Alvin W. Boese Papers.

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THE "MICRO-COMPANY":

Organizing for problem-oriented management

By J. WADE MILLER, JR. and ROBERT J. WOLF

IN THE "REAL WORLD" of business there are always skeptics to question any new managerial technique until it is proved more than a gimmick. For a technically oriented company, practical results at the B. F. Goodrich Company have shown that, for from being just a gimmick, the "micro-company" structure and the management procedures it entails are among the important administrative advances of recent years.

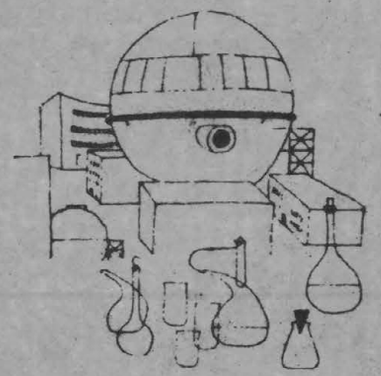
Goodrich has eight operating divisions and seven corporate staff divisions. The program described here centers primarily on one division, the B. F. Goodrich Chemical Company, but it affects one or more staff divisions.

The chemical division is the world's largest producer of vinyl plastic materials and nitrile specialty rubbers; since it was established in 1945, it has doubled its sales volume every five years. Plans were recently announced for construction of the division's eighth manufacturing plant in the United States, and it also has an extensive overseas operation.

Specialized Development

The Development Center of the chemical division is located in Avon Lake, Ohio, a small community near Cleveland, where the division has its headquarters. Opened in 1946, the Center now has about 540 employees, more than 200 of whom are professional engineers or scientists.

The work of the Development Center complements but does not duplicate that of the Goodrich Research Center at Brecksville, Ohio, which conducts fundamental and applied research on behalf of all divisions of the corporation. The Development Center is primarily



responsible for carrying out the technical development and successful commercialization of new chemical discoveries or inventions as well as developing new chemical processes and improving existing processes and products.

The survival of any company operating in the chemical industry depends on the quality and effectiveness of its technical organization. Our customers are technically sophisticated companies; most of our competitors are very competent in technical areas; and, because of the rapid rate of technological change, the creativity and timeliness with which development projects are carried out are critical to the company's competitive edge.

A Structural Overhauling

In 1959 we began to study the operation of the Development Center to determine how organizational structure and management methods might be further improved. The organization had been designed as a traditional management pyramid, with the director at the top and the working professionals at the bottom, and followed the traditional chain-of-command lines of authority and communication. The result sometimes was unnecessary diffusion of responsibilities and information, with consequent delays, misunderstandings, and inadequate solutions to technical problems. Moreover, in this pyramid type of organization, there is the ever-present concern that a person reporting to his immediate superior may pay more attention to the nuances of that relationship than to getting the work done.

When we began to examine the situation nine years ago, we were trying to carry out over 100 sepa-

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J. WADE MILLER, JR., *vice-president of personnel and organization for the B. F. Goodrich Co., who received his doctorate from Massachusetts Institute of Technology, was formerly with the Ford Motor Co. industrial relations division and the Dewey and Almy Chemical Co. as director of personnel administration and vice-president of the Central Services Division. Dr. Miller has also served as a member of many industry and government advisory groups on manpower and compensation.* ROBERT J. WOLF, *director of development at B. F. Goodrich Chemical Co., received his B.S., M.S., and Ph.D. degrees from Case Institute of Technology. Dr. Wolf joined Goodrich as senior technical man and later became project manager and manager of the Products Application Laboratory.* *This article is based on a presentation at the 1968 AMA Personnel Conference.*

Source: Personnel, July-August, 1968, pp. 35-42.

rate projects. By combining and restating these projects, we identified from among them 19 broad, basic problems (which now have been reduced to 13—seven new-product programs and six supporting existing product lines).

We then set two over-all and interrelated objectives for the changes we wanted to effect. The first, and most important, was to learn to live with constant experimentation with organizational structure, management methods, and operating procedures in the same way that we experiment with materials and products. This approach required understanding and acceptance by the company's management, as well as by management of the Development Center, of the premise that the functions and responsibilities of a manager are part of a continuous change process.

The second objective was to build an environment that would encourage the deep involvement of our personnel in the organizational objectives—in our case, the solutions of technical problems.

How It Works

To be more specific, let's consider a hypothetical problem of making a commercially feasible low-cost plastic that will withstand high temperatures. The problem has been broadly defined by a planning function and approved by company management, and funds have been allocated to begin work.

Now, instead of fragmenting the problem among functional groups as was done in the past, we establish a micro-company, representing all the action elements of a conventional company.

Individuals and the necessary staff are assigned from the appropriate functional groups—research, development, application development, marketing, engineering, and production. From this point on they report the status of the program periodically to the company management, which, in this micro-company, acts as a board of directors.

If the new product is unknown as a material, the first active phase is exploratory research, for which those who will head the micro-company's development and marketing later on act as an advisory committee, with a representative of the research group serving as chairman. Participation of the non-research personnel at this stage is on a part-time learning and advisory basis.

A discovery by research signals a new phase. Though still considered exploratory, development and limited marketing activity turns to reviewing what research has uncovered and devising methods of producing the product, making small quantities of it, beginning application studies, and taking samples to a limited number of potential customers. During this period

the development man serves as chairman of the committee.

When the task group has determined the composition and form of the new product and approximately how it is to be made, the orientation of the program shifts from technical activity to marketing. The committee becomes an action group, with decision-making responsibility assigned to the marketing head, and with the entire program geared to the needs of the marketplace. The questions to be answered now are who will buy the product, how much will they buy, and how much will they pay for it.

Emphasis on Time

At this point, the project is referred to as a Time-Oriented Program (TOP) and the project management is made responsible for meeting a tight time schedule established by the group. The total timetable includes goals for starting production and commercial sales of the new product; weekly objectives are projected through the life of the entire program and are updated monthly.

Early in this period, the development group provides for pilot equipment to make small quantities of the new product. A minimum amount of the product is tested in the field to spot its potential uses and improvable deficiencies. The marketers must avoid creating a demand that cannot be met until a large production unit has been built, but at the same time there is the urgent need to begin building demand so that sales from the production unit can start at a high level as soon as possible after plant startup.

When there has been sufficient success in these activities to warrant a production plant decision the third stage brings into action the production and engineering members of the group, who undertake the design, startup, and operation of the new unit.

By this time, research work has all but stopped; process development has begun a slow tapering off; and application and market development has reached a high level. The important tasks still to be done are the transfer of operating and product information from development to production and the transfer of marketing responsibility to the existing marketing organization.

The final phase of the program is sustaining in nature, with principal technical responsibility for plant operation, product quality, and cost improvement assigned to production, as the product goes into the established line. The problem is considered solved, and the new-product project group is dissolved.

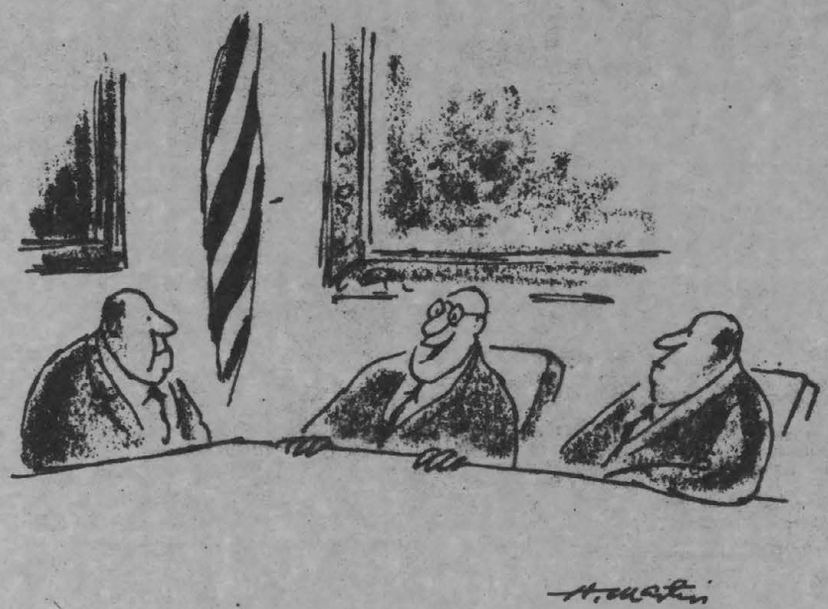
On Their Own

Throughout this problem-oriented process, although the project team's group heads and those working under them come from

different functional groups in the chemical company, and even different divisions of the company, it is strongly emphasized to them that they have the authority to act within their own group and that they are reporting to the project head. Further, they can and should initiate action to obtain management decisions at major points of change, affecting, for example, budget or time goals, negotiating of licenses, applications for patents, or even redefinition of the problem itself.

On the other hand, though the micro-company has the responsibility and authority to act on its own initiative, its members are fully aware that the company management is keeping abreast of the progress toward the solution of the problem and is willing to follow through by building facilities and applying market effort to commercializing the result. This management concern and support have proved to be a strong motivating force for the members of the micro-company group.

Another important input is the extraneous evaluation of the line scientists' progress, and of the solution itself, by the administrative



"Say, instead of parking meters why don't we install wishing wells?"

managers in the organization and by a separate technical advisory group.

The Development Center approach to technical problems necessitated some drastic changes in the thinking of the personnel involved. It took a long and careful "selling" process to convince the technical managers that, although three levels of management were being eliminated and they would be relinquishing authority previously held through the old chain-of-command structure, they would gain in terms of challenge, personal satisfaction, professional growth, and sense of achievement.

Theory Y in Practice

One of the key factors in the Development Center program has been a conscious effort to apply and manage according to modern views of the way people act and interact. In searching for a philosophical base, we found that in *The Human Side of Enterprise* Douglas McGregor expressed very well the kind of "people environment" we wanted.

Although we were already doing many of the things suggested by McGregor's Theory Y, we had not crystallized our approach, so a group of several of our most creative technical men was given the assignment of defining Theory Y in Development Center terms and sketching an operational plan to put it into effect.

This group concluded that a two-way bond of trust was the essence of McGregor's concept—that administrators must have confidence that scientists would achieve goals without control, and the scientists, in turn, must have confidence that administrators would recognize their accomplishments and suitably reward them.

A more specific blueprinting by this group of ways to create a Theory Y environment for the Development Center called for these moves:

- Educational sessions for everyone concerned in the understanding and application of the Theory Y philosophy.
- Establishment of demanding goals and time objectives for the project group and for each individual within the group.
- Greater professional training opportunities.
- The upgrading of existing performance requirements.
- A strong voice for both professional and nonprofessional people in goal setting and performance evaluation.
- Salary increases and promotions based on the achievement of project goals and individual goals.

Also stemming from these new concepts has been a considerable broadening of our internal educational programs. Since we are putting so much emphasis on the authority of knowledge, as distinct from the authority of position,

there is a greater need than ever before to keep the professional staff up to date in technology, a need we are trying to meet through special in-plant training programs, more attendance at professional conferences, and almost continuous interaction with technical consultants and university programs.

There is, of course, the requirement that the managers and the scientific personnel in the Development Center have better insight into human behavior, to understand themselves and their peers and to associate this understanding directly with their actions in the new organizational structure. This understanding and maturity are highly desirable in any organizational structure, but they are absolutely essential in one such as this.

Implementing the Theory

To build this orientation among Development Center personnel, we have introduced a series of programs structured around the Theory Y philosophy. These programs were designed for us by Professors G. W. Dalton and L. B. Barnes of the Harvard Business School, who tailored National Training Laboratory methods to the specific needs of various levels in the organization. There are programs for administrative management, the professional staff, and the nonprofessional staff. Every one of the 540 people in the Center has spent three to five full days in this activity geared to specific demands.

We have also found that this kind of training has opened other doors for us. For example, we are now conducting group sessions aimed at increasing individual creativity and think they are bearing fruit. One of the most important by-products has been the enhanced role of the nonprofessional technician.

During the last six years, the professional staff has remained the same size, despite a considerable increase in the budget, work load, and output of the Center. A good deal of the work previously done by the professionals is now being assigned to nonprofessionals, with the result that a large percentage of both professional and nonprofessional jobs have been upgraded. The nonprofessional staff is involved in extensive formal and on-the-job training in technical subjects to fit them to the increasing technical needs of their work.

Climate for Achievement

It should be added that a strong contributing factor in maintaining the Theory Y environment is the enthusiasm of the participants. The new concern for the "people" aspect of the business, the freedom to make decisions, the ability to communicate freely, unfettered by conventional organizational lines, have all convinced the participants that they are part of an experiment that is having dramatic and positive results. Most of them have become salesmen, eager to describe the program and win converts to it in other areas of the chemical division and the corporation as a whole.

Other results of the Development Center program, both tangible and indirect, include significant improvements in the turnover rate. For example, over the last 20 years the Development Center accounted for approximately 40 per cent of the entire turnover of professional people in the chemical division, but during the last five years that average has been sharply reduced, both relatively and absolutely.

We believe that one explanation of this stability is that our Development Center people find their jobs increasingly challenging and satisfying, a conclusion supported by attitude surveys conducted from time to time. Our people tell us through these surveys that they don't think their compensation is better than average, or that their working conditions and similar considerations are much out of the ordinary, but they do clearly indicate that they feel a high degree of involvement with, and enthusiasm for, their work.

Operating management is, of course, interested in personnel turnover and employee attitudes, but it has to be concerned primarily with performance measured in dollars and cents, and, after all, the prime objective in embarking on this Development Center program was to bring about an organization more effective in giving the company real competitive advantages.

The Practical Payoff

The program has effected at least four changes that realize some of these advantages. First, there has been a growth in both the number and quality of "initiative centers," or sources of ideas, throughout the chemical division, often well below the higher management levels. Second, time consciousness—crucial to any technical organization—has been sharpened markedly. Third, there has been an increased ability of widely distributed functional groups to work together. Fourth, the commitment of line scientists to meet goals and time pressures has been strengthened, and the extent to which they are willing to challenge decisions of others is significantly greater.

The result of all these developments has been that several new products have been launched, and others are currently well on their way, at significantly accelerated rates compared with similar projects in the past. The concept of attacking each problem as a whole problem through the micro-company approach has proved to be no flash in the pan, but a solid success.

For information on reprints of this article, see page 43.

Interoffice Correspondence 3M COMPANY

Subject: Meeting Minutes: Explore Means Whereby the Research Associate Could Further Aid 3M and the Dual Ladder System.

cc/ H. L. Anderson - 218-3
C. S. Miller - 235-3
Med. Prod. Lib.

Time Held: 12:00 Noon, July 8, 1970, Bldg. 218-3

July 21, 1970

Those present: Alvin W. Boese
William C. Flanagan
Samuel Smith
Harold G. Sowman
George V. D. Tiers

We began with a short review of the history of the early research associate position at 3M and its present evolution into the Dual Ladder System.

The present job description of Research and/or Development Associate was discussed (Technical Directors Guide, January 19, 1967, Section 7-10-1). There was a broad area of similarity in our individual work activities yet in other ways we demonstrated considerable variance between each other due to our diverse technical backgrounds and past subject studies.

We felt able to contribute to increase and expand technical innovations at 3M by suggesting the following considerations:

1. Increase the general information about the Dual Ladder System including the importance of the laboratory technician as an integral part of this system. Show that our technicians can advance to Research Associate (e.g. Mr. Alvin Boese).

2. Review the unpublished "3M Tartan" article on the Dual Ladder System and possibly update it for publication. Suggest the financial benefits of selecting this type of career path. Indicate a few goals for this "dual system" including the utilization of its membership as a fountain source for innovation and new technological developments for all 3M divisions and staff laboratories.

3. Use the Research Associates as a means of cross-fertilizing new ideas and technical contributions across divisional lines yet maintain individual divisional security. Let them contribute at technical audit reviews and technical council activities. Encourage a broader role for them to assist divisions other than their own. Consider the Research Associate's salary to come from staff funds (central job number) so it is not tied down to a specific divisional commodity. This can encourage their aid to other divisions and staff laboratory activities coordinated with each Technical Director. For instance, a Research Associate might charge his regular divisional time to his current project number while new unrelated activities could be charged to a staff R & D project number.

4. Let Research Associates interview laboratory technicians (T3's) for their viewpoints on the present and future of the Dual Ladder System. This may aid in reinforcing the acceptance and continued growth of the "dual ladder" program.

5. The role of all Dual Ladder Systems personnel is important, not just the Research Associate group. New employees, in particular, should realize the financial and prestige importance of becoming part of the "dual ladder" activity. The systems rewards and corresponding demands can become a new source of continued innovations and new business opportunities for 3M divisions.

When organizing the meeting, we were unaware of Dr. Carl S. Miller's appointment as a Research Associate. We wish to welcome him to future meetings.

In future meetings we are interested in outlining certain specific new research activity that may be of interest to our Central Research Laboratories.

WCF/bg W.C.F.

Interoffice Correspondence 3M COMPANY

Subject: Meeting of Research Associates

c-
H.P.Arneson 220-2E

September 3, 1970

TO: A. W. BOESE - 219-1
W. C. FLANAGAN - 218-3
C. S. MILLER - 235-3
H. G. SOWMAN - 201-3E
G. V. D. TIERS - 201-2S

FROM: S. SMITH - 236-1

Mr. H. P. Arneson, Mgr. Education and Training Dept., has kindly consented to discuss with our group the factors which inhibit creativity and productivity. It is hoped that you can attend this informal meeting which will be held at 1:00 on Thursday, Sept. 10 in 236-226B, the site of our last meeting.

You may recall that Carl Miller suggested that Mr. Arneson may be helpful in broadening our outlook concerning the problems of conducting research in the 3M Company. A brief conversation with Mr. Arneson convinces me that this meeting should benefit all of us.

SS/ah

Interoffice Correspondence 3M COMPANY

Subject:

September 4, 1970

S. SMITH

TO: A. W. BOESE
W. C. FLANAGAN
C. S. MILLER
H. G. SOWMAN
G. V. D. TIERS

FROM: H. P. ARNESEN - EDUCATION & TRAINING - 220-2E

Sam Smith invited me to meet with you to discuss creativity and productivity in 3M research. I thought you might be interested in the enclosed two articles as a prelude to such a meeting.

The author of the first one, Donald Pelz ("What it Takes to Make A Problem Solver Productive") is known for his research, and some biographical notes are included on the last page. The second, "The Coming Death of Bureaucracy", is by a well-known current author on effectiveness in organizations.

I look forward to our meeting next week.

Herb

HPA:~~ba~~
Attachments

The Coming Death of Bureaucracy

by Warren G. Bennis

In most organizations, the chain-of-command is set up on the lines of a pyramid—an arrangement we recognize as "bureaucracy." While it had its purposes, says the author, the bureaucratic pyramid is now obsolete. Here, he suggests a more flexible structure to meet the demands of our changing society. Dr. Bennis is Professor of Organizational Psychology and Management and head of the Organization Studies Group of the Alfred P. Sloan School of Management at MIT.

Not far from the new Government Center in downtown Boston, a foreign visitor walked up to a sailor and asked why American ships were built to last only a short time. According to the tourist, "The sailor answered without hesitation that the art of navigation is making such rapid progress that the finest ship would become obsolete if it lasted beyond a few years. In these words which fell accidentally from an uneducated man, I began to recognize the general and systematic idea upon which your great people direct all their concerns."

The foreign visitor was that shrewd observer of American morals and manners, Alexis de Tocqueville, and the year was 1835. He would not recognize Scollay Square today. But he had caught the central theme of our country: its preoccupation, its *obsession* with change. One thing is, however, new since de Tocqueville's time: the *acceleration* of newness, the changing scale and scope of change itself. As Dr. Robert Oppenheimer said, ". . . the world alters as we walk in it, so that the years of man's life measure not some small growth or rearrangement or moderation of what was learned in childhood, but a great upheaval."

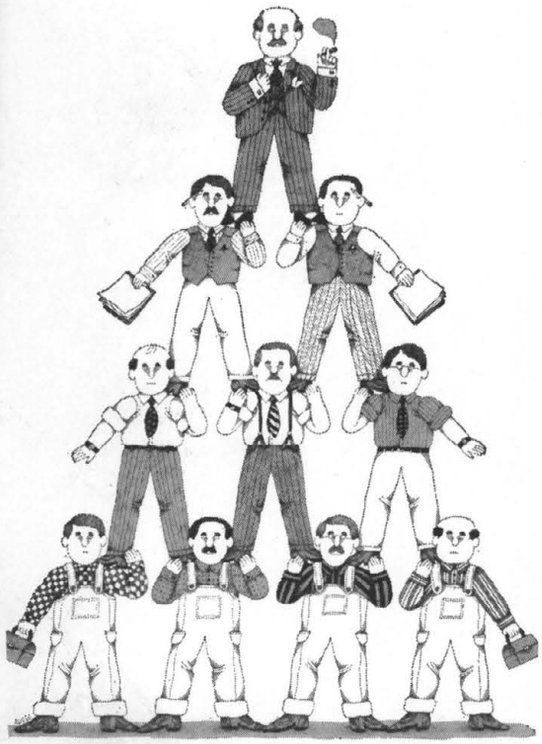
How will these accelerating changes in our society influence human organizations?

A short while ago, I predicted that we would, in the next 25 to 50 years, participate in the end of bureaucracy as we know it and in the rise of new social systems better suited to the 20th-century demands of industrialization. This forecast was based on the evolutionary principle that every age develops an organizational form appropriate to its genius, and that the prevailing form, known by sociologists as bureaucracy and by most businessmen as "damn bureaucracy," was out of joint with contemporary realities. I realize now that my distant prophecy is already a distinct reality so that prediction is already foreshadowed by practice.

I should like to make clear that by bureaucracy I mean a chain of command structured on the lines of a pyramid—the typical structure which coordinates the business of almost every human organization we know of: industrial, governmental, of universities and research and development laboratories, military, religious, voluntary. I do *not* have in mind those fantasies so often dreamed up to describe complex organizations. These fantasies can be summarized in two grotesque stereotypes. The first I call "Organization as Inkblot"—an actor steals around an uncharted wasteland, growing more restive and paranoid by the hour, while he awaits orders that never come. The other specter is "Organization as Big Daddy"—the actors are square people plugged into square holes by some omniscient and omnipotent genius who can cradle in his arms the entire destiny of man by way of computer and TV. Whatever the first image owes to Kafka, the second owes to George Orwell's *Nineteen Eighty-four*.

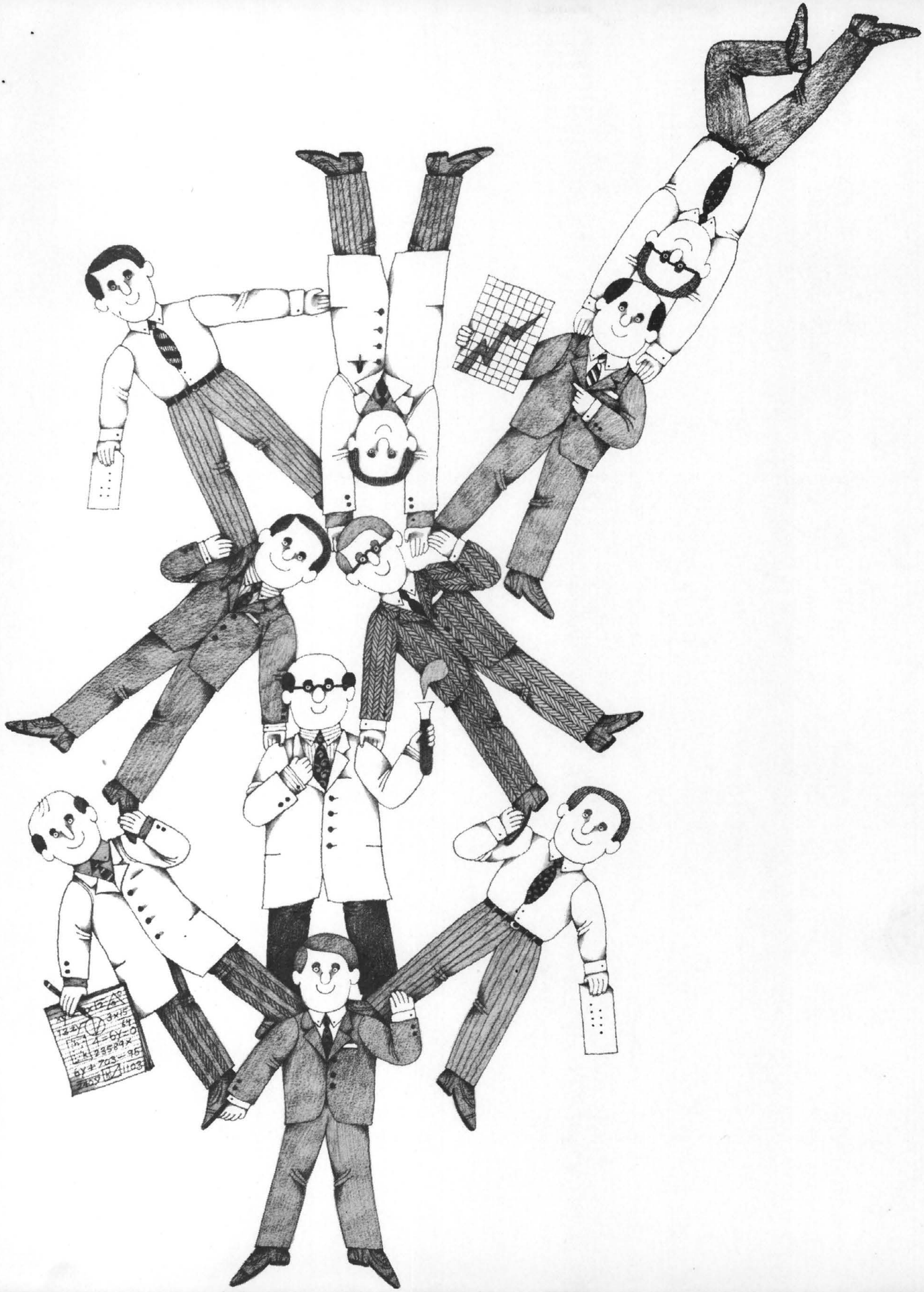
Bureaucracy, as I refer to it here, is a useful social invention that was perfected during the industrial revolution to organize and direct the activities of a business firm. Most students of organizations would say that its anatomy consists of the following components:

- A well-defined chain of command.
- A system of procedures and rules for dealing with all contingencies relating to work activities.
- A division of labor based on specialization.



The bureaucratic pyramid: has rigor mortis begun to set in?

Successor to bureaucracy (right): task-force team?



- Promotion and selection based on technical competence.
- Impersonality in human relations.

It is the pyramid arrangement we see on most organizational charts.

The bureaucratic "machine model" was developed as a reaction against the personal subjugation, nepotism and cruelty, and the capricious and subjective judgments which passed for managerial practices during the early days of the industrial revolution. Bureaucracy emerged out of the organizations' need for order and precision and the workers' demands for impartial treatment. It was an organization ideally suited to the values and demands of the Victorian era. And just as bureaucracy emerged as a creative response to a radically new age, so today new organizational shapes are surfacing before our eyes.

First I shall try to show why the conditions of our modern industrialized world will bring about the death of bureaucracy. In the second part of this article I will suggest a rough model of the organization of the future.

Four Threats

There are at least four relevant threats to bureaucracy:

(1) Rapid and unexpected change.

(2) Growth in size where the volume of an organization's traditional activities is not enough to sustain growth. (A number of factors are included here, among them: bureaucratic overhead; tighter controls and impersonality due to bureaucratic sprawls; outmoded rules and organizational structures.)

(3) Complexity of modern technology where integration between activities and persons of very diverse, highly specialized competence is required.

(4) A basically psychological threat springing from a change in managerial behavior.

It might be useful to examine the extent to which these conditions exist *right now:*

(1) *Rapid and unexpected change*—Bureaucracy's strength is its capacity to efficiently manage the routine and predictable in human affairs. It is almost enough to cite the knowledge and population explosion to raise doubts about its contemporary viability. More revealing, however, are the statistics which demonstrate these overworked phrases:

- Our productivity output per man hour may now be doubling almost every 20 years rather than every 40 years, as it did before World War II.
- The Federal Government alone spent $16 billion in research and development activities in 1965; it will spend $35 billion by 1980.
- The time lag between a technical discovery and recognition of its commercial uses was: 30 years before World War I, 16 years between the Wars, and only 9 years since World War II.
- In 1946, only 42 cities in the world had populations of more than one million. Today there are 90. In 1930, there were 40 people for each square mile of the earth's land surface. Today there are 63. By 2000, it is expected, the figure will have soared to 142.

Bureaucracy, with its nicely defined chain of command, its rules and its rigidities, is ill-adapted to the rapid change the environment now demands.

(2) *Growth in size*—While, in theory, there may be no natural limit to the height of a bureaucratic pyramid, in practice the element of complexity is almost invariably introduced with great size. International operation, to cite one significant new element, is the rule rather than exception for most of our biggest corporations. Firms like Standard Oil Company (New Jersey) with over 100 foreign affiliates, Mobil Oil Corporation, The National Cash Register Company, Singer Company, Burroughs Corporation and Colgate-Palmolive Company derive more than half their income or earnings from foreign sales. Many others—such as Eastman Kodak Company, Chas. Pfizer & Company, Inc., Caterpillar Tractor Company, International Harvester Company, Corn Products Company and Minnesota Mining & Manufacturing Company—make from 30 to 50 percent of their sales abroad. General Motors Corporation sales are not only nine times those of Volkswagen, they are also bigger than the Gross National Product of the Netherlands and well over the GNP of a hundred other countries. If we have seen the sun set on the British Empire, we may never see it set on the empires of General Motors, ITT, Shell and Unilever.

Labor Boom

(3) *Increasing diversity—Today's activities require persons of very diverse, highly specialized competence.*

Numerous dramatic examples can be drawn from studies of labor markets and job mobility. At some point during the past decade, the U.S. became the first nation in the world ever to employ more people in service occupations than in the production of tangible goods. Examples of this trend:

- In the field of education, the *increase* in employment between 1950 and 1960 was greater than the total number employed in the steel, copper and aluminum industries.
- In the field of health, the *increase* in employment between 1950 and 1960 was greater than the total number employed in automobile manufacturing in either year.
- In financial firms, the *increase* in employment between 1950 and 1960 was greater than total employment in mining in 1960.

These changes, plus many more that are harder to demonstrate statistically, break down the old, industrial trend toward more and more people doing either simple or undifferentiated chores.

Hurried growth, rapid change and increase in specialization—pit these three factors against the five components of the pyramid structure described on page 30, and we should expect the pyramid of bureaucracy to begin crumbling.

(4) *Change in managerial behavior*—There is, I believe, a subtle but perceptible change in the philosophy underlying management behavior. Its magnitude, nature and antecedents, however, are shadowy because of the

difficulty of assigning numbers. (Whatever else statistics do for us, they most certainly provide a welcome illusion of certainty.) Nevertheless, real change seems under way because of:

a. A new concept of *man*, based on increased knowledge of his complex and shifting needs, which replaces an oversimplified, innocent, push-button idea of man.

b. A new concept of *power*, based on collaboration and reason, which replaces a model of power based on coercion and threat.

c. A new concept of *organizational values*, based on humanistic-democratic ideals, which replaces the depersonalized mechanistic value system of bureaucracy.

The primary cause of this shift in management philosophy stems not from the bookshelf but from the manager himself. Many of the behavioral scientists, like Douglas McGregor or Rensis Likert, have clarified and articulated—even legitimized—what managers have only half registered to themselves. I am convinced, for example, that the popularity of McGregor's book, *The Human Side of Enterprise*, was based on his rare empathy for a vast audience of managers who are wistful for an alternative to the mechanistic concept of authority, i.e., that he outlined a vivid utopia of more authentic human relationships than most organizational practices today allow. Furthermore, I suspect that the desire for relationships in business has little to do with a profit motive per se, though it is often rationalized as doing so. The real push for these changes stems from the need, not only to humanize the organization, but to use it as a crucible of personal growth and the development of self-realization.*

The core problems confronting any organization fall, I believe, into five major categories. First, let us consider the problems, then let us see how our 20th-century conditions of constant change have made the bureaucratic approach to these problems obsolete.

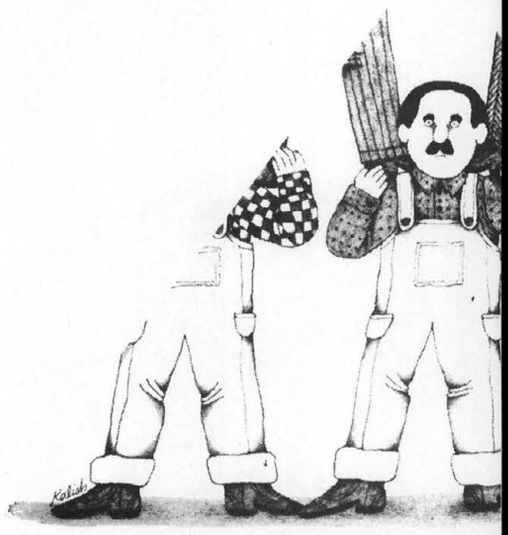
1. *Integration.* The problem is how to integrate individual needs and management goals. In other words, it is the inescapable conflict between individual needs (like "spending time with the family") and organizational demands (like meeting deadlines).

Under 20th-century conditions of constant change there has been an emergence of human sciences and a deeper understanding of man's complexity. Today, integration encompasses the entire range of issues concerned with incentives, rewards and motivations of the individual, and how the organization succeeds or fails in adjusting to these issues. In our society, where personal attachments play an important role, the individual is appreciated, and there is genuine concern for his well-being, not just in a veterinary-hygiene sense, but as a moral, integrated personality.

Paradoxical Twins

The problem of integration, like most human problems, has a venerable past. The modern version goes back at least 160 years and was precipitated by an historical paradox: the twin births of modern individualism and modern industrialism. The former brought about a deep concern for and a passionate interest in the individual and his personal rights. The latter brought about increased mechanization of organized activity. Competition between the two has intensified as each decade promises more freedom and hope for man and more stunning achievements for technology. I believe that our society *has* opted for more humanistic and democratic values, however unfulfilled they may be in practice. It will "buy" these values even at loss in efficiency because it feels it can now afford the loss.

2. *Social influence.* This problem is essentially one of power and how power is distributed. It is a complex issue and alive with controversy, partly because of



an ethical component and partly because studies of leadership and power distribution can be interpreted in many ways, and almost always in ways which coincide with one's biases (including a cultural leaning toward democracy).

The problem of power has to be seriously reconsidered because of dramatic situational changes which make the possibility of one-man rule not necessarily "bad" but impractical. I refer to changes in top management's role.

Peter Drucker, over twelve years ago, listed 41 major responsibilities of the chief executive and declared that "90 percent of the trouble we are having with the chief executive's job is rooted in our superstition of the one-man chief." Many factors make one-man control obsolete, among them: the broadening product base of industry; impact of new technology; the scope of international operation; the separation of management from ownership; the rise of trade unions and general education. The real power of the "chief" has been eroding in most organizations even though both he and the organization cling to the older concept.

3. *Collaboration.* This is the problem of managing and resolving conflicts. Bureaucratically, it grows out of the very same social process of conflict and stereotyping that has divided nations and communities. As organizations become more complex, they fragment and divide, building tribal patterns and symbolic codes which often work to exclude others (secrets and jargon, for example) and on occasion to exploit differences for inward (and always fragile) harmony.

* Let me propose an hypothesis to explain this tendency. It rests on the assumption that man has a basic need for transcendental experiences, somewhat like the psychological rewards which William James claimed religion provided—"an assurance of safety and a temper of peace, and, in relation to others, a preponderance of loving affections." Can it be that as religion has become secularized, less transcendental, men search for substitutes such as close interpersonal relationships, psychoanalysis—even the release provided by drugs such as LSD?

Recent research is shedding new light on the problem of conflict. Psychologist Robert R. Blake in his stunning experiments has shown how simple it is to induce conflict, how difficult to arrest it. Take two groups of people who have never before been together, and give them a task which will be judged by an impartial jury. In less than an hour, each group devolves into a tightly-knit band with all the symptoms of an "in group." They regard their product as a "masterwork" and the other group's as "commonplace" at best. "Other" becomes "enemy." "We are good, they are bad; we are right, they are wrong."

Rabbie's Reds and Greens

Jaap Rabbie, conducting experiments on intergroup conflict at the University of Utrecht, has been amazed by the ease with which conflict and stereotype develop. He brings into an experimental room two groups and distributes green name tags and pens to one group, red pens and tags to the other. The two groups do not compete; they do not even interact. They are only in sight of each other while they silently complete a questionnaire. Only 10 minutes are needed to activate defensiveness and fear, reflected in the hostile and irrational perceptions of both "reds" and "greens."

4. *Adaptation.* This problem is caused by our turbulent environment. The pyramid structure of bureaucracy, where power is concentrated at the top, seems the perfect way to "run a railroad." And for the routine tasks of the 19th and early 20th centuries, bureaucracy was (in some respects it still is) a suitable social arrangement. However, rather than a placid and predictable environment, what predominates today is a dynamic and uncertain one where there is a deepening interdependence among economic, scientific, educational, social and political factors in the society.

5. *Revitalization.* This is the problem of growth and decay. As Alfred North Whitehead has said: "The art of free society consists first in the maintenance of the symbolic code, and secondly, in the fearlessness of revision. . . . Those societies which cannot combine reverence to their symbols with freedom of revision must ultimately decay. . . ."

Growth and decay emerge as the penultimate conditions of contemporary society. Organizations, as well as societies, must be concerned with those social structures that engender buoyancy, resilience and a "fearlessness of revision."

I introduce the term "revitalization" to embrace all the social mechanisms that stagnate and regenerate, as well as the process of this cycle. The elements of revitalization are:

1. An ability to learn from experience and to codify, store and retrieve the relevant knowledge.

2. An ability to "learn how to learn," that is, to develop methods for improving the learning process.

3. An ability to acquire and use feedback mechanisms on performance, in short, to be self-analytical.

4. An ability to direct one's own destiny.

These qualities have a good deal in common with what John Gardner calls "self-renewal." For the organization, it means conscious attention to its own evolution. Without a planned methodology and explicit direction, the enterprise will not realize its potential.

Integration, distribution of power, collaboration, adaptation and *revitalization* —these are the major human problems of the next 25 years. How organizations cope with and manage these tasks will undoubtedly determine the viability of the enterprise.

Against this background I should like to set forth some of the conditions that will dictate organizational life in the next two or three decades.

1. *The environment.* Rapid technological change and diversification will lead to more and more partnerships between government and business. It will be a truly mixed economy. Because of the immensity and expense of the projects, there will be fewer identical units competing in the same markets and organizations will become more interdependent.

The four main features of this environment are:

- Interdependence rather than competition.
- Turbulence and uncertainty rather than readiness and certainty.
- Large-scale rather than small-scale enterprises.
- Complex and multinational rather than simple national enterprises.

"Nice"—and Necessary

2. *Population characteristics.* The most distinctive characteristic of our society is education. It will become even more so. Within 15 years, two thirds of our population living in metropolitan areas will have attended college. Adult education is growing even faster, probably because of the rate of professional obsolescence. The Killian report showed that the average engineer required further education only 10 years after getting his degree. It will be almost routine for the experienced physician, engineer and executive to go back to school for advanced training every two or three years. All of this education is not just "nice." It is necessary.

One other characteristic of the population which will aid our understanding of organizations of the future is increasing job mobility. The ease of transportation, coupled with the needs of a dynamic environment, change drastically the idea of "owning" a job—or "having roots." Already 20 percent of our population change their mailing address at least once a year.

3. *Work values.* The increased level of education and mobility will change the

values we place on work. People will be more intellectually committed to their jobs and will probably require more involvement, participation and autonomy.

Also, people will be more "other-oriented," taking cues for their norms and values from their immediate environment rather than tradition.

4. *Tasks and goals.* The tasks of the organization will be more technical, complicated and unprogrammed. They will rely on intellect instead of muscle. And they will be too complicated for one person to comprehend, to say nothing of control. Essentially, they will call for the collaboration of specialists in a project or a team-form of organization.

There will be a complication of goals. Business will increasingly concern itself with its adaptive or innovative-creative capacity. In addition, supragoals will have to be articulated, goals which shape and provide the foundation for the goal structure. For example, one might be a system for detecting new and changing goals; another could be a system for deciding priorities among goals.

Finally, there will be more conflict and contradiction among diverse standards for organizational effectiveness. This is because professionals tend to identify more with the goals of their profession than with those of their immediate employer. University professors can be used as a case in point. Their inside work may be a conflict between teaching and research, while more of their income is derived from outside sources, such as foundations and consultant work. They tend not to be good "company men" because they divide their loyalty between their professional values and organizational goals.

Key Word: "Temporary"

5. *Organization.* The social structure of organizations of the future will have some unique characteristics. The key word will be "temporary." There will be adaptive, rapidly changing *temporary* systems. These will be task forces organized around problems-to-be-solved by groups of relative strangers with diverse professional skills. The group will be arranged on an organic rather than mechanical model; they will evolve in response to a problem rather than to programmed role expectations. The executive thus becomes a coordinator or "linking pin" between various task forces. He must be a man who can speak the polyglot jargon of research, with skills to relay information and to mediate between groups. People will be evaluated not vertically according to rank and status, but flexibly and functionally according to skill and professional training. Organizational charts will consist of project groups rather than stratified functional groups. (This trend is already visible in the aerospace and construction industries, as well as many professional and consulting firms.)

Adaptive, problem-solving, temporary systems of diverse specialists, linked together by coordinating and task-evaluating executive specialists in an organic flux—this is the organization form that will gradually replace bureaucracy as we know it. As no catchy phrase comes to mind, I call this an organic-adaptive structure. Organizational arrangements of this sort may not only reduce the intergroup conflicts mentioned earlier; it may also induce honest-to-goodness creative collaboration.

6. *Motivation.* The organic-adaptive structure should increase motivation and thereby effectiveness, because it enhances satisfactions intrinsic to the task. There is a harmony between the educated individual's need for tasks that are meaningful, satisfactory and creative and a flexible organizational structure.

There will also be, however, reduced commitment to work groups, for these groups will be, as I have already mentioned, transient structures. I would predict that in the organic-adaptive system, people will learn to develop quick and intense relationships on the job, and learn to bear the loss of more enduring work relationships. Because of the added ambiguity of roles, time will have to be spent on continual rediscovery of the appropriate organizational mix.

I think that the future I describe is not necessarily a "happy" one. Coping with rapid change, living in temporary work systems, developing meaningful relations and then breaking them—all augur social strains and psychological tensions. Teaching how to live with ambiguity, to identify with the adaptive process, to make a virtue out of contingency, and to be self-directing—these will be the tasks of education, the goals of maturity, and the achievement of the successful individual.

No Delightful Marriages

In these new organizations of the future, participants will be called upon to use their minds more than at any other time in history. Fantasy, imagination and creativity will be legitimate in ways that today seem strange. Social structures will no longer be instruments of psychic repression but will increasingly promote play and freedom on behalf of curiosity and thought.

One final word: While I forecast the structure and value coordinates for organizations of the future and contend that they are inevitable, this should not bar any of us from giving the inevitable a little push. The French moralist may be right in saying that there are no delightful marriages, just good ones; It is possible that if managers and scientists continue to get their heads together in organizational revitalization, they *might* develop delightful organizations—just possibly.

I started with a quote from de Tocqueville and I think it would be fitting to end with one: "I am tempted to believe that what we call necessary institutions are often no more than institutions to which we have grown accustomed. In matters of social constitution, the field of possibilities is much more extensive than men living in their various societies are ready to imagine." ■

Source: "Innovation" magazine, Issue 9

If I'm right about all this, then this Issue 9 is not too bad a little sample to toss first into the flow of the 70s.

It includes in element **3hree** an example of that classic sort of technical change which dominated the 50s and continued even faster in the 60s. The technology of computer aided design and of tape-controlled machining is too powerful to permit much control of its human impact. Rather, we see the people affected—engineers, workmen, managers—simply trying to understand and adjust to the effects.

At the other extreme, element **8ight** is concerned quite directly with organizing for human goals. About ways in which some business organizations might incorporate some additional sorts of human goals into their own concept of a market. I confess to some difficulty in making Perlmutter's suggestions feel realistic, in the short run, but the interesting thing about the piece, to me, is the basic question it raises. For the enterprising, quasi-autonomous corporation is clearly the most powerful instrumentality ever devised for getting things done—certain kinds of things, that is. If society now wants a different kind of thing done, will anyone find a way still to use the corporate mechanism? Or will the business corporation be side-pocketed, while the fresh exciting things get done in other ways?

Element **7even** offers an instance of the stage reached right now by another shifting set of values, values involving race. There is an aloof no-nonsense air to this stage which I find rather encouraging, and I cannot be as pessimistic as author Bramwell about the direction of further shifts.

Finally, in element **6ix,** Allison's report on the federal technology assessment program deals directly with an element of the new value system. For this is a first attempt at figuring out how to implement the new doctrine that technology is not automatically a "good thing," that it is not an autonomous irresistible force, and that it ought to be judged and dealt with on the basis of its human effects—all its human effects.

What It Takes to Make A Problem Solver Productive

Mostly it takes tension between opposing influences. That's what • Donald Pelz • concludes when he analyzes the often-baffling results of research which tries to find out why some styles of laboratory management are more effective than others.

Most thoughtful managers of R&D laboratories have solid convictions about the goals of the organizations they run, but they are less certain about how to motivate their technical men toward these goals: If you insist that your staff tackle only the problems you see as essential to the organization, you may squelch their enthusiasm—maybe even lose them to competitors; but if you allow them undue leeway to pursue their own leads, they may go off on irrelevant tangents.

In this article I'd like to put forward some ideas on how something as seemingly simple as the climate of communication among researchers can motivate them to undertake the right problems and solve them effectively.

My thinking is partly data-based, partly buttressed by the ideas of others on the nature of creative people, and in part the result of speculation based on my own experience with and observation of such men. I'm hoping that you'll react to these ideas, for the ultimate test of their validity is how they sit with men who manage R&D day-in and day-out. To this end, there's a feedback mechanism discussed at the conclusion of my remarks. I hope you will take advantage of it.

Inasmuch as the argument is a bit complex, I'd like to preface it with a few words about the structure of what is to follow.

First, I shall review two broad concepts labeled "security" and "challenge," which have proved useful to me in understanding a number of seemingly contradictory findings from a study that my colleague, Frank Andrews, and I did a few years ago on eleven R&D organizations.

Second, I would like to compare these concepts with some that other writers have used—particularly the notion of communication "bonds" and "barriers."

In the third section I shall explore further the question of how both challenge and security, as well as communication bonds and barriers, are linked in the problem-solving process.

Moreover, I shall put forward some principles by which working managers might shape the communication climate in their laboratories so as to affect these basic components and thus get their researchers to become better problem solvers.

Let me begin with the matter of autonomy among researchers. Over three decades ago the distinguished head of research at Eastman Kodak, C. E. K. Mees, wrote: "The best person to decide what research work shall be done is the man who is doing the research, and the next best person is the head of the department, who knows all about the subject and the work; after that you leave the field of the best people and start on increasingly worse groups, the first of these being the research director, who is probably wrong more than half the time; then a committee, which is wrong most of the time; and, finally, a committee of vice presidents, which is wrong all the time." This view is widely shared among scientists. Autonomy or self-direction is felt to be an essential condition for scientific achievement—perhaps the most essential one. A close second, of course, is resources. When my colleagues and I began our research on scientific organizations, with the National Institutes of Health being the first, we asked laboratory directors how they managed research. They were likely to answer: "All you can do is find a good man, give him the facilities he needs, and leave him alone."

Hence when we undertook the comparative study of eleven industrial, government, and university laboratories that I referred to a moment ago, we asked several questions about freedom and autonomy. In one question, for example, we asked the individual researcher to estimate how strong a voice various people had in deciding his technical assignments: What percentage of the total weight was exerted by himself, his immediate chief, his colleagues, research directors, nontechnical executives, or outside sponsors?

The more weight a man claimed for himself, and the less for other people, the more he was likely to regard himself as autonomous or free. We then plotted this measure of autonomy against several criteria of performance—such as the judgment of technical colleagues, and the number of recent publications, patents or unpublished reports.

Upon examining our data, we found (with an important exception) the expected trend: As autonomy increased to a high level, performance also increased. But only among scientists and engineers without a doctoral degree. Among men with a doctoral degree, we found a surprise: Performance increased with autonomy up to the point where half the weight was exerted by the man himself; after that, when he felt largely or wholly autonomous, his performance dropped to mediocre.

These results were puzzling. Why should nonPhD's perform better when they had considerable autonomy, but not PhD's? We proceeded to dig further. We ascertained how many decision-making sources exerted at least a slight weight in the man's assignments. Was this choice concentrated in one or two sources? Three? More? What we observed was unexpected: As more decision-making sources were involved, performance of the PhD's also rose.

If Mees was right in his skepticism about research directors and vice presidents, how could we account for the finding that scientists who allowed these gentlemen some voice in selecting their problems were more effective by scientific standards?

Our research results contained other puzzles. As I shall discuss in a moment, the conditions that accompanied achievement often appeared contradictory. In searching for a framework to accommodate these inconsistencies, I was led to the idea of "creative tensions" in the research and development climate—the idea that a sense of "security" and a sense of "challenge" can combine to spur a scientist to creative problem solving. In the paragraphs that follow, I shall outline just enough of this concept to advance my hypothesis concerning communication among researchers; you will find it elaborated further in the *Science* magazine article cited at the end of this discussion.

In looking over our research data, it became apparent that technical achievement was high under several conditions in the laboratory which served to protect the individual researcher from the demands of the environment, or which promoted continuity or stability. To designate any such protecting condition, I used the term "security."

Personal autonomy is such a source of protection, and there are many others. Possession of a doctoral degree, for example, makes it easier to say "no" to a department head. Evidence of this in our study showed up in the fact that PhD's were less often reorganized into new groups. Length of time in the same group, or length of time on the same project, can also provide security. Among the younger scientists and engineers in our sample, performance was positively corelated with length of time on one's main project. Longevity on a group or a project enables one to build up specialized knowledge, and the specialist is better able to resist a disrupting assignment outside his specialty.

Perhaps the most important source of security, in the sense in which I'm using it, is self-confidence or self-esteem. The better performers in our sample preferred to rely on their own ideas. Of course, it's debatable whether achievement generates confidence or whether confidence stimulates achievement (I shall come back to this matter of causality later on). But in either case, it is undeniable that a self-assured person is better able to ignore disrupting demands.

Now in examining our data further for conditions under which technical achievement proved high, we found several which appeared to be the opposite of security—conditions which served to expose the individual to demands of the environment, or to disrupt his ongoing patterns. As a general label for conditions like this I used the term "challenge."

One example is the involvement of several other people in selecting assignments. Here, the technical man is exposed to other peoples' ideas or criticisms. Challenge can arise from facing an unfamiliar problem, from encountering approaches different from his own, from having flaws in his solution pointed out.

Diversity of activity can provide challenge. Our data showed that the most effective scientists and engineers, both in research and in development labs, were not those who concentrated on research only, or on development projects only, but those who did some of each. Nor did these same high performers concentrate wholly on technical activity as such. Rather, they spent up to one-quarter of their time on administration or teaching.

Challenge can also arise from dissimilarity among or disagreement with colleagues. In older groups, whose members had been together several years, the more effective groups were those in which the men differed in their technical approach to problems and engaged in intellectual dispute.

In pondering this evidence of achievement flourishing under conditions that seemed antithetical, I began to wonder whether beneath the apparent disorder there might lie a more basic order. Did achievement flourish not in spite of the contradictions but because of them? Was problem solving stimulated by a "creative tension" between some conditions that gave security and others that provided challenge? Let us see how this might be so.

Consider the case of independence versus interaction. A dominant trait of first-rate scientists is their self-reliance, their insistence on their own ideas, faith in their own judgment. To measure the strength of this trait among our sample, Andrews and I constructed an index of "motivation from one's own ideas," using items from our questionnaire in which the scientist reported a stimulus from his own previous work and his own curiosity.

It turned out that our high performers were strongly motivated by their own ideas, by stimulation from within. But at the same time they did not avoid stimulation from without. They interacted more vigorously with colleagues than did less effective scientists. The same trend has been noted by other investigators. Tom Allen at MIT and Schilling and Bernard at George Washington University observed, in industrial and government labs, a positive relationship between the performance of engineers and scientists and the extent of their communication with other members of the organization. Effective performers, in short, seem to be men open to both internal and external stimuli.

Are the two types of stimuli incompatible? Not logically, of course, but psychologically each tends to weaken the other. We know from everyday experience something that psychological experiments have verified—that in the face of social concensus it is difficult to maintain one's independence. Yet creative scientists are able to do this and to flourish.

Herbert Shephard, a management consultant wise in the ways of R&D people, has borrowed a term from personality theory to shed further light on this phenomenon. The creative man, he says, must be able to act alone, to compete or rebel, when that is what the task requires. But he must also possess what O. J. Harvey and his colleagues at the University of Colorado call "autonomous interdependence." That is, the creative man must also be able to depend on others and to join with them in intimate teamwork, when that is what the task requires.

Interestingly, one can find this same dissonant blend in the worlds of letters and of common sense. Take Emerson's essay on "Self-Reliance," for example, in which he used "the world" to mean one's social milieu:

"It is easy in the world to live after the world's opinion; it is easy in solitude to live after our own; but the great

man is he who in the midst of the crowd keeps with perfect sweetness the independence of solitude."

For Emerson's "great man" substitute "creative scientist," and you have the tension between independence and interaction.

Or take the commonly held adage that necessity is the mother of invention. There is certainly some pertinence here, if "necessity" is taken to mean not merely adversity but rather the perception of a problem, coupled with the belief that a solution can be found. In fact, awareness of a problem is among the most essential forms of challenge. It sounds commonplace to say that problem solving requires that a problem be perceived, but the point is easily missed by many who proclaim the virtues of idle curiosity and serendipity.

Necessity, then, is a form of challenge which can spur invention. But invention in my conceptual framework has more than one parent. Necessity is better called the father of invention. Challenge in my view is a masculine attribute. The mother of invention is rather security. When the masculine and feminine components are joined, the creative tension between them can give birth to technical achievement.

In concluding this part of my discussion, I should like to make more explicit two features of this creative tension concept.

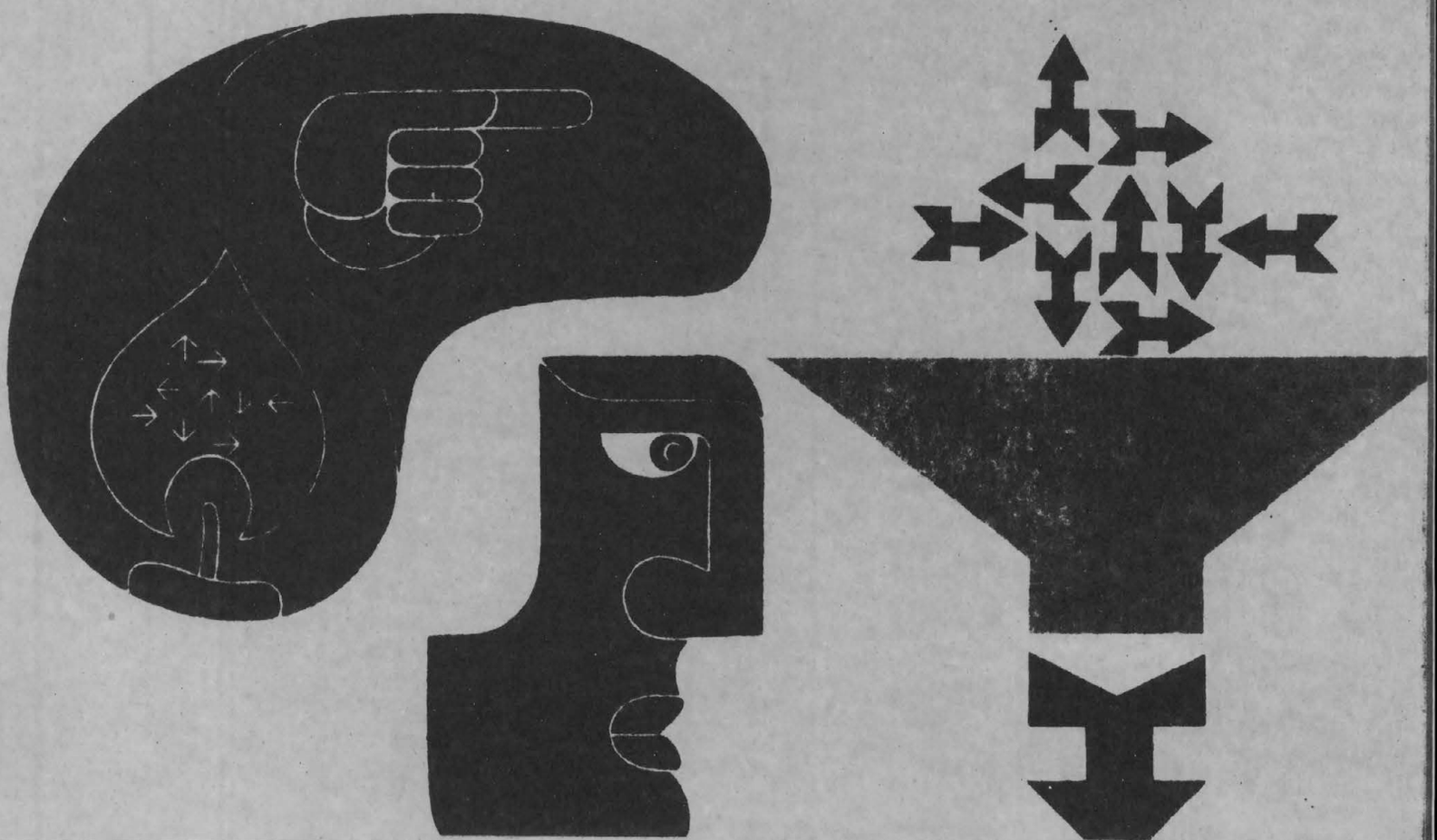
First, I do not consider the optimal climate to lie halfway between extremes—at some compromise between security and challenge. Rather, the creative scientist needs a lot of both. He should be exposed to disrupting demands from his organizational environment, and at the same time have the means to filter these demands.

Very broadly, my major hypothesis is that for creative problem solving to occur there must coexist conditions both of strong security and of strong challenge. But coexistence need not mean strict simultaneity; the two conditions can occur in succession—periods of intense exposure followed by periods of withdrawal, with the cycle periodically repeated.

A second hypothesis is a plausible corollary; namely, that the intensity of the two components must be in balance. The stronger the security, the stronger must be the challenge if creativity is to flourish. Otherwise the individual or the group will stagnate. On the other side, if security is weak then challenge must also be mild; too much challenge in this case will arouse anxiety and rigidity.

Some hints of this corollary appeared in our data. Among men of lower status in the organization, or among those who felt they lacked influence—that is, men low in security—maximum performance occurred when their assignments were affected by somewhat fewer other people.

At the other extreme—that of high security—we pressed the question of why scientists with maximum autonomy were only average performers. One clue emerged from our measurements on the tightness or looseness of coordination within the department where such men resided. Now a loose organization does not



make demands on its members. We found that when scientists were both autonomous and in loose departments, they withdrew from contact with colleagues, and they specialized in narrow areas. They were even less involved in their work! In short, they minimized their challenge.

But—and here's the point—it was precisely under these conditions of high security (as defined by looseness of coordination) that challenge was shown to be most essential. We found performance to be most strongly corelated with stimulation from the man's environment. It would seem, therefore, that a non-demanding organization permits an autonomous member to withdraw into an ivory tower of maximum security and minimum challenge, where he can grow comfortably stale.

A little while ago I said I would take up the question of causal sequence, and right here is where it should be examined: If we do observe that creative performance is strong in the presence of both security and challenge, how is this association to be interpreted?

One view is that the individual creates his own conditions. An outstanding scientist can insist on autonomy and stability, and he thereby generates his own security. His achievements can also attract attention from colleagues and top management, who then become eager to seek his help; thus he generates challenge.

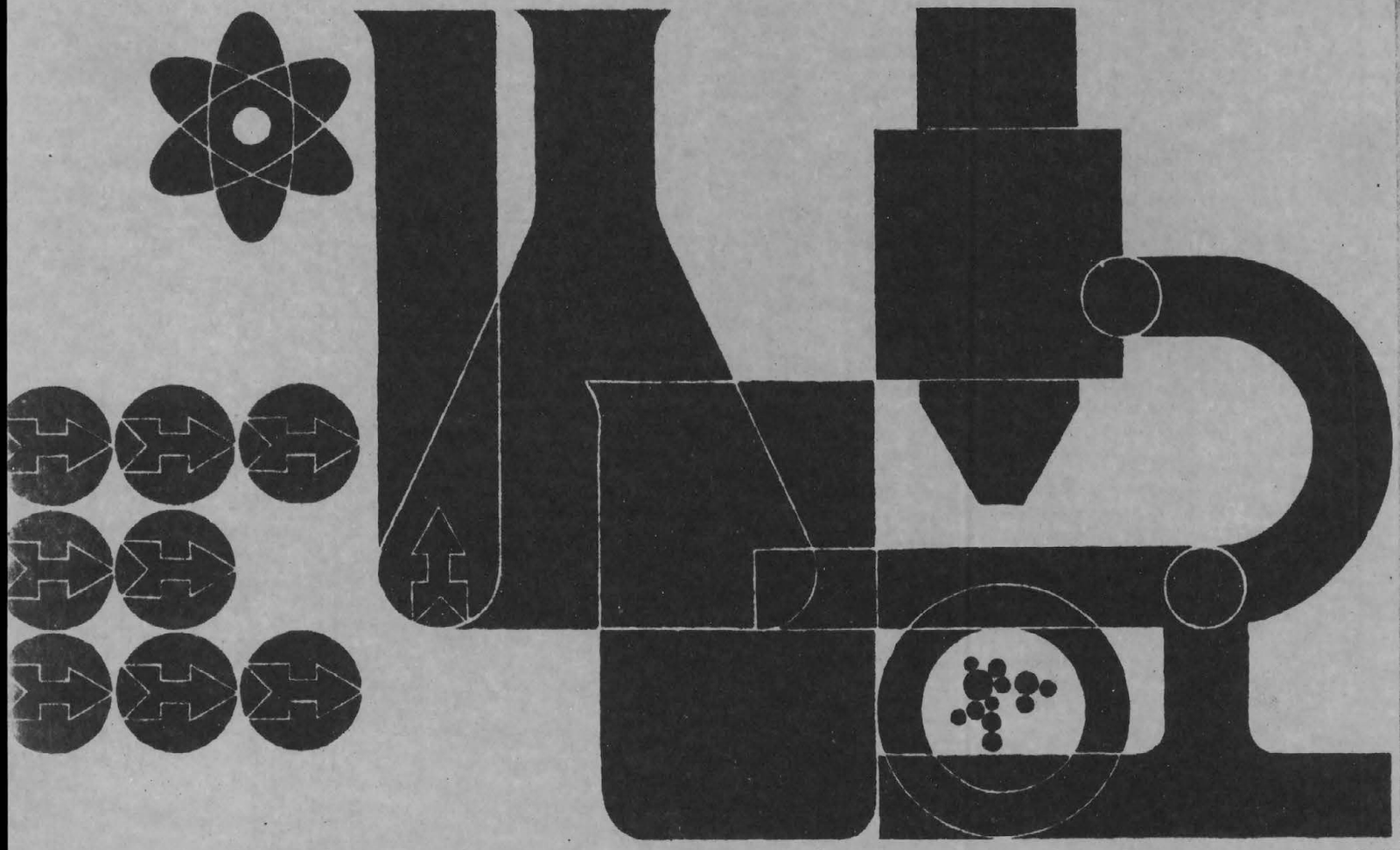
But what about the reverse sequence? Can the right combination of externally generated security and challenge stimulate a technical man to perform above his "natural" level of competence?

Many technical readers will subscribe to the first sequence since it happens all the time. It is consistent, too, with Mees's view quoted earlier, or with the philosophy that all a lab director can do is to recruit good men, give them facilities, and leave them alone. Implicit in this viewpoint is the conviction that you can smother a good man with rejection, or starve him with poor equipment, but you can do nothing to boost his achievement beyond certain "natural" limits of his competence or training.

But I believe that the second sequence can also work. Or, to change the slant slightly, I favor a circular or feedback interpretation of creative performance in which both sequences operate: achievement engenders conditions which, in turn, stimulate achievement. But, most important, I would argue that the cycle need not start only with the individual and his given abilities. A research manager can, I believe, promote conditions which will help a man to achieve, and can thus cause the circular process to operate more intensely.

As a prelude to constructing a model of how such a circular process might work, I want to draw upon the thinking of Jack A. Morton, vice president of Bell Telephone Laboratories. As you will see, his notion of communication "bonds" and "barriers" ties in rather nicely with the ideas about creative tensions between security and challenge that I have been discussing.

The focus of my own studies, as discussed thus far, has been on the individual and his interactions with other individuals and groups.



Morton looks rather at the departments within a research and development structure and their relation to each other and with the rest of the company. His approach is that of the systems engineer, and his analogy is an electronic device or system in which "the thing being processed is information . . . that goes from one person to another . . . Just as in an electronic circuit, you use insulators, conductors, semiconductors, to build barriers and bonds to the flow of electrical information." He argues that both barriers and bonds are needed to keep the total R&D system productive.

Now an information or communication barrier is intended to buffer the individual from outside stimuli; hence the parallel with security. A communication bond, of course, ensures exposure to outside stimuli; hence the parallel with challenge.

Morton defines two kinds of bonds and barriers. One kind he calls "organizational," meaning linkages or separations created by lines of authority and responsibility in the organizational structure. The second kind of bond or barrier is "spatial," arising from physical closeness or separation.

Information must be transmitted between basic and applied research, between applied research and design development, between design and manufacturing. The people in each must be able to understand the others, and be able to work together if the total organization is to operate. Yet if the design or engineering groups can dictate to the research groups, this will stifle the latter's freedom. How do you accomplish the first but avoid the second?

The answer adopted by Bell Labs is not total separation. If you separate the groups physically as well as organizationally, there will be too great a barrier to the forward flow of new knowledge and designs and to the feedback flow of evaluation. Says Morton, "Now we know we should never have a space barrier and an organizational barrier on top of one another. We use organizational and spatial links in complementary relations—wherever we have a space barrier we also have an organizational bond, and vice versa."

A nice example of the same philosophy was given not too long ago by Jack Goldman, then head of the Ford Scientific Laboratory and now in charge of R&D at Xerox. Ford Motor Co. had acquired the Philco Corporation, and the Scientific Laboratory wanted to establish a basic research group in electronics The Scientific Lab was in Detroit, Philco in California. Goldman created a group of basic researchers, which he made organizationally responsible to himself. But he located the group physically at Philco's California plant, so that contact between research and engineering could stimulate discovery. Between them, that is, he placed an organization barrier but a spatial bond.

There is an obvious parallel between this strategy of Morton's (and Goldman's) and my central hypothesis—that conditions of challenge and security should be complementary and balanced for creative achievement to occur. With this parallel in mind, I want to move on now to the circular mechanism I spoke of earlier when talking about the matter of causality. Through what sequence of events does a combination of security and challenge lead to creative achievement, and how does achievement in turn strengthen security and challenge? Further, what kinds of communications climates will enhance or inhibit these reciprocal processes?

If the several causal linkages can be clarified, I believe we can find ways to modify the climate of communication—the mix of barriers and bonds. To this end, I'm going to outline a model of the problem-solving process, incorporating as I go the notions of security and challenge. Then I shall focus on what seem to be the critical linkages between events in the hypothesized network, points at which managers might effectively intervene. The manner of the intervention will be suggested by additional findings from our study of R&D organizations. Finally, I shall comment on aspects of the climate in which this intervention would take place, again drawing upon research data where it is helpful.

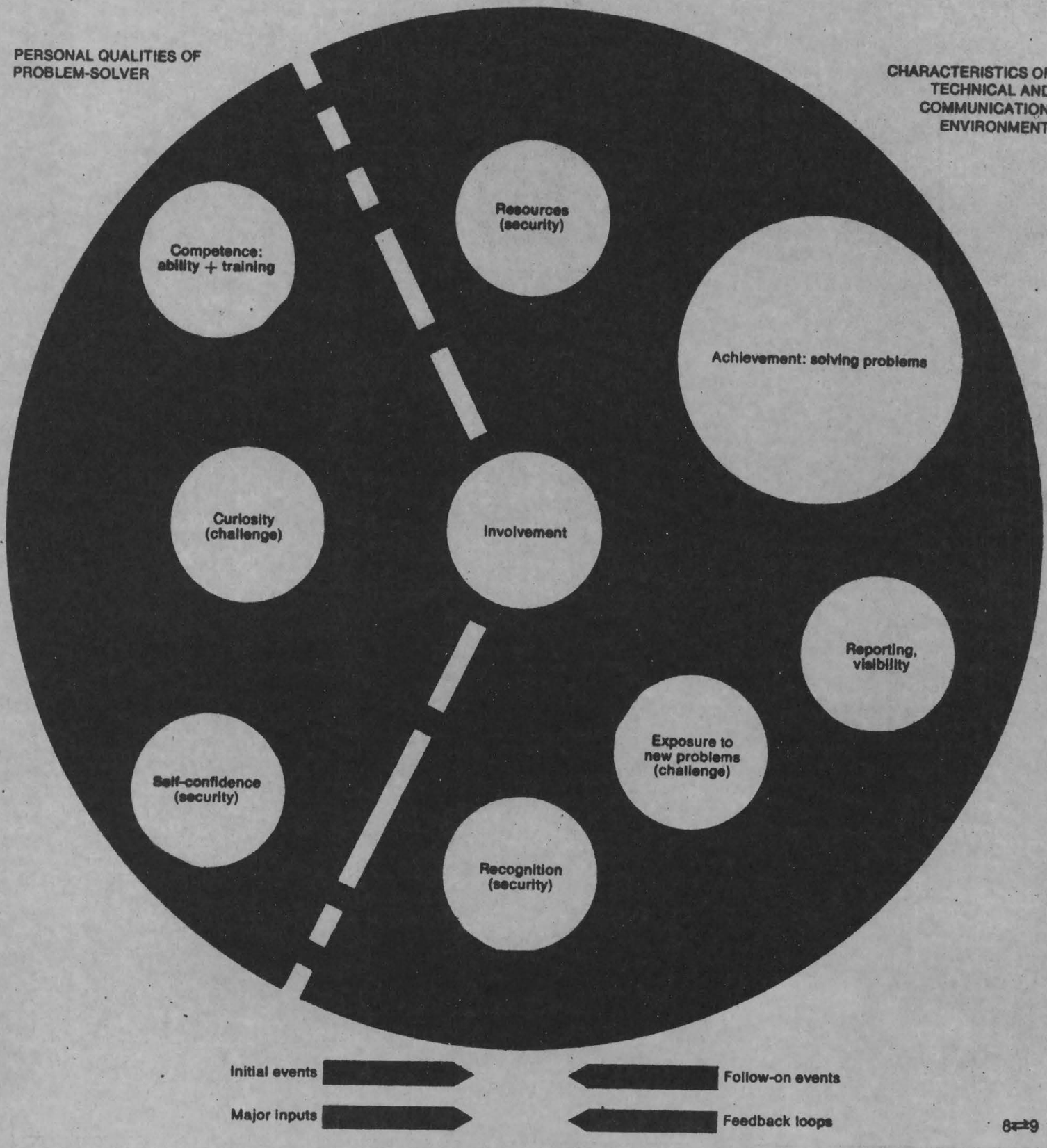
As the adjacent diagram suggests, there are two main components in this model of the problem-solving process: the qualities of the individual problem solver (left half of the diagram), and the technical environment in which he works (right half). Let's start with the first of these components.

There are really four key qualities of the individual himself, but the three shown at the far left group logically together. The first of these is simply competence, arising from the man's intellectual ability and from his training and experience. A second is self-confidence, which sometimes appears as dominance or even arrogance, and is widely found in assessments of creative individuals. A third characteristic I have labeled curiosity. This may appear in several forms, such as zest for new experience, or enjoyment of puzzles.

A little apart from these three qualities I have placed the fourth one—involvement—the capacity to become absorbed in the problem-solving activity. In our study, the more effective scientists in all settings were deeply involved in their work. I've located this quality midway between personal qualities on the left and the technical environment on the right because it depends partly on a personal capacity for enthusiasm, and partly on the nature of the work itself.

Model of The Problem-Solving Process

The Author's model of how problems get solved is a complex interaction between qualities of the researcher himself (at left) and characteristics of the environment in which he works (at right). Many of these qualities and characteristics can be interpreted, as explained in the text, in terms of "security" for the researcher or "challenge" to him. Creative tension between these two factors, says the author, tend to spur the researcher to achieve solutions to problems.



Some of these personal qualities reinforce others, as the arrows suggest. Competence usually increases self-confidence, which in turn sustains curiosity—especially when one is probing into unfamiliar territory. The combination of self-confidence (a security factor) and curiosity (a challenge factor) will heighten involvement.

The connection between competence and curiosity is less clear. On the one hand, you have to know something about a field to realize where its puzzles lie. But if you know a great deal you will take much for granted, and curiosity is inhibited. This is why the arrow between them is marked (±). To emphasize the point, I cite the comment of a physics professor renowned for his gift for turning out PhD aspirants, many of whom went on to high achievement: "My method? I spend as much time talking about what the field doesn't know as about what it does."

Each of these four personal characteristics is essential to problem-solving. Absence of any one can block the effect of the others. The roles of competence and curiosity are obvious; they are necessary, but by themselves not sufficient. Involvement serves to keep the mind absorbed and the energy flowing, for problem-solving is tough work.

The role of self-confidence is less appreciated than that of the other three qualities. Problem solving is a hazardous enterprise, beset with frustration, failure, and hostility. Creativity can be threatening to an organization and the organization tends often to react by suppressing it. So it can take enormous confidence in one's own ideas, sustained over years sometimes, before one is able to prove them out and win acceptance.

The next step in the model network is technical achievement—attacking and solving significant problems. As the arrows indicate, all the personal qualities contribute here, and you must also have adequate resources in the form of equipment and assistants. (There are other inputs, of course, which I have not tried to picture.)

Achievement is likely to trigger follow-on events, provided that the achievement becomes known through some form of reporting or visibility—a most important step, whether it be done by publication, seminar, personal dialog, or whatever.

Hopefully, there follows recognition—and I mean this in the basic sense of awareness and appreciation rather than monetary reward. One preferably gains recognition not only from one's immediate colleagues or boss, but also from executives at higher levels, and perhaps from the lay public. Whatever the source, recognition acts as a security factor, of course.

As the individual's work becomes known, other people begin to exchange ideas with him, perhaps to seek his help on their problems. These contacts lead to another step in the network by increasing his exposure to new problems, to other areas of inquiry. These are all a natural source of challenge.

With the basic elements of the model in place, the feedback loops can now be completed. Achievement means more experience, and this directly increases competence. Recognition reinforces self-confidence; exposure to new problems nourishes curiosity; and both of them strengthen involvement. Achievement also gains the problem solver access to additional resources.

Sustained by heightened self-assurance, intrigued by bigger problems, armed with added knowledge and resources, the individual is able to accept tasks of increased difficulty and risk. And thus the conditions are set for further achievement in the next cycle.

Now I want to examine some of the points in this model where the manager can intervene to good effect, for I believe the R&D manager can do far more than simply provide assignments and resources and then wait for the man's personal qualities to produce results.

One of the manager's essential functions, it seems to me, is to prod the younger technical man into early achievement, and then to push its visibility and recognition. Too often this function is obstructed by typical company practice: When a new man is hired, he is assigned to first one department, then another, and another—all this to give him a well-rounded picture, to diversify his interests.

But the younger man is more in need of a solid foundation of success. We found in our study that among scientists and engineers under 30 years of age, performance was strongly correlated with having worked on his main project for one or two years. Of course, the area in which the young man focuses should be compatible with his interests. But he should be urged to focus soon, on a task that is challenging but within his reach, and to stay with it. His manager should give him every assistance in producing a creditable outcome, and should see that the outcome is publicized.

Behind all this is the fact that confidence in your own ideas is a fundamental security factor. A dominant personality helps, to be sure, but even more helpful is achievement you can claim as your own. That's why the research manager should see to it that, at least once or twice a year, each man generates a product or part of a product—whether a publication, a technical report, a patent application, a design—which he helped create, and which bears his name.

I have said that achievement is likely to increase exposure to new problems, which in turn will stimulate curiosity. These feedback loops offer excellent opportunities for managerial intervention. Let me take a couple of examples.

In listening to laboratory administrators recount successful developments, one finds many anecdotes in which the manager brought together a research man and some applications people to talk about a problem on the applications front. At first the research man could see no relevance to his own endeavors. As they talked, he became aware of possible connections, and saw exciting possibilities of translating the practical problem into a form which his theory could attack. Often, in the translation process, questions would arise for which the theoretical background provided no answer, and the researcher was stimulated to devise one.

This is a common enough tale, when you think back on your own experience. But how often are such confrontations deliberately set up so as to speed up the feedback loops? Not often enough I suspect.

My second suggestion for intervention arises from an important finding from our research study. We wanted to find out how the performance of a scientist or an engineer related to the amount of time he spent, by his own estimate, on strictly technical activity as against administration or teaching. As you might expect, the more time spent on research or development work the higher the performance—but only up to a point.

It turned out that the men who spent about three-quarters of their time on technical matters and one-quarter in teaching were more effective technically than those who spent full time at the bench. This result makes sense, since students provide challenge by forcing the teacher to test and expand his ideas. But we were surprised to find that technical men who spent about one-quarter of their time in administration were also more effective technically than full-time researchers. Why?

It could be simply because the best men are given administrative assignments, but I think we must also consider the possibility that some forms of administrative activity can serve as a challenge to technical creativity.

For example, serving on a department-wide committee (whatever its ultimate effectiveness) can bring a man into contact with others he might not ordinarily encounter. It can help to build communication bonds where spatial and organizational bridges are lacking. Now such committee assignments normally go to the senior staff. But what if a deliberate effort were made to involve junior men as well? What if each technical man, new as well as old, were involved in some sort of cross-organizational administrative activity a few times a year? I argue that technical performance would improve, rather as our study data indicated.

As you think about my rough model of the problem-solving process, and check it out against your own experience, I am sure you will see other specific points of effective managerial intervention. Rather than pursue such specific actions further, I should like to examine briefly several aspects of the general climate for communication over which managers have control, and to suggest some attitudes which may lead to more creative achievement.

The first aspect arises from the question of just who should decide what tasks the researcher should undertake. Our study data suggest that multiple involvement is needed in such decision making. When the chief alone had the main voice in determining a man's assignments, performance was lower than under any other condition. By contrast, in development-oriented labs, weight shared jointly by the investigator and his chief was a favorable condition, while in research-oriented labs joint weight shared between the man and his colleagues proved favorable.

Now what this says to me, in terms of the communication climate in the lab, is that the smart manager will assure that multiple channels exist for disseminating the individual's work and for recognizing his achievements. Not one man but several must know what he is doing—including people outside his own section, and those at higher levels. Then, whenever the investigator allows other people to have a voice in deciding his assignments, he is also letting them appreciate his achievements. This provides security as well as challenge.

Connected with this aspect of multiple channels for communication is the matter of the personal interaction that takes place through them. Effective technical men, we know, communicate often with many other people in a variety of roles. What creative functions are served by frequent and diverse communication?

I have already suggested that communication not only provides challenge in the form of unsolved problems, but also security in the form of recognition for accomplishment. Glancing once more at the model diagram, it's clear that interaction can also stimulate curiosity, and can build self-confidence.

Another major function is assuring relevance. Does the technical man attack problems that are central or peripheral to the organization's concerns, or to the discipline's state of knowledge? Communication with superiors helps to assure organizational relevance; communication with colleagues solidifies scientific relevance.

Creative thinking is said to occur when previously known but unassociated elements are brought together in combinations that are both novel and useful. If so, interaction among persons with different approaches can provide a diversity of inputs and thus help creative problem-solving.

And lastly, we saw from the model that achievement depends in part on the personal quality of involvement. Is the technical man gripped by what he is doing? Or is it just a job, one of several interests? Enthusiasm is contagious. If supervisors or colleagues are interested in what you are doing, and express this interest, your own involvement is heightened. Thus the strengthening of motivation is an important function of interaction.

Earlier in this article I suggested that challenge can be provided by dissimilarity between the researcher and his colleagues, and by disagreement on technical strategies. How much conflict, and of what type, is desirable? How much is harmony needed for creative problem-solving?

The ultimate answer may depend on where we focus in the continuum from the generation of a new idea to its final incorporation in a changed technology. When the necessity is to originate or to invent, perhaps more disagreement is needed and more disharmony can be tolerated. When the task is rather to execute designs already agreed upon, the tolerance is lower, and disagreement can become disruptive.

It is important to distinguish between two forms of disagreement—technical and personal. Our study data suggest that intellectual disagreement and conflict can facilitate problem-solving. On the other hand, personal conflict or hostility probably inhibits it. Hostility will usually block the channels of communication—by preventing people from talking together who should be talking, or preventing them from saying what they should be saying.

When we examined groups of researchers who had performed well together over a considerable period, we found that they attached great value to intellectual disagreement (a challenge factor) in conjunction with personal agreement or attraction (a security factor). Such groups remained effective if, on the one hand, they maintained social cohesion—if the members valued one another and voluntarily sought contact with each other. On the other hand, group effectiveness continued if the members maintained different technical strategies, and (surprisingly) were somewhat hesitant to share their technical ideas freely with colleagues. They seemed to be intellectually wary of each other—respectful but argumentative. Here again is a creative tension between security and challenge.

Critical evaluation of a proposed solution to a knotty technical problem is essential at some point, but how can it occur without blocking communication? My own view is that if an atmosphere of trust and confidence can be generated, a high level of intellectual conflict can be tolerated without damage to the communication channels.

Precisely how this can be accomplished is the subject of a whole other article. Nevertheless, we can certainly say that having the right leader plays a big part—a leader who believes in what John Stuart Mill called the "morality of public discussion."

There is great potential, too, in the introduction of sensitivity training into more R&D organizations. If it's done carefully, one can gain valuable insights from an open discussion of how one's actions affect other people, and how they in turn affect him. Ultimately, as interactive skill is increased, and along with it one's security in communicating with others, the prevailing trust among members of the organization will rise. And as this occurs, greater intellectual conflict can be permitted.

But whatever the wellsprings of a more trustful climate, it seems to me that the end objective should always be to nurture Emerson's great man "who in the midst of the crowd keeps with perfect sweetness the independence of solitude." Among such men, I am sure, are to be found the creative problem solvers of this world.

Comments the Editor (FP):

One of the personal qualities that author Donald Pelz attributes to the creative researcher is curiosity. Pelz himself is an inquisitive (and creative) fellow. This side of his nature is typified by his request at the beginning of his article in this issue. He said, in effect, "I'm going to think out loud a bit about what makes researchers creative; when I'm done, I'd like to know what you think of my ideas."

As I edited his article, I pondered what might make the best feedback mechanism. A certain number of readers, of course, would jump at an opening like that and write their reactions directly to him. But then I thought, Pelz is a behavioral scientist (a social psychologist), and asking questions is his forte. So why not let him devise his own questions, and we'll put them in the Response Sheet for this issue.

Donald C. Pelz

This is what we've done. Although space is limited on this questionnaire of ours, Pelz has worked out a simple rating scale on how you see your own organization in terms of its promoting security and challenge, respectively. I suggest that you respond to his questions, and we'll let you know what the combined reader-replies look like.

If you want to comment on other aspects of his article, such as his circular model of the problem-solving process, write him a letter. Dr. Pelz can be reached at the University of Michigan's Institute for Social Research, where he is a program director in the Survey Research Center. The mailing address is simply Ann Arbor, Michigan 48106.

Or, if you'd like to talk to him directly, he's kindly agreed to be in his office all day on March 11 for this purpose. The direct number will be (313) 764-8397. Mark it on your calendar.

Though author Pelz touches on the highlights of his research into R&D organizations in his article, the detailed findings will be found elsewhere. Look in his book, "Scientists in Organizations," by Pelz and Andrews (Wiley, 1966, $11), or in two *Science & Technology* articles: "Freedom in Research" (February 1964) and "Diversity in Research" (July 1964). His security-challenge concept is treated more fully in "Creative Tensions in the R&D Climate" *(Science,* July 14, 1967). On the question of autonomy, and how it affects the performance of scientists as against engineers, see "Autonomy, Coordination, and Stimulation, in Relation to Scientific Achievement," by Pelz and Andrews *(Behavioral Science,* March 1966). And on communication bonds and barriers, look up Jack Morton's article, "From Research to Technology" *(Science & Technology,* May 1964).

Interoffice Correspondence 3M COMPANY

Subject:

9/22/70 Changed name Research Area to more meaningful title

September 11, 1970

TO: AL BOESE - NEW BUSINESS VENTURES - 219-1
BILL FLANAGAN - MEDICAL PRODS. - 218-3
CARL MILLER - GRAPHIC SYSTEMS - 235-3
HAROLD SOWMAN - CENTRAL RESEARCH - 201-BE
SAM SMITH - CHEMICAL DIV. - 236-1
GEORGE TIERS - CENTRAL RESEARCH - 201-2S

FROM: HERB ARNESEN - EDUCATION & TRAINING - 220-2E

Following our meeting yesterday I was asked to convey to you a copy of the meeting record. It is attached. I believe it is a verbatim copy of the notes except for some rearrangement of order as was noted in the margin.

At the end of the meeting it was also agreed that the attached articles might be of interest; they are: "The B. F. Goodrich Article", "Corporate Decentralization Called Necessary", and "Management by Creativity and Innovation".

Sam has asked me to remind you that we will meet again at 2:00 pm Tuesday, September 22, in the same room, 236-226B.

I enjoyed our meeting yesterday and hope you felt it worthwhile. I look forward to our being able to arrive at some conclusions at our next session.

Herb

HPA:ba
Enclosures

Note: The following has meaning only for the meeting attendees and is not intended for use by others.

FACTORS THAT FAIL TO CONTRIBUTE MAXIMALLY TO (OR INHIBIT) CREATIVITY AND PRODUCTIVITY IN 3M R & D:

Dual ladder
. Must include technicians.
. Is it an attractive route?
. Maybe dual ladder should have different distinctions.
. Use of dual ladder varies greatly across company.
  -- Some use this as holding position for later promotion.
. Location of Research Associate within division causes marriage to division product vs. availability to entire company. (Corporate funding was mentioned as an alternate.)

Technicians
. Recognition
. Reward
. Innovation
. Have contributed
. Can go up dual ladder (and have--Al)
. They may not know.
. Are they on team?

Morale
Problems:
. Can't know title--technician up scale
. Don't know title
. "Specialist" now derogatory.
  "Research Associate" has meaning only within 3M.
  "Sr. Research Specialist" is higher than "Research Associate" elsewhere--at University "Research Associate" is a peon.
  Comparative rank (of dual positions) not understood.
  Rewards also not understood.

Insecurity (job security)

Degree people need to be motivated
. Are they on the team?
. Tend to perform like technician
. Don't take initiative
. Should know what he is going to do

Creativity incomplete until associated with product; thus, anything between the R & D such as:
. Shortage of development personnel
. Short memory of early contributor--(recognition) morale
. Mutual trust
  -- openness to exchange ideas and help
  -- possessiveness
. Pirating--write up patent of work of others
. Long delay in feedback on record of invention

(New Sheet)

Patent problems

- Failure to provide adequate patent
  Lawyers to secure inventions for 3M. Ex: Turn down ideas as unpatentable which are later patented by other companies.
- Restrictions on writing patent proposals
- Methods of writing patent proposals vary between divisions.
- (An alternate method was described--that of Dupl. Prods.)

(New Sheet)

Possible stimulants

- Special parking
- Sabbatical
- Picture on special wall
- Limited tenure (7 yrs.)--reinstatable
- Accumulated vacation

(New Sheet)

Proposal:

1. Correct inadequacies of dual ladder system
   - differences of application
   - too few people at top
   - update job description.

   Consider:

   - Representation on Bd., Mgmt. Committee, Tech. Council
   - All Research Associates on Tech. Council
   - Freedom of mobility
   - Freedom to serve community
   - Overt recognition

2. Promulgate (publicize) the dual ladder system to those on it and to all others.

3.

TO: RESEARCH ASSOCIATES

FROM: BETH ANDERSON, SECRETARY TO HERB ARNESEN

Here are the articles that should have been attached to the letter dated September 11, but which, unfortunately, went out much later. Due to the rush they were ommitted.

Thank you.

BA

THE CHRISTIAN SCIENCE MONITOR, Tuesday, July 21, 1970

New breed of employee

Corporate decentralization called necessity

By Richard A. Nenneman
Business and financial editor of The Christian Science Monitor

Boston

Do you ever get the feeling, Mr. Businessman, or you, Mrs. Pennysaver, that the pace of life is too fast—that you'd like to stop the world and get off for awhile?

If so, you aren't alone. Yet, while that is a decision that individuals sometimes do make, it is one that no corporation operating within the disciplines of our system can afford to make. In fact, business seems to be caught in a web of its own making in which it has to spin harder just to stay even with the competition.

David J. BenDaniel, a visiting lecturer at the Harvard Business School who is about to rejoin the General Electric Company, where he is manager of advanced programs in its Schenectady Research and Development Center, told in an interview of steps GE is taking to stay even with, or ahead of, the pack.

Professionally, Dr. BenDaniel is a thremonuclear physicist. He is also keenly sensitive to human beings and their attitudes toward work and its organization. He and his wife have run a coffeehouse for young people, and he is currently chairman of the Police-Community Relations Committee in Schenectady County, New York.

Program to decentralize

GE, he noted, has for many years been engaged in a program to decentralize into product-oriented operating groups. Each of these groups has its own profit-and-loss responsibility. This allows for more initiative at lower levels in the company. Smaller business units are, in theory, more adjustable to changing conditions. This, in turn, should make the entire company more adaptive.

This decentralization of a large company isn't unique to GE, of course. Decentralization is a necessity for this generation, Dr. BenDaniel noted, and isn't caused solely by the corporate need for flexibility. It also is a demand of today's new employees.

College graduates today want meaningful work. They also want to work in an environment they can relate to. This means, he said, working either in a small company or in a large one that has found out how to imitate the positive aspects of work in a small environment.

New operation seen

But Dr. BenDaniel wants to go one step further. When he returns to the firm, he wants to head up a new operation to set up new technical ventures in which GE has a minority interest. The idea behind this embraces both the needs of the company and the desire of young entrepreneurs to work where they can "do their own thing."

The opertaion would exploit a fraction of GE's technology not being used by the company itself. Any corporation carrying on many major research and development (R&D) programs finds many more opportunities than are appropriate for internal exploitation.

The idea is that, if GE has decided not to go further with a particular development within the company itself, it may then make a decision to make it available to others—either through an outright license or to a new venture in which it will become only a minority stockholder—to develop the idea commercially.

Promise offered

The men who have worked on the project in its R&D stage might even want to go with the new company as principals. Commented Dr. BenDaniel, "A man means a great deal to an organization when he's running with an idea. But he isn't much good if the idea is turned off for purely internal reasons, however legitimate. His main interest lies in exploiting the work he's given his heart to."

The new operation offers a promise to both young technical talent and business talent (such as Harvard MBAs). Indeed, Dr. BenDaniel himself sees this as perhaps the best way large corporations can continue to attract top entrepreneurial talent. (Another Boston area professor, Jay Forrester at Massachusetts Institute of Technology, has remarked that he could set up a small company employing five men and give them a more exciting challenge than most large corporations do.)

Any development that promises to speed up the use of new technology can be quite valuable. Yet without applying the following specifically to General Electric, this is but one of the ramifications, and perhaps a disturbing one, of the accelerated technological pace of business life in general today.

Rocks foreseen

Here is how. The latest McGraw-Hill survey of corporate R&D plans shows an increase in spending of 18 percent between now and 1973 (from $20.7 billion to $24.3 billion). For anyone thinking America's economic salvation lies in staying ahead in technology, this sounds good.

Underneath the placid surface of these figures, however, lie some rocks that may have jagged edges. First, the government's share of R&D spending is expected to drop from 45 percent (1969) to 37 percent (1973). Many foresee a long period of decline in government spending in this area. It may be too early to say it categorically, but the danger exists that basic research in the United States faces a major setback in the '70's.

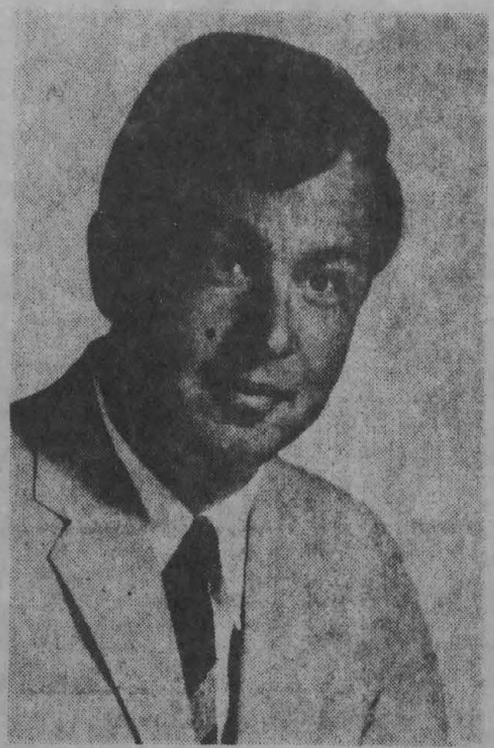
Even the 18 percent three-year increase projected by McGraw-Hill, if it materializes, might not represent any increase in real terms. Second, because of today's profit squeeze there are signs the corporate money going into R&D will be less research-oriented, more development oriented.

But today's profit squeeze doesn't explain the entire problem. The profit squeeze is probably not a temporary phenomenon and is exacerbated by that furious pace of competition that makes one wish he really could stop the world.

Recovery-time factor

Competition often decreases the time available in which to recover profits from a new product. As this becomes a general situation, it seems inevitable that there will be another, critical look into the corporate funding available for R&D, as well as its distribution. Expected future profits must bear some relationship to past R&D costs. It's even possible, noted Dr. BenDaniel, that many firms will decide it's better to be a quick second than to be first. The recent experience of Japanese industry, vis-à-vis the other industrial nations, is a case in point.

Here, then, is a seeming contradiction in need of resolution. On the one hand, heightened technological competition, which is a peculiarly American credo. On the other, the danger that our commitment to basic research could falter, one of the consequences of fierce competition making less money available for that purpose.



David J. BenDaniel

Decentralization is a necessity for this generation, according to this General Electric physicist-manager.

Management by Creativity and Innovation

F. D. Barrett, president of Management Concepts Ltd. of Toronto, discusses a theory of management relevant to our changing times in the Summer 1970 issue of *The Business Quarterly*. We quote the following excerpts:

The ability to think imaginatively has always been a valuable element in successful business and management performance. But in the present period of radical flux and change, it is taking on both a new importance and a special urgency. Fortunately today we know more about how to exercise ingenuity, imagination and creative thinking than ever before. An increasing number of managers are making a point to learn and use some of the new creative thinking methods which are now available. These methods can be employed to generate ideas at such strategic levels as how to redirect the course of the business. Or they can be put to work at such tactical levels as to how to reduce costs.

The enterprise which wishes to be innovative has to make it a deliberate objective and conscious policy. In the management world the single most important factor influencing creative activity is the organizational climate. But organizational climate can turn off, or turn on, creative output with equal ease. Most business and public organizations were historically set up upon a hierarchical, bureaucratic model. A quasi-authoritarian basis is created which encourages conformity and uniformity. Bureaucracy discourages that independent and autonomous thinking which is the essence of creative innovation and personal ingenuity. Other features of organizational climate which suppress creative thinking are: undue respect for existing policies and practices; frequent reference to past precedents and experiences; lack of strong orientation toward the future; absence of planning and management by objectives; excessive caution, coupled with severe criticism for errors and mistakes; dislike of the different or unusual and preference for the customary, the orthodox and the established.

Aspects of organizational climate conducive to the release of ingenuity are: scepticism toward existing policies and practices, decision making which is future-oriented, a planning and objectives management-style, relative indifference to minor errors, and an appetite for constructive novelty.

The larger societal environment within which managers are currently operating is clearly one in which change is associated with intense conflict and even physical violence. Despite this, it is on the whole an environment in which innovation and creativity are less rejected than in earlier periods and in which the conflict is not so much over innovation per se but over its direction, rate and feasibility. The emerging value system of youth, in particular, contains strong seeds of the curiosity, scepticism and desire to experiment and innovate which are the mark of creativity. On the whole it appears that the contemporary social environment is becoming rapidly one which supports the concept of innovative organizations and innovative managers.

As myth and folklore had it, creativity was something one had or didn't have; was rare, indeed the exclusive property of people we called "geniuses"; and functioned in a totally mysterious manner via "inspiration," "intuition" or even "revelation." It is now clear that every normal person has creative ability, even though the ability differs widely, and that the average person possesses a considerable amount of this ability, even though he may make little use of it. Secondly, the mental processes, while not yet completely understood, are processes which rely on perception, imagination and an odd mental activity called "divergent thinking."

Divergent thinking is thinking which moves out and away from the problem instead of diving into it analytically. Divergent thinking processes are disorderly, erratic and zig-zag as with the "breakthrough." Characteristically, the answer, the new idea, appears suddenly. Solutions arrived at by divergent thinking almost always seem obvious and simple after the fact. We wonder why it was so hard to find.

Let's take an example to illustrate divergent thinking in action. White paint had been spilled on a pink patio tile, had dried and had left a large stain. Our homeowner, encountering it, immediately responded by bringing out a string of orthodox solutions — use a wire brush, burn it off, use turpentine, etc. A friend who was with him, more inclined to take divergent approaches, solved the problem by suggesting "why not just turn the tile over?" Divergent thinking characteristically produces simple answers.

The ability to converge logically and the ability to diverge imaginatively do not seem to necessarily go together. Hence, organizations are populated with a number of smart, logical and analytical people who are capable of less creativity than others who are more imaginative but less analytical. Non-innovative organizations may put all their convergent thinkers at the top and their divergent thinkers at the bottom. Innovative organizations may do the opposite.

In the traditional educational system, emphasis was placed mainly on memory and formulae, on acceptance of orthodoxy, on logic and reason, and on the common-sense judgment and conventional wisdom. In the grade school, the use of curiosity and imagination, essential to idea-germination, was suppressed.

The compounding or multiplying effect of the new is associated with a peculiar phenomenon called "synergy." Synergy makes the whole both more than the mere sum of the parts but even something different from the parts. Water, to illustrate, exhibits the wholistic or synergistic phenomenon: it has properties more than and different from the sum of its constituent parts, hydrogen and oxygen. In business, for example, when the principle of insurance was put together with the principle of savings, the life insurance industry was created; when movies and the automobile were put together, the drive-in theatre was created; when the sales and financing of automobiles were put together, General Motors Acceptance Corporation was created.

The trend toward increased management by innovation may therefore bring about subtle but profound changes in the criteria used for management promotion and personnel selection. In addition, it will give increased encouragement, and even impose a demand upon, all organization members to exercise imagination and divergent thinking more frequently and more effectively. The trend will also generate more investment in creativity training.

(Complete article on request from: The Business Quarterly, School of Business Administration, The University of Western Ontario, London, Canada. Price $1.25)

Interoffice Correspondence 3M

Subject:

September 15, 1970

TO: A. W. BOESE - NEW BUSINESS VENTURES - 219-1
W. C. FLANAGAN - MEDICAL PROD. DIV. - 218-3
C. S. MILLER - GRAPHIC SYSTEMS - 235-3
S. SMITH- CHEMICAL DIVISION - 236-1
H. G. SOWMAN - CENTRAL RESEARCH - 201-BE
G. V. D. TIERS - CENTRAL RESEARCH - 201-2S

FROM: SHARON SCHALZ, SEC'Y. TO DR. KROGH - 201-1S

This note is to confirm that a Research Associates meeting will be held in Dr. Krogh's office (201-1S) on Monday, September 21, beginning at 9 a.m.

Interoffice Correspondence 3M COMPANY

Subject:

March 7, 1973

TO:

AL BOESE	CARL MILLER
BRYCE CLARK	HAL SOWMAN
CARL DAHLQUIST	GEORGE TIERS
BILL FLANAGAN	SAM SMITH

FROM: WARREN BECK - 209-1W

Attached you will find a note describing an informal meeting procedure which has been used in what was once the Reflective Products Lab. The procedure worked well. In fact, so well that it has survived numerous reorganizations and management changes over a ten year period and, with no urging on my part, is still used by a small core group as an important means of communication. It is my thought that the research associates could benefit from a similar practice, at least while the group is small. I'd like to suggest that we try out some informal plan on a monthly basis for a while.

Questioning of a few of you indicates that such a plan would receive a favorable response. I am making the big assumption that that will be the case and am attaching a questionnaire to this note. On the basis of your responses I will set a day and a place for us to meet the first month (April).

Warren

WRB:eg

enc.

MINNESOTA MINING AND MANUFACTURING COMPANY

ST. PAUL, MINNESOTA

INTEROFFICE CORRESPONDENCE

SUBJECT: CUCAMOOD
(Club for Uninhibited
Communication Among Managers
Of Our Department)

CONFIDENTIAL

November 12, 1962

TO: J. L. CURTIN
J. V. ERWIN
R. E. HOLMEN
M. D. JOHNSON
J. D. TOMLINSON

FROM: W. R. BECK

This is a formal attempt to picture our informal luncheon group, and I hope this is as formal as we ever become. I believe the free-thinking spirit of the group will best be maintained if it never has a formal organization and never has specific responsibilities. We should keep our group free of any influences which would tend to inhibit free flow of communication.

With the above in mind, I would like to propose the following principles to keep us from stifling ourselves:

1. The group should remain small.

2. There should be no one in the group who has administrative authority over others in the group, or who answers to someone in the group.

3. We lunch at 11:30 the first and third Wednesday of each month. Place to be spontaneously decided each time.

continued . .

4. We occasionally (never twice in a row) invite a guest who would be likely to contribute to or benefit from our session.

5. When ideas (technical, organizational or political) develop within our group, the carrying out of the idea should be done entirely outside the auspices of our group.

6. No written records of any kind shall be kept.

Please make any comments you want and we can re-circulate this or discuss at our next meeting.

WRB

WRB:eb
(11/12/62)

I would, would not, (circle one) be in favor of an 11:30 monthly lunch meeting.

The best days of the month for me are: _____
(1st Monday, 2nd Weds., 2nd Thurs., etc.)

The worst days of the month for me are: _____

The best location would be:

- Executive buffet _____
- Tartan Park _____
- Hafner's _____
- Other _____

Have a secretary call each associate and arrange for reservations at a different place each month. _____

Return to: Warren Beck
Special Enterprises
209-1W

FORM 2237-C

IMPORTANT MESSAGE FOR YOU

FOR Al Boese

FROM Beth Anderson

OF Mr. Arnesen's sec.

PHONE _____ EXT. _____

TELEPHONED	
CALLED TO SEE YOU	
WANTS TO SEE YOU	
PLEASE PHONE HIM	
WILL CALL AGAIN	
RETURNED YOUR CALL	

REMARKS Res. Associates' Meeting tomorrow 2:00 Bldg. 236- Room 226B

DATE 9/21 TIME 10:05

D

NAME OF PERSON RECEIVING MESSAGE

Interoffice Correspondence 3M COMPANY

Subject:

March 21, 1973

TO: AL BOESE, 53-6
BRYCE CLARK, 235-3F
CARL DAHLQUIST, 201-2E
BILL FLANAGAN, 218-3
CARL MILLER, 235-3G
SAM SMITH, 236-1
HAL SOWMAN, 201-2E
GEORGE TIERS, 201-2S

FROM: WARREN BECK - 209-1W

With one exception, the returns of the survey are in and a preference has been expressed for the executive buffet on a Wednesday, with no conflicts. The preferences were not strong, but clear enough so that we should start that way. So our lunch meetings will be at 11:30 in the executive buffet, 222-1, on the second Wednesday of each month.

To get the ball rolling, at least for the first time, I will have my secretary call each of you the morning of April 11, then reserve a table for the number planning to attend. There will be no agenda, no records, no officers, no responsibilities. Just come and bring yourself up-to-date on research associate activities.

Warren Beck

WRB:eg

Interoffice Correspondence 3M COMPANY

Subject: Research Associates
Lunch Meeting

cc: J. R. Johnson ** 201-1S
J. H. Prager ** 201-1S

August 3, 1973

TO:

WARREN BECK	** 201-1W
AL BOESE	** 53-6
BRYCE CLARK	** 235-3F
CARL DAHLQUIST	** 201-2E
BILL FLANAGAN	** 218-3
CARL MILLER	** 235-3G
SAM SMITH	** 236-1
HAL SOWMAN	** 201-2E
GEORGE TIERS	** 201-2S

This is a reminder of our next Research Associate get-together which, through the courtesty of Dr. Prager, will be held in private dining room No. 3, Bldg. 222-1, on Wednesday, August 8 at 11:30 AM (rest of year schedule: September 12, October 10, November 14, and December 12, to be held in private dining room No. 1.

At our last meeting, it was suggested that we take turns presenting, briefly and informally, at each meeting, some item of particular interest. It was suggested that this be some aspect of work we are doing, i.e. new possible product, or process, brief summary of work we are doing, a problem presentation, etc. Following an alphabetical order, Beck offered to provide the first of these presentations at the meeting on Wednesday.

As reported to us by Sam Smith, Dr. James R. Johnson has expressed a desire to attend our next meeting and wishes to some day, discuss his program with us. He is being put on the copy list, along with Dr. Julie Prager, so that they may feel free to attend when they wish.

Interoffice Correspondence 3M COMPANY

Subject:

July 1, 1968

TO OUR ORGANIZATION

We take pleasure in announcing the appointment of Mr. A. W. Boese as Research Associate, New Business Ventures Division. He will report to the division's technical director, Dr. W. S. Friedlander.

Elected last year to 3M Company's Carlton Society, Al is an outstanding example of the creative, innovative individuals who have built the company's reputation for new products. Starting with 3M in 1930, it was not until 1939 that he began his long and productive association with non-woven fiber research, development, and manufacture. Al played a key role in the establishment of technology which led to products sold today by many of the company's divisions.

The position of Research Associate was created expressly for the recognition of outstanding research accomplishment and offers the dedicated individual an opportunity to maintain his research career without the burden of administrative responsibilities. In accordance with requirements, Al's appointment has the approval of the President of 3M Company.

Until space becomes available in Building 219 later in the year, Al will continue his work in the Tape Laboratories, Bldg. 230, Extension 35297. We anticipate that the results of his research will be made available most quickly through the well-established pilot group of the New Products Development Department; but, as always, Al's advice and experience on non-woven technology are available to anyone in 3M Company with a need to know.

We hope you will join us in extending congratulations and best wishes to Al Boese in his new position.

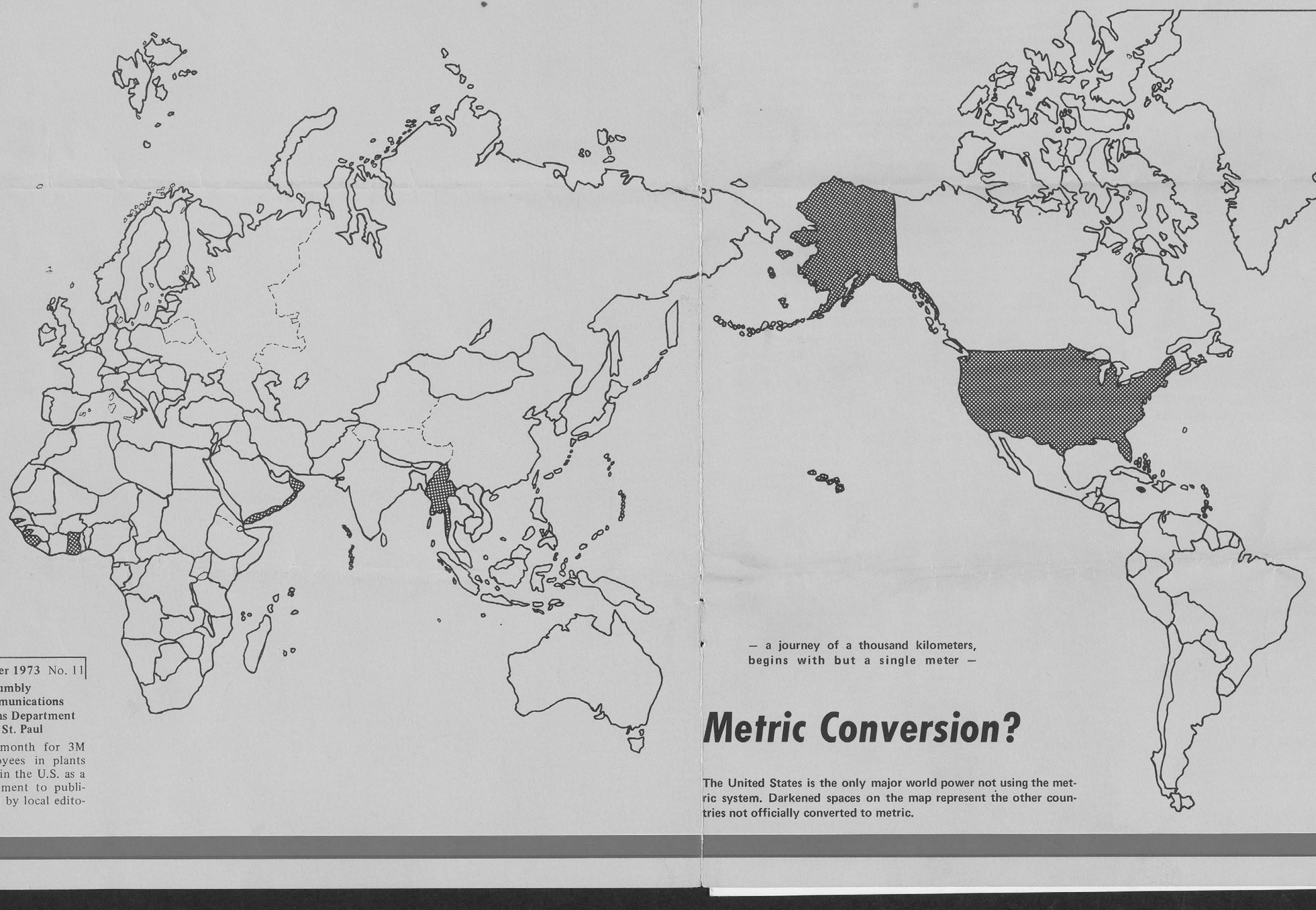
A. H. Redpath
Retail Tape and
Gift Wrap Division

R. M. Adams
New Business Ventures
Division

MASTER
Megaphone

3M COMPANY

NOVEMBER 1973
VOL. 8 NO. 11



Vol. 8 November 1973 No. 11

Carl Lumbly
Branch Communications
Public Relations Department
220-6W, St. Paul

Published each month for 3M Company employees in plants and subsidiaries in the U.S. as a corporate supplement to publications produced by local editorial coordinators.

— a journey of a thousand kilometers, begins with but a single meter —

Metric Conversion?

The United States is the only major world power not using the metric system. Darkened spaces on the map represent the other countries not officially converted to metric.

How will adapting metric standards of weights and measures affect this man's job? How will it affect yours?

3M Ready

Possible Change To Metric Foreseen

You are at dinner with your spouse. The host, after asking you if you want five milliliters of sugar in your coffee, jokes about how many centimeters you've added around the middle and then tops it off by telling you about the lovely three hectare homesite they just bought.

Is he putting you on?

No, he is just preparing you for the possible change in the U.S. system of weights and measures which will be from the "customary" inch-pound system, to the not-so-customary, centimeter-kilogram or metric system.

—customary system just doesn't measure up—

The metric system, or the International System of Measurement Units as it is also known, is the most widely used system of weights and measures in the world today. In fact, the U.S. is the only major world power not using the metric system; heading the ranks of such countries as Barbados, Burma, Ghana, Jamaica, Liberia, Muscat, Tonga, Nauru . . . and Southern Yemen.

In 1866, three metric bills were introduced that were eventually passed by Congress. The most important of the three legalized the use of metric weights and measures in this country, but did not make them official. Proponents of the bill stressed that the intention of Congress was not to make the metric system compulsory, but rather to permit its use while stimulating interest in reform.

Since that time, there have been several concerted efforts to pass legislation through Congress authorizing an official U.S. conversion to metric standards. Until recently, all of these moves have met with considerable resistance on the grounds that conversion was not yet necessary. Many observers feel the passage of such legislation is now more likely.

A report on metrication issued in 1971 by the Department of Commerce, estimates that the total cost of the conversion could run as high as $50 billion, but more likely will be around the $10 billion level.

Sensing an eventual changeover, 3M has had active conversion programs under way for several years. A Metric Advisory Committee was established to follow developments in metrication and make appropriate recommendations.

The committee is made up of representatives of technical, manufacturing, international marketing, engineering and purchasing areas of the Company. Its secretary, Marvin A. Adams, senior manufacturing specialist in staff manufacturing explained that the federal legislation most likely to pass in Congress will call for a 12-year conversion plan. But according to Adams, it would not take that long for 3M to be totally metric. He said six divisions already have formal plans in operation.

Three factors likely to make the changeover fairly easy for 3M are:

1.) Most of 3M's products are soft goods that do not require extensive modifications.

2.) A dual dimensioning system in packaging, listing both the customary measure and its metric equivalent, has been in effect throughout the Company for some time.

3.) 3M's overseas manufacturing facilities already use the metric system, so there is an established internal base from which to work.

According to Adams, "Manufacturing would probably bear the greatest cost, but by changing gradually, and substituting customary equipment with metric equipment as it wears out, the overall cost would be reduced considerably."

While the changeover of machinery may not be so difficult, it may be a bit more confusing for the machinery operators. That is, people. But basically, the system is so logical that confusion will probably be minimal. In fact, if you like money, you'll love metric, because they're both based on the decimal system. Familiar, logical and simple base ten.

Some of the problems in our customary system have stemmed from the arbitrary standards of measure used to set it up. For instance, the yard was established as the distance from one king's nose to the end of his thumb if he had his arm outstretched. An inch was scientifically determined as the length of the end joint of an adult's thumb. A foot was, of course, the approximate length of your average foot. And the mile was set as the distance traveled by a Roman soldier in a thousand two-paced strides.

Therefore, in our present "customary" system, you just about have to memorize every increment of the system in order for it to make sense. There are 12 inches in a foot. But there are three feet in a yard. So there are then 5,280 feet in 1,760 yards because a mile has 32 rods, making it four-fifths of a furlong, which is . . . well anyway, you get the idea.

While not nearly as . . . glamorous, the metric system is based on a much more consistent standard. In 1790, France's scientific academy created a system based on a unit of length equal to one-ten millionth of the distance from the North Pole to the Equator along the meridian of the earth. The name "meter" was applied to the unit of length, and measures of volume and length were also derived from that basic unit. So, each measurement in the system relates to the others and to nature.

The appropriate prefix is attached to the word "meter" to denote the relationship. For example, the prefixes milli-, centi-, and kilo- stand for one-thousandth, one-hundredth and one thousand, respectively. Thus, a millimeter is one-thousandth of a meter, a centimeter is one-hundredth of a meter and a kilometer is one thousand meters. Seems reasonable.

In the metric system, just as in our monetary system, simply moving the decimal point shows the relationship of the parts to the whole.

3M employees will have to become used to thinking in terms of this system, because the success of the conversion is not the number of machines which get changed over, but the number of people who understand and use the system.

To operate a tape slitting machine the operator needs to know that he is slitting 19 millimeter tape, instead of 3/4-inch tape. The conversion will be crucial at the level of the new information the employee needs to effectively do his job. But, this information must be supplemented by information the individual needs to live comfortably in a metric environment. Such as, the manner in which canned and bottled goods are labeled; distances marked on highways; and the ways quantities of recipes are described.

U.S. Is Getting Ready

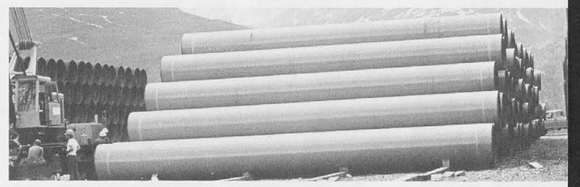
A good deal of conversion is already underway. Every shopper knows that many of the packages are marked in both the customary and metric weights and volumes. In some states, the distances between cities are marked in miles with the metric equivalent next to it, in order to start motorists thinking in kilometers. The pharmaceutical industry has been labeling contents in terms of grams and liters for some time. Film is measured in millimeters. More and more, service stations are getting in supplies of metric tools for work on automobiles made overseas.

Individuals can start making the changeover in their homes too since preparing now, will make the national changeover an easier process. Programs to upgrade metric educations in schools will be vital. We'll all have to start thinking metric.

Admittedly, a good bit of ground will have to be covered before the changeover is complete, but after all, "A journey of a thousand kilometers begins with but a single meter."

All packaging labels would be changed.

This car has a kilometer indication on its speedometer, and an engine measured in cubic centimeters.



This pipe is being used in what may soon be referred to as the 1280-kilometer long Trans-Alaska Pipeline.

UNDER METRIC, YOU MIGHT HEAR –

"My liter runneth over."

"First down and 9.144 meters to go for a touchdown."

"Say, have you been following the Indy 800?"

"But officer, I can't be drunk. I only had 500 milliliters of . . ."

"I'd walk a kilometer for a Camel."

"The winning beauty contestant was a stunningly perfect 91-61-86!"

3M Pays Off

Converting Hours To Dollars

If given a choice, would you continue to work for 3M without ever knowing when you would be getting your paychecks? Didn't think so.

3M doesn't think so either, which is why we have a payroll department ... to make sure you get that check when you expect it.

A simple goal – but not a very simple task. More than 42,000 3M employees in the United States are paid through this department. The payroll options for this group range widely. Hourly-paid; biweekly; salaried monthly-paid; monthly exempt; extra compensation; commissioned; sick leave; overtime; vacation time; and the list goes on and on. But every Friday, – someone is receiving a paycheck.

Department officials estimate that during 1973 they will have sent out 1,340,000 checks for a payroll figure of one-half billion dollars. Of these checks, they figure only one check in a thousand doesn't arrive when expected. To help make this kind of record possible, the payroll department staff sometimes work several shifts; collating and organizing stacks of information, and processing miles of computer tape.

L. Joseph Thompson, department manager, has been with the payroll department for eight years. He coordinates the efforts of the crew whose job it is to turn hours into dollars for 3M employees.

The process begins when your timecard is turned in, when your hours are placed on a timesheet or when someone records the time you've accumulated. Any special figures, such as sick leave, vacation or overtime are also recorded. These cards or sheets are then rushed to the payroll department office in St. Paul. Once there, things happen in a hurry.

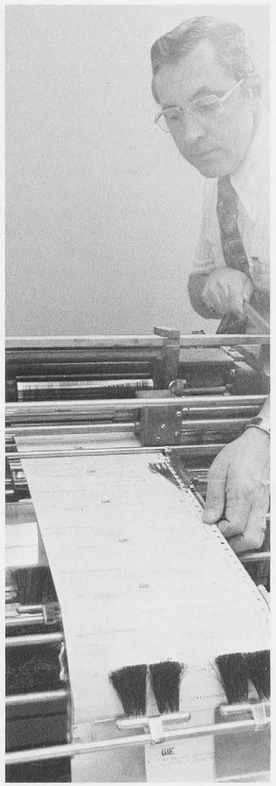
Payroll clerks tear open envelopes clearly marked "RUSH TO PAYROLL DEPARTMENT." (People don't fool around where their paychecks are concerned.)

The information in these envelopes is checked and catalogued by the clerks. Numbers of hours are checked against rates or salary figures; special and standard deductions are examined and the addition on timecards is double-checked for accuracy. From there to keypunch, to be put on data cards.

This step is probably the most important. The information gets shuffled, punched, stacked, sifted and comes out as an employee's check.

In each step along the way, care is taken to make sure the correct information gets on the right card. Once past this point, a mistake will have to be processed.

Keypunchers feed all the necessary data from the information they are given onto data cards, which are then marched over to the computer room.



Bob Navis operates automatic signature machine.

Basically, three things happen in the computer room: First, data cards are read by a card reader machine which records the information on magnetic tape.

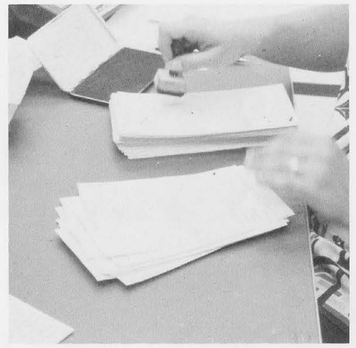
Secondly, the magnetic tape containing the new payroll information is fed into the main computer and compared with a computer master record. Kept on this master record is all the payroll information about 3M employees currently on the payroll. By checking the new information against the master record, the payroll department can be sure that there is an employee for every timecard or sheet. The computer sends out a message if there are any discrepancies, and these are followed up by the payroll department.

Data card information is read onto magnetic tape.

and then...

Mary Casey verifies special deductions.

and then...



Timecards and sheets are checked.

and then...

Keypunchers put data on cards.

Finally, the computer reads your tape, decides, very objectively, how much money you should get, and prints out a check to you, and every other U.S. 3M employee for, hopefully, the correct amount.

But it's not over yet. Remember? Each check usually comes in an envelope with a window showing your name. And inside, the check has been signed by Donald E. Garretson, vice president and treasurer. No, Mr. Garretson does not spend his entire week signing 3M payroll checks. In fact all 42,000 checks are signed by a single machine using a name plate bearing Mr. Garretson's signature.

Once signed, the checks are stacked and run through an automatic stuffing machine which seals them in envelopes with the name visible through the plastic window.

The only remaining task is getting the checks to employees ... The whole process usually takes two days – Monday and Tuesday. If there are any holdups (delays, that is), it's usually because bad weather, or mechanical failure slows the delivery system. But if all goes well, hopefully, by Friday everyone who should have a check, does.

But it's not over yet for the people in payroll. The rest of the week is filled with the business of processing terminations and new hires. Questions concerning checks and records are answered through correspondence and over the phone. Payroll keeps contact with department heads and branch managers to make sure that any errors in their payroll are corrected. Also, new timecards and timesheets must be mailed out.

And that's that ... at least, until Monday, when the whole process of converting hours to dollars starts again.

...finally.

Checks are stuffed and stacked before delivery.

He Does It His Way

Research Associates—

Opt To Stay In Lab
Constantly Questing
Burning Desire To Create

For those who may visualize corporate research as scientific regimentation – formalized, sanitized, computerized and anesthetized – 3M's nine research associates represent the ultimate in refreshing testimony to the contrary.

With each standing tall in his history of distinguished technical accomplishment and outstanding contributions to 3M growth, this select group of men mirrors the long standing Company research and development policy of encouraging creativity by giving the individual freedom to exercise his own initiative.

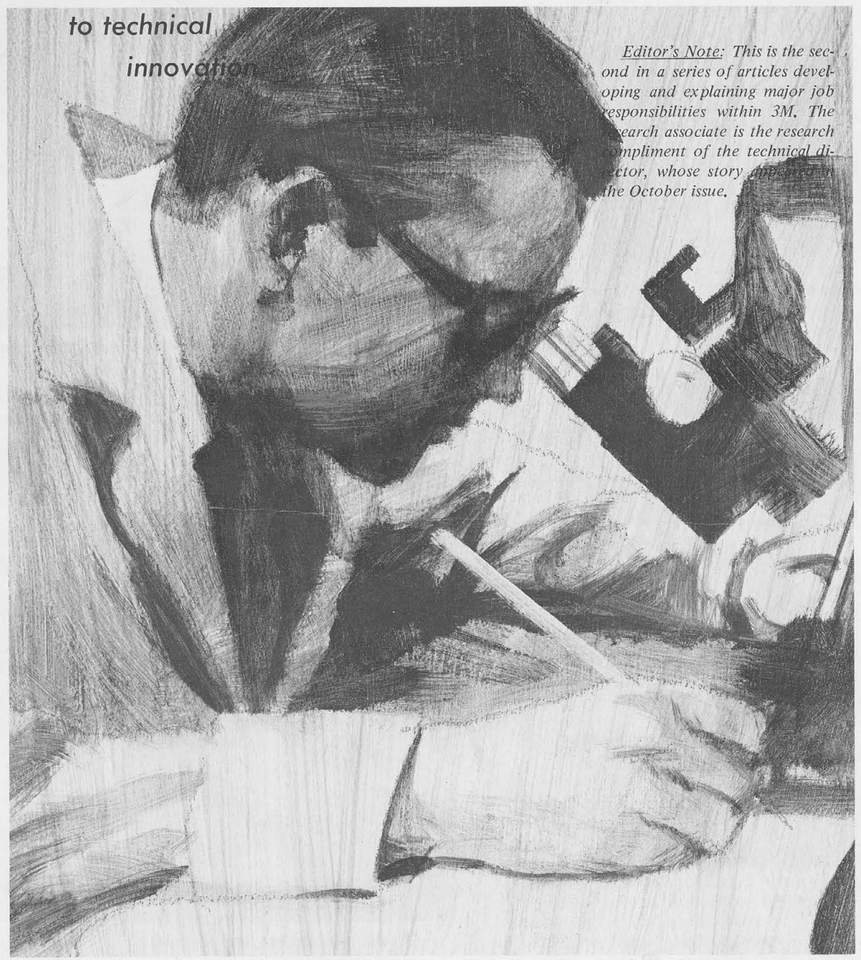
Research associates may well be the most "individualized" individuals in 3M. They fit no stereotyped mold. Collectively, they defy job description because each is unique in his own right ... unique in scientific achievements, and unique in the way each applies his talents to technical innovation.

The importance of the position can be seen in the fact that an appointment must be approved by the president of the Company.

An idea man, a self-starter who can move independently, the research associate is motivated by a burning desire to do creative things that no one else has ever done before.

His joy is in tackling difficult technical problems, coming up with solutions that are of value to the Company and watching his idea grow into a completely new 3M business.

"... each applies his talents to technical innovation."



Editor's Note: This is the second in a series of articles developing and explaining major job responsibilities within 3M. The research associate is the research compliment of the technical director, whose story appeared in the October issue.

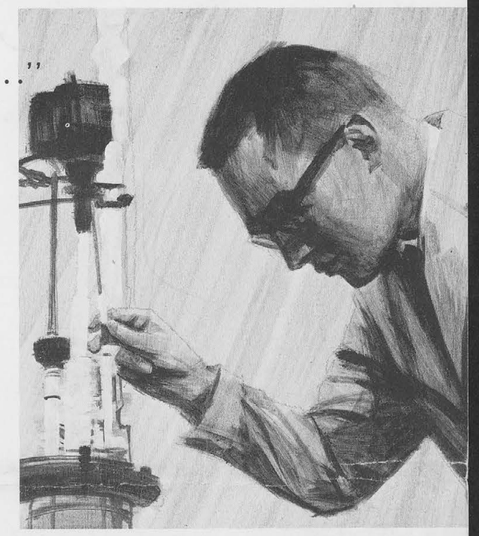
his choice... lab work

Organizationally, the research associate is the "dual ladder" equivalent of a technical director. Dual ladder refers to a career development system in which members of the 3M scientific community may achieve recognition and reward for personal progress in either management or the continued pursuit of their technical interests in the laboratories.

Unfettered by administrative responsibilities – although some of them have had extensive experience in this area – the research associate has the freedom and responsibility to choose new areas of science and technology for the Company to explore. This is done without regard for whether the proposed project is related to current 3M interests.

An example is Carl A. Dahlquist, research associate in the polymer research laboratory at Central Research. A member of the Carlton Society, 3M's "Hall of Fame" for technical people, and the Company's first research associate. Among Dahlquist's achievements is the development in the 1940's of a backsize for pressure-sensitive tapes. This backsize was a major breakthrough in adhesives technology, and made possible the high speed rewinding of tapes.

"... quietly probe the unknown and uncharted..."



Today he is deeply involved in the investigation of polymers which may be used in artificial organs for the human body.

The work schedules of Dahlquist and his fellow research associates quickly dispel any notion that their almost complete job freedom means that they spend all of their time dreaming and puttering away their hours in the isolation of some remote laboratory.

They do quietly probe the unknown and the uncharted, but they also are at the center of a beehive of activity. Their consultation is continually sought by division and Central Research management and laboratory personnel who have the highest regard for a research associate's store of experience and expertise in his field of specialization.

The street runs the other way, too. Research associates frequently enlist the assistance of other 3M scientists in their experimental work.

Outside the Company, these men are active in presenting scientific papers and attending the meetings of professional organizations. They are regarded as authorities in their fields, and make a steady contribution to 3M's worldwide research image. They also are invaluable to the Company's scientific personnel recruitment program.

"... freedom to fail... and try again."

With laboratories adjoining their offices in most cases, 3M research associates enjoy small-group mobility. They often may be found clad in a lab coat and preparing their own samples, making up chemical solutions or washing out test tubes alongside a laboratory technician.

For them, the detail work in conjunction with research is as much a part of the fascination of discovery as is the thrill of standing at the brink of a scientific breakthrough. They love their work and where it's done.

Informality as a way of life is evident, too, when the research associates get together for their monthly luncheon meetings. There are no agendas, no minutes of the meeting and no note-taking. Each takes his turn at talking about a current research project, and over-the-coffee-cup discussions follow.

These men know the warm glow of success. They also know the frustration and heartbreak of laboring long and hard to make a new discovery that led to nothing of commercial value to 3M. More importantly, they know that the Company's research philosophy includes the freedom to fail ... and try again.

To the approximately 4,000 technical men and women in some 50 3M laboratories, the research associate is an inspiration and an assurance that intellectual curiosity, persistence, courage and professional performance will be recognized and rewarded.

He offers living proof that whatever the educational background, whatever the technical discipline ... there is room at the top for the person who demonstrates scientific prowess, initiative and a strong desire to achieve.

Because of his pioneering successes, the family of research associates will grow in the future. Others, too, will take up the challenge and build a career by reaching out beyond the horizon.

3M's Corps of Research Associates

Warren R. Beck	Special Enterprises Department
Alvin W. Boese	Corporate Innovative Laboratory
Bryce L. Clark	Duplicating Products Division
Carl A. Dahlquist	Polymer Research Laboratory, Central Research Laboratories
Dr. Arthur R. Kotz	Imaging Research Laboratory, Central Research Laboratories
Dr. Carl S. Miller	Duplicating Products Division
Samuel Smith	Chemical Resources Division
Dr. Harold G. Sowman	Advanced Research Programs Laboratory, Central Research Laboratories
Dr. George V. D. Tiers ..	Chemical Research Laboratory, Organic Group, Central Research Laboratories

"His joy is in tackling difficult technical problems."