bracket 60 to 65 by retaining the formula retirement annuity given above but reducing the annuity factor for early retirement by 1.2%/year, so that the annuity factor for retirement at age 60 became 94% instead of 67% of the formula annuity. More recently Sandia has had under active consideration the extension of the straight line dependence on down to age 55 at this same slope, so that the annuity factor for retirement at age 55 would then become 88% instead of 49% of the formula annuity.

If the changes now under consideration are instituted, they would result in a relatively flat dependence of annuity on retirement age, which makes early retirement much more attractive. However, until these or comparable changes are made the basic flaw in the system is the relatively small total annuity resulting from the above formula, which turns out to be at best only about one-half that provided by UCRS or PERS. Sandia management has already taken steps to improve the retirement package by introducing a voluntary savings plan for salaried employees,

*Based on career average salary.

2

in which the company contributes half as much as the employee up to the maximum of 3% by the company to 6% by the employee, beyond which the employee can invest up to a maximum of 10% of his salary. But the company maximum remains 3% and is classified as deferred income. Since Sandia employees are also eligible for social security, for which the company and the employee each currently pay $405.60/year for those with salaries of $7800 or more, the company now has a combination of elements which will provide fairly generous total retirement pay for those who contribute at the maximum rate to the savings plan with benefits which make early retirement down to age 60 a reasonably acceptable choice. During recent reductions in force at Sandia, voluntary early retirements have contributed significantly. Added features of the plan which encourage voluntary early retirement have been (1) the addition of $30 a year to the annuity for each year of participation in the plan for those retiring in the age range from 60 to 65, payable until the employee reaches age 65, e.g., an additional $900 per year to age 65 for an employee retiring at age 60 with 30 years of plan participation, and (2) a lump sum severance pay of 39 weeks' pay for 20 years of service plus 3 weeks' pay for each year of service over 20 years. For an employee age 60 or over, payment is limited to 39 weeks of pay since he is eligible for a non-actuarily reduced annuity.

RAND Corporation is one of several organizations visited which participate in retirement plans through the Teachers Insurance and Annuity Association (TIAA) and its affiliate, the College Retirement Equities Fund (CREF). This is the organization under which many private universities and independent research institutes provide retirement, disability and death benefits. TIAA is a nonprofit insurance and fixed annuity company founded in 1918 by the Carnegie Foundation for the Advancement of Teaching. CREF is a separate, companion, nonprofit corporation established in 1952 to provide lifetime variable annuity incomes based on the performance of a broadly diversified common stock fund, so that the amount of the annuities paid at any time depends upon the market value of the fund's security portfolio. The advantage of CREF to a participant is that the value of the diversified portfolio shares in the long-time appreciation of the common stock averages and therefore provides a partial hedge against inflation. As is the case with most organizations which participate in TIAA-CREF, RAND permits its employees to specify the proportion of their annuities invested in the fixed annuity of TIAA and the variable annuity of CREF; they may designate that up to 100% of the premium be placed with CREF with any remainder going into TIAA. Participants at RAND contribute 4% of salaries, less their social security tax ($405.60 for the year in 1971 for those earning $7800 or more) and RAND contributes to the fund the amounts given in the following listing, less the company's equal social security tax for the participants.

Participants' age	RAND'S contribution (percent of earnings)
29 and under	4
30 through 34	8
35 through 44	11
45 through 49	14
50 to 65	17

Employees are fully vested in the retirement plan after six years of service, two-thirds vested after five years and one-third vested after four years.

As is the case with all TIAA-CREF retirement plans, the RAND plan is actuarial in form and is therefore disadvantageous for early retirement. Most TIAA-CREF plans have flat contributions regardless of age; however, RAND'S plan was designed to approximate a flat benefit through increased contribution at increased age. Normal retirement age is 65, but employees may retire at any time and receive whatever annuity results from actuarial accounting. Because input into the plan by RAND is initially very small and does not become anywhere near adequate until the employee reaches age 45, the fund available for early retirement is even less than that for UCRS-PERS for which input from the beginning totals about 17% of salary (employee plus University contributions). The present shortcomings of the RAND plan for early retirement are in part due to the fact that it has been in effect only since 1957.

The inadequacy of the RAND retirement system for the encouragement of early retirement was publicized by Albert Latter, who with D. Holliday and A. Smith wrote a report entitled "A New Retirement Plan for RAND Research Workers," in which supplementary annuities and a mandatory retirement age of 55 are advocated. Their contention is that since each person who is retired at age 55 at a salary typical of senior professional employees (which at RAND is appreciably higher than at LLL) is replaced by a new employee averaging about 30 years of age and therefore at a much lower salary, the cost of the supplementary annuities would be completely or mostly compensated by this difference in salary between the retired employee and his young replacement.

RAND management has recognized the inadequacy of the present retirement plan and has considered an alternative plan by which RAND would continue to pay into the plan for an employee who retires at age 55 the same amount it would have paid in had the employee continued at work to age 65. Table 5 shows for a typical RAND high-salary history the retirement pay under the present system, that proposed by a consulting actuary and that proposed by Latter. For comparison, the UCRS retirement pay is given even though the assumed salary is well above typical Laboratory salaries. The figures in the table show that RAND's present retirement plan results in an even steeper dependence on age than that of UCRS, that the proposal of RAND's consulting actuary is much less dependent on age and reasonably generous, whereas that of Latter et al., is very generous indeed.

The contention that the supplementary annuities required to implement Al Latter's plan would be offset by the lower salaries of the young replacements has been disputed. The feature of Latter's plan which does not correspond with what is wanted at LLL is the inflexible mandatory retirement age of 55. A more flexible system, which encourages but does not require such an early retirement, has been the goal unanimously approved by the LLL Associate Directors, department heads and division leaders.

The U. S. Civil Service Retirement System, as represented by the Naval Ordnance Laboratory, is in many respects

Table 5. Comparison of retirement proposals at RAND for employees hired at age 30.

Age	30	55	65
Salary ($K/yr)	14.0	34.0	44.0
Present plan ($K/yr)		12.0[a]	46.0[a]
Actuary's proposal ($K/yr)		15.0	23.0
Latter's proposal ($K/yr)		28.0	—
UCRS ($K/yr)		10.4	33.5

[a]These figures are computed on the assumption that RAND had participated in TIAA-CREF beginning 25 years ago. Actual retirement pay under the present plan would be appreciably less because of the comparatively short time during which the CREF variable annuity fund has been accumulating.

Table 6. UCRS and civil service monthly annuities based on $24,000 "high 3" average salary.

Age at retirement	Years of service	Starting age	Monthly annuity ($)	
			UCRS	Civil service
70	40			1,525
65	35		1,519	1,325
60	30	30	1,002	1,125
55	25		625	925[a]
70	35			1,325
65	30		1,302	1,125
60	25	35	835	925
55	20		500	725[a]
70	30			1,125
65	25		1,085	925
60	20	40	668	725
55	15		375	—[b]

[a]Possible only if job is abolished; otherwise, minimum service years for retirement at age 55 is 30.

[b]Not possible to retire at age 55 with only 15 years of service.

the most satisfactory we have seen in terms of the potential annuities paid and in terms of dependence of annuity on retirement age. Employees pay 7% of their salaries into the fund, and the government contributes the remainder. Mandatory retirement age is 70. Optional retirement is available to those of age 62 with 5 years of service, 60 with 20 years of service and 55 with 30 years of service. A recently added option is retirement at age 55 with 20 years of service if one's job is abolished.

The basic annuity is defined by the following sum:

(1) 1.5% of the "high 3" average salary multiplied by the years of service up to 5.
(2) 1.75% of the "high 3" average salary multiplied by the years of service between 5 and 10.
(3) 2% of the "high 3" average salary multiplied by the years of service over 10.

Civil service employees are not eligible for social security.

It is significant that for all categories shown in Table 6, the civil service retirement pay is greater than UCRS at age 60 and less at age 65, and for retirement at age 55 (where permissible), civil service pension is about 50% greater than that for UCRS. The other striking difference is that the civil service pension depends upon years of service only and not specifically on the age of retirement, whereas under UCRS an employee with a "high 3" salary of $24,000/year and 25 years of service receives $625/month retiring at age 55, $835/month retiring at age 60 and $1085 retiring at age 65. The dependence on age is, of course, a direct reflection of the actuarial purity of UCRS. The civil service retirement system is not only reasonably generous, but is also relatively weakly dependent on age (2%/year), so that early retirement is a much more acceptable choice than for any of the other systems we have studied; it is particularly generous for those who enter the system at an early age, such as 30 or less. Last year 102 people retired at NOL, nearly one-third of those eligible for retirement.

The retirement annuities available at various ages for a number of the organizations visited are given in Table 7 for an employee whose assumed salary history is given in the upper section of the table.

Analysis and Modifications Favoring Early Retirement

Recent layoffs of professional personnel, particularly in the aerospace industry, have jarred both employees and managements into the realization that retirement systems generally work well only if there is a high degree of security in employment. Retirement systems seem to have been designed with the expectation that the typical employee will join the organization at the age of about 30 and remain employed in the same organization until retirement at age 65. A career interrupted by a layoff, say at age 45, with subsequent employment by another organization, will in all cases studied result in very low (if any) retirement annuity. With a few exceptions—such as those organizations which participate in TIAA-CREF (the system participated in by many private universities)—the retirement fund accrual built up in employment in an organization is not transferable to the retirement fund of another organization in the case of change of employment. The almost total lack of "portability" of retirement accruals stands out as one of the most inequitable features of retirement systems. Whether the recent flood of layoffs, which have made the inequity so obvious, will result in cooperation between retirement funds in establishing portability is not yet evident. Portability exists between organizations which participate in TIAA-CREF, between the University of California and other public agencies

participating in the California Employees' Retirement System and between the civil service organizations of the Federal Government. However, for many professionals laid off during the past two years there is no recourse from the loss of retirement rights except for their social security accumulations, and for many it is now too late to build up an acceptable retirement annuity even if new employment can be found.

The shock effect of the loss of retirement rights has been a significant stimulus to the movement toward the organization of unions for professional personnel, a movement which is most evident in the Los Angeles area. Another possibility is that social security will eventually be

Table 7. Comparison between several retirement systems.

(a) Assumed salary history

Age	Salary ($/yr)	Age	Salary ($/yr)	Career average	"High 3" average	"High 5" average
30	7,000	55	20,000	12,900	19,400	18,500
35	9,000	60	22,000	14,250	21,600	21,000
40	11,000	65	24,000	15,700	23,600	23,000
45	14,000	67	25,000	16,200	24,500	24,060
50	17,000	70	25,000	16,850	25,000	24,900

(b) Retirement annuities ($/yr) for assumed salary history

Retirement age		55	60	65	67	70	
LLL (C)	UCRS	6,060	10,800	17,950	19,600	—	(1)
	New PERS	6,870	12,960	19,970	21,900	—	(1)
Civil Service (NOL) (C)		9,000	12,160	15,600	17,200	19,062	
Standard Oil of California (NC)		3,540	8,110	12,280	—	—	(2)(3)
Sandia Laboratories (C)		2,720	6,951	9,656	—	—	(1)(3)(4)(5)
General Electric Co. (NC)		—	11,400	14,600	—	—	(3)
Bell Laboratories (NC)		4,625[a]	6,300	8,050	—	—	(1)(3)
Battelle Memorial Institute (NC)		3,103	5,943	11,437	—	—	(1)(3)
Oak Ridge National Lab. (NC)		3,570	6,930	8,850	—	—	(3)
Jet Propulsion Laboratory (NC)		2,516	4,608	8,640	—	—	(1)(3)(4)
Applied Physics Laboratory (C)		7,600	11,200	16,200	—	—	(1)(3)(4)

[a]With special approval only.

(1) Plus optional deferred income savings plan.
(2) Plus optional stock purchase plan.
(3) Plus social security, which currently amounts to a maximum of about $2,556/year for retirement at age 65 for a single man and $3,840/year for a married man with dependent wife of the same age.
(4) Optional portion of contributions assigned to variable annuity.
(5) Additional $30 per year × years of participation in the plan for those retiring in the range 60 to 65 payable until the employee reaches age 65. Significant changes are under consideration.
(C) Contributory - employees share the cost.
(NC) Non-contributory - paid for entirely by the employer.

expanded to meet more adequately the needs of professional and administrative personnel. In either case the responsibility for defining retirement privileges would to some extent be taken out of the control of management, but the problem of portability would be solved.

Table 7 illustrates the wide range of retirement annuities offered professional employees by different organizations. The principal complaint of the managements of many of the organizations we visited was that the existing retirement systems are inadequate in terms of the annuities available even for retirement at age 65. When this is the case, changes in the annuity-versus-age schedule do very little toward encouraging early retirement because in any case the retirement pay is so low that employees will put off retirement as long as possible. To make early retirement reasonably acceptable, the basic annuity for retirement at age 65 and 35 years of service must be two-thirds or more of the "average high 3" or "average high 5" salary, and the dependence of retirement factor on age not greater than about 2.5%/year. At age 55 an employee could then retire somewhat gracefully with a retirement annuity of about 42% of his applicable salary, and at age 60 with about 54% of his applicable salary. These percentages are more favorable if put in terms of take-home pay because of the substantial reduction in income taxes. Other benefits such as severance pay and inducements designed to encourage early retirement also contribute significantly.

In considering early retirement we have primarily in mind those employees whose salaries will have leveled off with very small to zero raises for the previous several years. This should in the future be typical of professional employees of advanced age who are low ranked. Top ranked employees are highly motivated and continue to be productive, so that their salaries continue to increase significantly. These highly productive people are not likely to choose early retirement nor to be encouraged by management to do so. For these employees, UCRS and PERS are as good as any retirement system we have seen and far better than most, with retirement factors typically in the range 60 to 75% of the applicable salary.

The problem therefore, is to find a modification of UCRS and PERS, probably in the form of a supplemental annuity, which combined with the regular annuity will allow graceful retirement down to age 55. One possibility is to supplement the UCRS and PERS retirement factors as illustrated in Figure 6, shown for an employee entering employment at age 30. In both cases the straight line portions of the curves are extended from age 65 back to age 55 for UCRS and from 63 back to 55 for PERS. The proposal is for LLL to purchase annuities from operating funds for those retiring prior to age 65 for UCRS and age 63 for PERS to bring total retirement pay up to the straight lines shown in the graph. To carry on with the comparisons shown in Table 7, Table 8 repeats the figures previously given for UCRS and PERS and also shows the additional annuities required under the proposed supplemental plan for the particular salary history adopted for Table 7.

The salary-history pattern chosen for Table 7 and Table 8 represents that of an employee who continues to receive modest

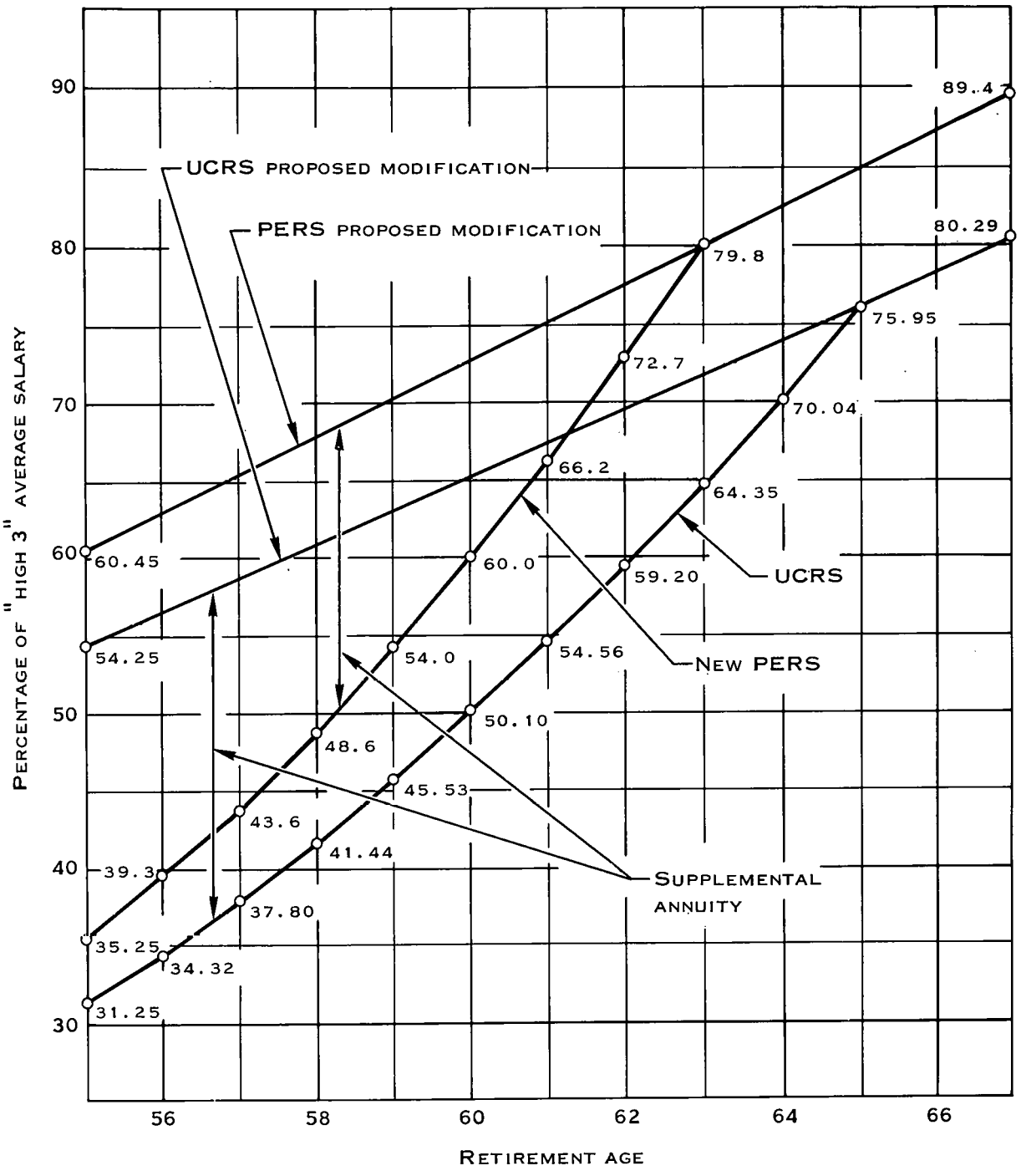

Figure 6. Annuities for employees starting at age 30 for UCRS and new PERS.

salary raises up to his mandatory retirement age. For such a person, early retirement, even with the supplement, is not an attractive choice because his retirement annuity is increasing due to two factors—his annual salary increase and his added years of service. For an employee who has peaked out in salary, however, the increase in retirement pay is only 2.17%/year for UCRS and 2.42%/year for the new PERS. Indeed, if management wants to encourage an employee

Table 8. Early retirement annuities ($/yr)—a proposed supplement to UCRS and PERS.

Retirement age	55	60	63	65	67
UCRS	6,060	10,800	14,700	17,950	19,600
Supplement	4,440	3,200	1,600	—	—
Total	10,500	14,000	16,300	17,950	19,600
PERS (New)	6,870	12,950	18,190	19,970	21,900
Supplement	4,780	2,640	—	—	—
Total	11,650	15,600	18,190	19,970	21,900

to retire early because of lack of productivity, the most effective action to take, assuming the supplementary annuity were adopted, would be to inform him that his salary has reached its peak considering his value to the Laboratory and he should not expect significant salary raises for the future. However, under UCRS up to age 65 and PERS up to age 63, the annuity factor increases so rapidly with age that even the prospects of a zero raise would still not make the choice of early retirement attractive. If selective early retirement is to be an important element in maintaining a professional staff of high productivity at Livermore, some modification or supplement to the present UCRS and PERS such as that described above will be needed. The cost of such a supplement would be considerable and only partly offset by the fact that for each senior employee retired with a supplementary annuity a much younger person at considerably lower salary will be employed to take his place. The benefit in terms of new technology gained and of opportunities for advancement of younger employees may more than justify the added cost.

Employee Evaluation Practices

Every organization has procedures for assessing the quality and competency of its staff. Methods vary from informal to highly formal and may involve the use of written performance appraisals, development plans, ranking systems, skills inventory programs or other forms of measuring staff quality. Gauging staff quality is typically a practice wherein modification and change frequently occur generally for one of two reasons; either the existing method is not accomplishing its intended purpose or the need for improvements becomes self-evident.

In our survey, we found a wide variety of practices (as well as opinions) relative to evaluative techniques, some of which are described in this section of our report.

APPRAISAL SYSTEMS

Written Performance Appraisals

LLL and 10 of the 18 organizations surveyed require that a written appraisal of the performance of every professional

employee be completed on at least an annual basis. Three organizations have "optional" policies wherein the decision to complete written appraisals is made by the management of individual operating units within these organizations. The remaining five surveyed organizations have no written appraisal programs although some form of performance documentation may be practiced by groups within these organizations. Only Los Alamos Scientific Laboratory of these last five has a formal grievance procedure. If a grievance should arise which involves a question of performance, the LASL management relies largely on the record of salary progression as being indicative of the employee's performance. At LLL the written appraisals prove to be important documentation in grievance cases, but if poorly done can be detrimental to the procedure.

Brookhaven National Laboratory and Battelle Memorial Institute also do not have written appraisal or ranking programs. Unlike Los Alamos, they do not have to be concerned about formal grievance action by professionals. The criterion of employee performance at these two organizations is based primarily on supervisory judgment or on the collective evaluation of a number of superiors familiar with the employee's work. In the case of Brookhaven some promotions in rank also require evaluation of scientific output by outside experts.

Bell and Sandia Laboratories have used written appraisals in the past but both discarded them in favor of formal ranking systems with good results.

Appraisal Format

Most of the participants who have written appraisal programs favor a narrative style format. One organization uses a check list style. Others use a combination of these two methods. One participant, Jet Propulsion Laboratory, has no set format, and each division in the organization may use a different approach in developing a format tailored to fit its own situation. This is quite similar to current LLL practice. Most organizations had tried a variety of styles in evolving their current formats. Most would agree that future changes are likely.

Goal Setting

Of the 10 organizations using written appraisals, 6 incorporate a goal-setting approach in their evaluation procedure. Accomplishments during the year are compared with job goals that were formulated at the beginning (or during) the period being reviewed. Typically, goals for the forthcoming year are included in a separate section of the appraisal form. One shortcoming of the goal-setting technique is that it may not indicate the relative importance of the job being done, with the result that the employee may be misled. When properly administered, however, the goal-setting method is stimulating both to the employee and his supervisor and leads to a better mutual understanding than other less specific appraisal techniques.

Positive Comments Only

The Aerospace Corporation which uses a performance documentation form, and

Oak Ridge National Laboratory follow a practice of including only positive comments in the appraisal form. Both organizations allow the employee to see his own appraisal. During our studies we frequently discussed the relative advantages and disadvantages of including "positive only" comments in appraisals. Those who favor the "positive only" approach believe that criticism does not promote enthusiasm on the part of the employee. We reviewed a large quantity of literature on this subject and found differences of opinion even among the "experts."

Derogatory Comments Recorded Separately

At The Aerospace Corporation and Oak Ridge National Laboratory derogatory comments are recorded separately from the appraisal form. This documentation is not filed with the appraisal. (There is no formal grievance procedure for professionals at either organization.) At TRW, Inc. - Systems Group negative comments are recorded on the appraisal form which is shown to the employee. However, additional negative comments may be recorded separately without the employee's knowledge and can be used as a matter of record at some future date. TRW has a grievance procedure, but until the recent cut backs, professional employees tended not to use it. (We were told that the TRW management was in the process of reviewing their performance documentation practices as a result of increased grievance procedure activity on the part of professional employees.)

Employee Access to Appraisal Form

As a uniform practice in six of the surveyed organizations, the appraisal is shown to the employee. The other participants using the written appraisal system give their supervisory staff the option of deciding whether or not the employee will be shown the evaluation. The option usually practiced is to show the appraisal to the employee. However, if there is a formal grievance procedure and there are negative comments on the appraisal, the employee is allowed to see his evaluation in every instance.

Lockheed Missiles and Space Company is the only participant that gives each employee a copy of his appraisal. Jet Propulsion Laboratory supervisors may give each employee a copy of his appraisal on an optional basis. Individual supervisors may distribute copies if they so desire or, in certain instances, the employee may be given a copy of his appraisal on request.

Two organizations, Atomics International and Rocketdyne divisions of North American Rockwell, require every employee to sign his appraisal form attesting to the fact that he has seen it. At Jet Propulsion Laboratory and TRW, the appraisal is shown to the employee at the supervisor's option. The employee who does read his appraisal is expected (but not required) to sign it as confirmation that he has read and understood the appraisal—not that he necessarily agrees with the contents.

Performance Interview

In all but one of the organizations visited supervisors are required to have

a performance interview with the employee after a performance appraisal is written. Six organizations adhere to a practice of documenting what is discussed during the performance interview. At all six there is a conviction that it is as important to document what is said during an interview as it is to conduct the appraisal itself.

Management Review of Appraisals

We identified at least five participants that have some procedural method for insuring a management check of appraisals completed by lower levels of supervision. In most cases, one to two levels of higher supervision check appraisals prior to the scheduling of interviews. At Chevron Research Company, the head of each of its eight departments reviews the written appraisal of each of his professionals to insure some degree of uniformity in the administration of the appraisal program. The President reviews the appraisals of the 12 employees who report to him, plus those of 50 to 60 outstanding employees who are judged to have top management potential. The President also meets with department heads annually to assign each professional employee to a quintile ranking for the purpose of salary administration. Appraisal, while related to ranking, is done separately and is intended to assist each employee in recognizing his specific strengths and weaknesses, leading to emphasis on his strengths and correction of his weaknesses. Ranking is used to determine the proper pay level.

Management Philosophy Regarding Appraisals

Most (but not all) of the 10 participants using written appraisals attach considerable importance to this phase of management responsibility. Following our discussions at these organizations however, we came away with the distinct impression that in at least a few cases, what was stated as administrative policy was not being practiced. At one company an official outlined corporate policy on the subject, stating that written appraisals were needed to insure uniform documentation of performance. But several of the supervisory staff stated that they didn't feel the appraisal program was very effective because not much effort was being put into the over-all administration of the plan. At still another company, some managers were unhappy with the existing program, but since no effort was being made to improve the system they would continue to comply with the administrative requirements of the current appraisal policy.

For a variety of reasons, eight of the organizations surveyed do not require written appraisals. We heard the opinion expressed that written appraisals are a waste of time and do not always adequately assess the quality and competence of the staff. Other evaluative methods such as discussion of each employee by supervisors with higher management were judged to be more effective in providing management with a meaningful appraisal of the relative value of individual members of the staff.

Career Development Plans

One of the most typical questions a personnel man or manager will ask an applicant or employee is: "What would you like to be doing five years from now?" This is often a difficult question to answer,

particularly for the person who has given little or no thought to the idea of planning a course of self-development in order to achieve a desired goal. And this is the very reason the question is asked. A manager can plan an employee's development, but it is much more desirable (and effective) if the employee participates in the planning and agrees to a future course of action.

Most organizations have procedures which provide the employee and his supervisor an opportunity to agree on future work assignments which are in the best interests of the employee and organization. Generally, the opportunity comes when the supervisor and employee periodically discuss what needs to be accomplished. This implies a discussion of the employee's performance and an agreement on what part the employee will play in the future operation of the work unit.

In most of the organizations we visited the annual performance interview provides the employee an opportunity to discuss his future work and, in its most abbreviated form, this is career planning. Survey participants using the "goal-setting" approach (see page 61) in performance appraisals clearly have a short-range form of career development planning built into their procedures. As an example, the management of the Jet Propulsion Laboratory has recently instituted a system of formal, written appraisals in a standard format applicable to all professional employees. The format incorporates provisions for the mutual establishment of objectives by the supervisor and employee. The employee signs this portion of the appraisal form to signify his concurrence with the stated objectives. Although the appraisal of past performance is discussed with the employee (primarily in relationship to previously established objectives), the employee is not given a copy of the appraisal.

However, unlike "goal-setting" which typically describes an employee's assignment over a one-year period, career development planning covers a greater time span and tends to be somewhat broader in its application. At Lockheed, selected salaried employees complete a "Personal Development" form outlining what they would like to accomplish in the future in terms of the work assignment and describing what position they hope to attain as a result. Chevron Research and Standard Oil Company of California use what may be referred to as a "placement recommendation" form which is used in conjunction with the performance appraisal. Applied Physics Laboratory has a "Record of Professional Work" which is used as a long term goal-setting type of document. At the General Electric Company, Research and Development Center, they call their form a "Performance Review—Individual Planning Supplement." It is used on an optional basis with strong encouragement that it be used for all staff members under 50 years of age. Most of these "development" programs are on a 5- to 10-year time scale.

Under proper management, these programs give the employee an added degree of participation in decisions affecting his career. For management, these programs provide an additional element useful in the planning of manpower utilization and serve to identify, at an early

stage, promising employees with leadership potential who can be properly developed for future roles in the management structure.

Objectives Achieved by Performance Interviews

One of the most important aspects of any appraisal program, and one which should be of primary interest to management, is the performance interview. Communication between the supervisor and the employee regarding performance versus expectations is to be encouraged regardless of the appraisal method being used. In order of priority to management, the interview achieves the following objectives:

- Guarantees that a conversation dedicated to performance will take place between each professional employee and his direct supervisor on a regular basis and that, hopefully, some of the content will be recorded.
- Allows the supervisor to discuss the employee's shortcomings, how serious they are, what the employee should do about them, and what the consequences will be for his failure to correct them.
- Gives the employee the undivided attention of his supervisor to talk about matters important to him.
- Provides an opportunity to discuss snags in the work assignment.
- Enables the supervisor and the employee to discuss future work.
- Initiates a discussion of the employee's future.

RANKING SYSTEMS

Ranking provides a means of comparing the relative value of each employee with others in the organization and serves as an important guide to the management of salaries.

There are many methods of ranking, the least complicated being numerical ranking which requires a 1-2-3, etc., order distribution from top to bottom. The numerical system is specific in that it places each employee in a definite relative position within the rank order and is typically employed when evaluating small numbers of employees. Numerical ranking is extremely difficult to accomplish with large groups of professionals or when the ranking in many sub-groups must be integrated into a rank ordering of the entire organization.

Another ranking method, and one which is most commonly used, is called group ranking. This form of ranking is generally used in evaluating large numbers of employees. The number of groups within a total system may vary. As an example, many Lawrence Livermore Laboratory divisions distribute their employees within three percentage groups, top 25%, middle 50% and bottom 25%. Many other organizations have chosen to distribute their populations into quartiles, quintiles, octiles, etc.

Regardless of the ranking method used, the same factors are helpful in determining each employee's rank, and these factors usually include professional capability, supervisory capability, job performance and effectiveness, flexibility, growth potential and relative value of the job being done. The rank position of a professional is a measure of his over-all value to his orgainzation resulting from a consideration of all the above factors.

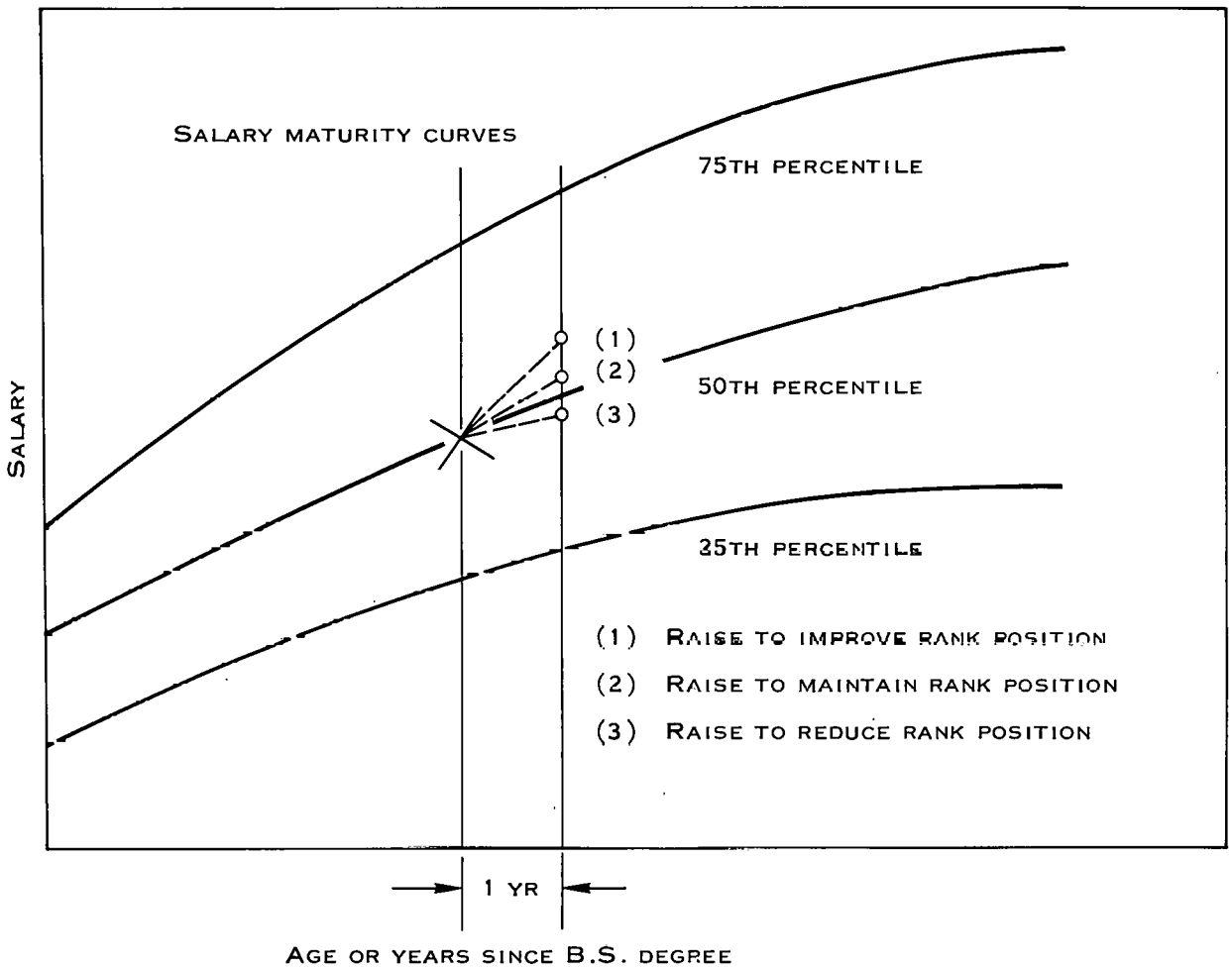

Figure 7. Salary correlation with rank position.

Ranking results are usually correlated with salaries to determine if salary inequities exist and how raises may be distributed to reflect the organization's ranked value of the employee. Figure 7 demonstrates how salary increases are selected to reflect the results of an annual ranking process. When an employee is changed in rank position it may take several years for the proper salary actions to bring him in line with others of the same rank. Salary maturity curves are used to provide comparisons.

Well over half of the organizations we surveyed have formal ranking systems, and many of these same organizations administer performance appraisal programs as an adjunct to their ranking acitivites. In these situations we generally found that the written appraisal was designed to provide the organization with a documented history of employee performance, and that the ranking system was used to support salary actions, to identify top performers as a basis for future promotion and low performers for decisions which might include layoff.

Applied Physics Laboratory has a most detailed and carefully constructed ranking system which consists of two aspects. First, employees are graded on "rating factors" over a 10-point scale which

ranges from 0 to 3+. Second, and as a completely separate exercise, supervisors must rank their people from top to bottom in order of merit.

The results of these two grading methods are then compared, and a forced correlation between the two systems is made for all employees. This exercise is supplemented by a "Record of Professional Work" (in essence, a record of accomplishments) which is completed by each professional employee, supplemented by an appraisal written by his supervisor.

The criteria used in most systems of ranking are typified by the standards used at Atomics International and Rocketdyne. At these divisions of North American Rockwell rank is measured by the capability to contribute and is determined by assessing demonstrated performance, the relative value of the work being done, versatility and ability to apply pertinent skills and experience to the goals of the organization, and the capacity for future growth.

Bell and Sandia Laboratories practice an octile system of ranking. Supervisors generally conform to the formalities of the system, but are fully aware of the subjective nature of judgments of relative merit. The system is administered fairly rigidly with emphasis on the value of the "collective judgment" of the supervisors participating in the ranking. We were told that by the time an employee's rank has been reviewed by all levels of supervision, the subjective element of a single supervisor's judgment has been largely mitigated so that the ranking of each employee has considerable objective validity. First-line supervisors rank their people within four age groups and meet with the next highest level of supervision to integrate their separate rankings. This procedure is repeated up to the top level of management and when completed, every employee has been octile-ranked within his particular age group. Ranking by age group prevents comparisons being made, for instance, between new graduates and 25-year veteran employees. The criteria for ranking decisions are based on an employee's sum total relative contribution with emphasis on the excellence and worth of his performance in his current assignment with consideration of his potential for continued growth. Employees are encouraged to view the octile charts with their supervisors and can closely determine their ranking from their age and salary level. The employee's rank is freely discussed during performance interviews if the employee so desires.

There is no written appraisal program at Bell or Sandia as both are satisfied that the octile ranking system by itself adequately serves their purpose. Generally an annual performance interview is conducted with each employee and the results are documented. The management at both organizations believe that a history of an employee's octile rank positioning provides a sufficient record to refute any charges of unfair treatment.

The Engineering Department of Standard Oil Company of California uses a quintile ranking system for all professional employees. The quintiles relate to salary progress categories, each employee's salary progress relating to the quintile to which he has been assigned. Chevron Research Company uses a similar but not identical quintile system, which is applied only to those employees of 10 or more

years of service. For the initial 10 years, salaries are based upon entering qualifications such as highest academic degree, grade-point average and previous applicable experience. Unlike Bell and Sandia, the management at both Standard Oil and Chevron Research believe it is unwise to tell the employee his specific rank position. If the employee asks, he may be given a general idea of his position, but both organizations are of the opinion that this type of information is primarily for management use.

At General Electric, Research and Development Center, a forced ranking program, referred to as the "totem pole" system, is used. An important goal of this program is to achieve a high correlation between comparative salaries and totem pole positioning. Another important objective is the identification of low ranked employees. These individuals are observed closely for possible corrective measures which may include termination. One company spokesman stated, however, that despite this program of identifying marginal performers, appropriate action had not consistently been initiated promptly in all cases because of the reluctance of supervisors to deal effectively with this type of problem.

A number of survey participants have informal and/or optional procedures for ranking employees. At Los Alamos, for example, ranking is not a formal requirement, but some individual operating units practice various forms of ranking. At RAND Corporation we were told that no formal ranking system was utilized. However, when the salary board meets to consider salary adjustments, members discuss the relative value of employees and adjust salaries accordingly. Although this procedure is informal it is a form of ranking which RAND management believes is as effective as the more formal procedures.

In the course of our study, we found that most survey participants practice some form of ranking. Some regard ranking programs as a necessary element in salary and personnel management and have formal systems which are administered on a uniform basis throughout the organization. Others permit individual operating groups to practice various forms of ranking on an optional basis or depend upon thorough informal discussions with top management participation as a means of merit ranking. Regardless of the method used, our investigation revealed that ranking of professional employees is widely practiced and is generally regarded as an essential element in salary and personnel management.

SKILL INVENTORY SYSTEMS

Optimum utilization of available skills is always a desired operational goal. Appraisal records, career development plans and ranking information all serve to support a supervisor's awareness of the talents which exist in the organization. A personnel skill inventory system is an additional aid that may be utilized by management to identify staff capabilities.

A. A. Flakol informed us that Lockheed has had a skills inventory system since 1952. At present LMSC (as well as the other major companies of the Lockheed Aircraft Corporation) utilize the "Personnel Information and Capability System (PIC)," which is in daily use throughout

the Corporation. All salaried employees are requested to fill in forms from which keypunch cards are prepared and the information entered into a computer data bank. This inventory is searched for candidates with the education and experience needed to fill positions throughout the Corporation.

Another example of a skill inventory system was described to us during our visit to the Jet Propulsion Laboratory. W. H. Padgham, Assistant Director, Personnel and Supporting Services, recently introduced a computerized system for recording information about the capabilities of JPL professionals. Each professional employee completes a set of capability forms which permits later identification of needed or desired skills when work assignments must be filled. Using the Informatics Mark IV software package this information is stored on magnetic tape and can be scanned at any time to identify employees with desirable skills for special assignments, or for other purposes such as contract proposal input. Mr. Padgham remarked that the system had been used on the average of once a day since it became operational in September 1970.

Although our survey indicated that formalized skill inventory systems were not being used in other participant organizations, the advantages of such a system, as described above, would be of considerable value to any organization that could utilize its potential sufficiently to balance the associated operational costs.

Concluding Remarks

When we embarked on the foregoing study one of the ground rules was that two of our three-man group should be amateurs in the personnel field. We are concluding the investigation with that reputation unblemished. We are still amateurs, but a great deal of knowledge has been acquired in the course of the study. It was Dr. May's intent to have the work undertaken by technical management personnel like ourselves who could gain viewpoints of our counterparts regarding the difficulties in operating with professional personnel practices that might be second nature to a personnel specialist. Under this directive we concentrated as much as possible on the technical professionals' attitude toward managing their personnel and tried to draw from them how they felt procedures might be altered to achieve a more dynamic organization in the currently depressed economy.

We were pleased to find that there was a sincere interest in the subject of our study in the organizations we visited and a strong willingness to respond to our approach. We found the excellent response largely responsible for our ability to cover as much ground as we did. It was particularly gratifying to exchange viewpoints and elicit advice from the highest levels of management in the various organizations.

As amateurs in the personnel field we found that we had certain prejudices and areas of ignorance that were modified as we proceeded with our interviews and with the subsequent reporting of our findings. Here are a few highlights

of our survey that we have often reflected upon.

- There are no secret techniques that provide for the maintenance of vitality in an organization. Relating successful R&D to turnover rate, staff age, age distribution, tenure or to various layoff policies was not always possible. There was no clear, consistent pattern to the effect of those factors on the quality of performance.

In particular we found that lower staff age was not believed to be as directly related to over-all performance as might first be thought. The situation we found was described by one researcher who said, "There is no excuse for not having a dynamic staff these days, regardless of age." There are many influences on the performance of scientists and engineers that equal or exceed the influence of age, and we have tried to retain that perspective in our report.

- There was an impressive concern for employees as human beings in all the discussions relative to maintaining vitality in an organization. There was naturally a concern about the bad image that would result from callous practices, and in addition there was a sincere desire to be fair and considerate of employees' welfare. Capricious and impulsive actions to overturn an existing professional staff to achieve a change in capability seem very unlikely.

On the other hand the demand for thorough evaluation of performance is seen as a growing responsibility in a climate in which more and more the continuance of employment will be earned by performance. Programs requiring a great deal of courage, compassion and justice are being initiated to carry out the responsibility of supervision.

- Corrective actions are being planned, and some programs are underway to achieve a vital organization where the highest levels of management have dedicated their own time and some considerable effort to the task. It became very clear in the course of our investigations that the isolated efforts of a well-intentioned personnel department or the most earnest group leaders acting on their own could do very little to gain support and enthusiasm for programs of revitalization. There is apparently no substitute for the strong leadership of a president or director in executing programs designed to prevent stagnation of a professional staff, especially when hiring stops or personnel levels begin to decline.

- The continued success, and even the existence of R&D organizations depend to a large degree upon the achievements of a very few highly gifted individuals. A major responsibility of management is to identify truly gifted individuals early in their careers and to nurture them to assure maximum utilization of their talents.

- It was reassuring to discover the sense of responsibility inherent in the search for better systems for early retirement. It is natural for an organization to look for avenues of relief from excess personnel. Most organizations declined the temptation to terminate older employees unless their performance had deteriorated quite significantly. Improved early retirement systems are consistent with a national trend toward earlier retirement and are also being sought to provide an

honorable and financially comfortable avenue of escape for employees who should be terminated for obsolescence or poor performance.

- From discussions with the leadership of some organizations we detected a feeling of apprehension that professional unions may become established in the next few years. The current cutback in many R&D budgets is hastening the confrontation with the issue of unionism. The main arguments for professional unions are the opportunities for portable pension plans and the governing of layoffs by seniority. Should professionals turn in great numbers to union representation, managements will have little latitude to innovate in programs to keep their staffs dynamic.

After a childhood of frenzied growth and rich budgets, many research and development organizations will mature in today's austere climate into stable and valuable national resources. There seems to be little longing for "the old days"; instead, there is a desire to establish a new and adjusted level of effort and to get on with the work at hand.

Acknowledgments

Those with whom we discussed policies and practices affecting professional personnel are listed alphabetically under the names of the organizations we visited in making this study. We are deeply indebted to these individuals for taking time out from their busy work schedules to answer our questions and for their frankness in discussing sensitive matters pertaining to the management of professional personnel.

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