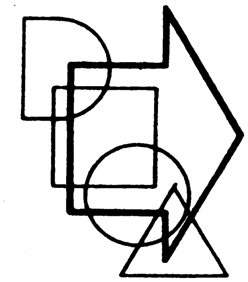
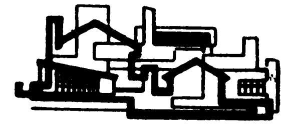
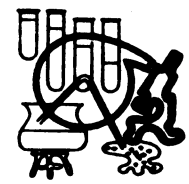
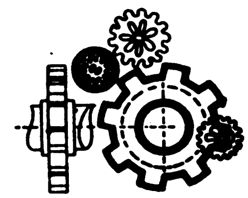
PROCEEDINGS

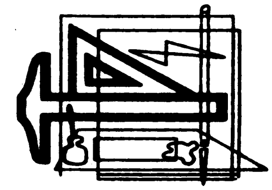


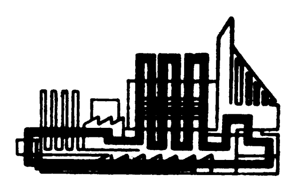
TWELFTH ANNUAL INDUSTRIAL ENGINEERING INSTITUTE











UNIVERSITY OF CALIFORNIA

BERKELEY **February 5 and 6, 1960** **LOS ANGELES**

PROCEEDINGS

TWELFTH ANNUAL

INDUSTRIAL ENGINEERING INSTITUTE

Presented By

UNIVERSITY OF CALIFORNIA

THE COLLEGES OF ENGINEERING

THE SCHOOLS OF BUSINESS ADMINISTRATION

UNIVERSITY EXTENSION

At Berkeley and Los Angeles
February 5 and 6, 1960

In Cooperation with:

AMERICAN INSTITUTE OF INDUSTRIAL ENGINEERS
Los Angeles, Peninsula, San Francisco-Oakland, and Sacramento Chapters

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS
Los Angeles and San Francisco Sections

SOCIETY FOR ADVANCEMENT OF MANAGEMENT
East Bay, Los Angeles, Orange Coast, and San Francisco Chapters

AMERICAN SOCIETY FOR QUALITY CONTROL
Los Angeles and San Francisco Bay Area Sections

AMERICAN MATERIAL HANDLING SOCIETY
Los Angeles and Northern California Chapters

THE SOCIETY OF APPLIED INDUSTRIAL ENGINEERING
Los Angeles Chapter

AMERICAN SOCIETY OF TOOL ENGINEERS
Golden Gate, Los Angeles, San Francisco, and San Gabriel Valley Chapters

Editor: John G. Carlson, Lecturer in Production Management
University of California, Los Angeles

TWELFTH ANNUAL

INDUSTRIAL ENGINEERING INSTITUTE

of the

UNIVERSITY OF CALIFORNIA

Additional copies may be obtained from:

Proceedings Sales
University Extension
University of California
10851 Le Conte Avenue
Los Angeles 24, California

Price: $3.50

Please make check or money order payable to:

The Regents of the University of California

Lithoprinted in U.S.A.
EDWARDS BROTHERS, INC.
Ann Arbor, Michigan

FOREWORD

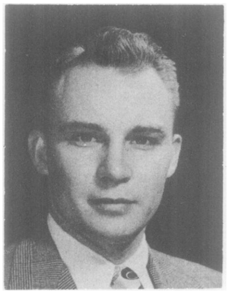
John G. Carlson
Editor and General Chairman
12th Industrial Engineering Institute

We have complied to the expressed desires of our participants and have stressed the case study approach to applications of the latest developments in industrial engineering and management. Each paper herein is based on experienced programs representing the petroleum, airframe, film products, chemical, paper, metal working, automotive and insurance industries. We offer these presentations in complete form and submit that they represent a balanced and significant contribution to the advancement of this profession.

Many would look upon the present-day industrial engineer as an embodiment of an operations research team in one man. The design and control of the work environment is interdisciplinary. Modern industrial engineering activities often unite mathematics with managing, simulation with supervising, optimizing with operating, and statistical inference with stark realism.

Industrial Engineering, challenged by its basic tenets, is developing and prospering through assuming competence and confidence in its own discipline and in the disciplines offering assistance either in approach or in direct solution of its problems. Further development and application of technical and administrative skills are required in order to offer the competence industry and our nation so richly desire and deserve.

Special acknowlegment is due to our speakers who journied from far and near to bring us the latest in approach and application in this ever widening field of engineering and management. We are indebted also to the session and activities chairman and the many people from University Extension who contributed to the administration of this institute.

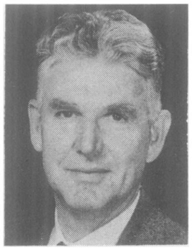


John G. Carlson

INSTITUTE AND SESSION CHAIRMEN

LOS ANGELES SESSIONS

SESSION CHAIRMEN



Ralph M. Barnes

James M. Gillies

Morris Asimow

Joseph D. Carabino

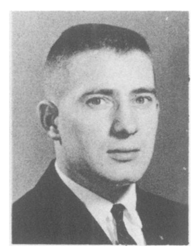
Elwood S. Buffa

Robert. B. Andrews

ACTIVITIES CHAIRMEN

Levi J. Knight

Kendall R. Wright



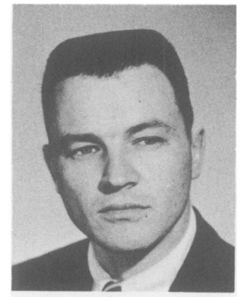
R. Geo. McFadden

John J. Barry

James L Williams

Sam M. Houston

INSTITUTE AND SESSION CHAIRMEN



George P. Redman

BERKELEY SESSIONS

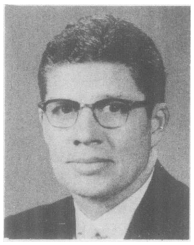
SESSION CHAIRMEN

Max E. Shaffer

Edwin F. Ghiselli

Charles Driesbock

Stanley J. Hotchner

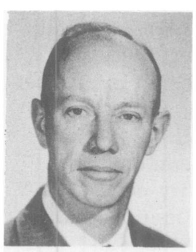


Homer T. Craig

Ewald T. Grether

Frank W. Peters

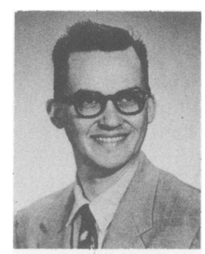
ACTIVITIES CHAIRMEN



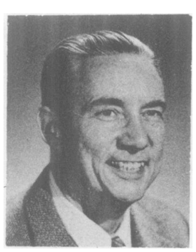
James S. Campbell

Thomas H. Hazlett

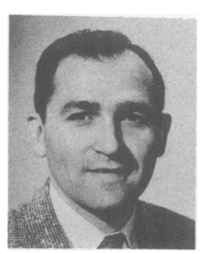
E. Paul DeGarmo



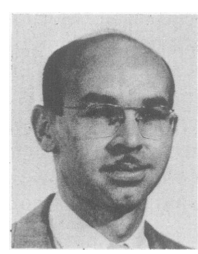
James Cumming



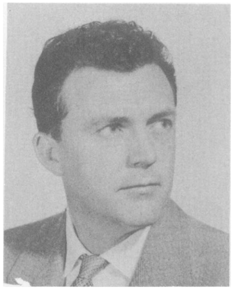
E. C. Keachie



Louis E. Davis



James T. Lapsley



WELCOMING REMARKS

John R. Whinnery
Dean, College of Engineering
University of California
Berkeley, California

I wish to sincerely welcome you to Berkeley and to the Twelfth Industrial Engineering Institute. This Institute has been, and I hope will continue to be, the type of cooperative effort between industry and the university of which we can be truly proud.

As I have only recently come to my present position, I am still being educated in the matter of Industrial Engineering, along with several other branches of Engineering which I observed before only as an outsider. As a citizen and an employee of several large industrial organizations, I have been impressed and very proud of the industrial potential of our country, and its continually increasing efficiency, and know something of the part Industrial Engineering has played in this. I know, however, that you did not come here for self congratulations, but more to be challenged and to prepare yourselves for the problems of the future. The beginning of a new decade is always a natural time for everyone to take stock of future trends a bit more than in the day-by-day or even year-to-year planning. All predictions are that the industrial growth in this country will continue, and that the current decade will be one of the most challenging of all in terms of filling the needs of our rapidly increasing population with ever more efficient means.

The above is largely a continuation, but if this decade is to be really different from any other, it will be in the manner in which the international view of industrialization looms larger than in the past. C. P. Snow in "The Two Cultures" (a little book which I think should be required reading for both technical and nontechnical persons in our present civilization) has stressed the determination and rate at which the undeveloped countries of the world are moving in this respect. Whereas the industrial revolution took something over a century in a western Europe and this continent, Russia has accomplished it in 30 years, and China appears to be reducing the time scale to a decade. If this acceleration continues, the revolution in the other Asian and in the African countries is scarcely imaginable. President Kerr, after his trip to Africa of a few years ago, also made very strongly this same point. It appears that the undeveloped countries are determined to have industrialization and have it soon, whether we like it or not, and they may not much care what political compromises they have to make to get it.

This trend is both an opportunity and a challenge. The challenge is that as other countries with cheaper labor move into the world markets, our own products will find increasingly severe competition even in our own country and Industrial Engineering will have to continue at an accelerate rate its part in making our production techniques more efficient. The opportunity is that with our know-how in these matters we can help the undeveloped countries in their struggle to obtain the freedom from want, and in addition to the great humanitarian consequence, this can, if used correctly, be the most important of all political tools.

The second and main point of Snow's book on "The Two Cultures" is one that Chancellor Seaborg touched upon in his introduction to you last year. This is the increasing difficulty of communication between the technically trained and the nontechnically trained groups, just at the time when the largest problems of our world are combined social-political-engineering-scientific. It seems to me that Industrial Engineers are in an excellent position to help act as a bridge between these two cultures, for by the nature of their problems they must be able to take part in management and communicate with business experts, psychologists, economists and social analysts. On the other hand they now take part in very difficult mathematical analysis through operations research methods, and must also know an increasing amount of scientific base to be able to design and control processes that depend upon increasingly sophisticated principles. As an example, the Esaki or Tunnel diode, which was scarcely known a year ago, will be built by the millions within the next year. This utilizes an effect which violates classical principles and can only be predicted by quantum mechanics. Even quality control of such production requires a knowledge of the factors entering into its performance and thus a fair knowledge of modern physics.

Thus the range of areas, social on the one hand and scientific on the other, that you as Industrial Engineers must know, is increasing at a great rate and this is the difficult part of this problem. The opportunity is that mentioned before, of occupying a position where you must communicate with both groups and thus may act in some measure as a model for providing communication links between the "two cultures."

I am sure that this conference will contribute to the meeting of these challenges and opportunities, and wish you all success in it.

TABLE OF CONTENTS

GAINING ACCEPTANCE TO NEW IDEAS IN THE POWER STRUCTURE OF AN ORGANIZATION

Robert R. Blake
Department of Psychology
The University of Texas

Change—change—change! The explosion of scientific, technological and human knowledge during the past quarter century has driven the word change into the thinking of every thoughtful person. In many fields it no longer is possible to stand still and repeat the patterns of yesterday. It is even becoming difficult to recognize ordinary evolutionary patterns of change. Where changes used to occur slowly, now they happen suddenly. The successful product of a few years ago is a drug on today's market. Current technology already looks antiquated against the background of tomorrow's blueprints. The promise is a world, in a decade or two, different in radical ways from today. Though change will come, it will carry a backwash of conflict, dislocation, and disruption with it, unless we develop the skills necessary for successful accommodation to modern science and technology.

Conventional Modes of Resisting Change

What symptoms appear when needed changes are interfered with or scuttled? There are a lot. Everyone here has either used one of the conventional techniques of opposing change or had it used on him. Plans get sabotaged by delay tactics. They are filed, sent to a committee, or postponed for additional study. Perhaps funds or personnel are unavailable to carry them into effect at the moment, so they hang fire. Change may be avoided simply by denying the need for it. A proposed change may bogg down because no agreement on how to implement it can be achieved, and so on. One result is that needed change is not accomplished easily and, indeed, often it is effectively forestalled.

The result? The phrase "resistance to change," has come to be used as though change is inherently threatening and always opposed by people or organizations intrinsically geared to withstand the onslaught of every suggested modification. Yet nothing could be further from the truth! Inherently threatening or not, the dynamic of the ostrich is not limited to ostriches. Even if you don't like it, burying your head in the sand is no solution. At best it delays the inevitable. Problems of change are critical in our time and need to be recognized so that change can be accomplished in an orderly insightful way.

Perhaps a useful way of exploring difficulties in introducing new ideas is to evaluate customary approaches for understanding behavior which hinders innovation. One reason given for failure to alter existing ways of working is *habit* and a second is *tradition*. Both are wrong. Neither leads to effective action. It's all too easy to say that a shift cannot be made because of a habit so the remedy is to "break the habit." This type of analysis rarely produces change.

Although problems of change are apt to appear different in content, that does not mean that the structural way of thinking about them is different. Standard patterns of behavior, regardless of the specific content they represent, are subject to analysis in a single basic manner. An approach I would like to propose is to replace the usual habit or tradition approach with a Lewinian force-field analysis of stable or fixed behavior. This method of examining any given situation provides a far truer picture of change and resistance to it. Then I will propose that change is easy to achieve, once the conditions of resistance to it are understood. Finally, I will give some examples from a program of planned change which now is being carried out and which, I think, demonstrates that intelligent people contribute new ideas and even seek for change, once the conditions are understood.

The examples below, one of a personal habit, the other of a cultural tradition, demonstrate the conventional in contrast with the force-field analysis of behavior.

Smoking: The Habit Way of Thinking About It

"How much do you smoke?" I ask a student, and he answers, "Oh, a pack a day."

"Why?" I ask, and he tells me, "Got the *habit.*"

I ask him how long he has been smoking this amount and he tells me three or four years. He goes on to say he can't stop smoking because he has acquired the habit. I want to know what he means when he says he has acquired the habit.

We continue to talk about why he smokes. He says cigarettes taste good; they help him to feel sophisticated. Here we have two driving forces to support his habit of a pack a day. "Why don't you smoke four packs a day?," I ask. That question produces a resumé of statistics, linking cigarettes to cancer and heart trouble. These are restraining forces that hew away at his "habit" of a pack a day. The cost of a package of cigarettes, like the current linking of tobacco to illness, is a restraining force that keeps his "habit" at one pack rather than two or four a day.

I wonder if he ever smokes more or less than the established amount of a pack a day. I learn that around examination time, he steps this up to two packs a day. I also discover, after additional questions, that he doesn't smoke while he is visiting his parents during holidays or vacation time because they don't approve of smoking. They would be shocked to learn that he had taken up this habit.

What is this student saying? I could show you his habitual level of a pack a day on a diagram and then show how an additional driving force—the pressure of examination—shoots this level much higher, or how the bias or censure of his parents decreases his level far below a pack a day—to none in fact.

These are new forces that can be introduced momentarily, driving his consumption up or restraining him from smoking. He shifts his personal "habit" with changing forces in the field of experience. His behavior varies with his situation. Though they aren't supposed to, "habits" change in line with new facts.

Bathing Suits: The Traditional Way of Thinking About Them

A bathing suit is interesting to think about. If you look back at the old Pathe News reels of World War I, you will see a very different situation than if you go to Atlantic City today. The bathing suit used to have skirts down to the knees and sleeves down to the elbow. When we think about bathing suits and how they have changed through the years, we automatically link these changes to the force fields inherent in the passing years.

Even in 1915 there were driving forces operating to make for lesser amount of coverage, freedom to swim, comfort, and so on. But also there were stronger restraining forces to keep bathing suits from getting skimpier—strong moral imperatives. Today we don't look at bathing suits with such stringent modesty; the skirts and sleeves can be discarded. Comfort, freedom to swim, and attractiveness of appearance have remained strong driving forces to eliminate even more of the traditional suit. By the time fashion achieved the ultra-abbreviated Bikini, the moralistic factors were still strong enough to say, "That's going too far!" Fashion may operate as a force inducing change, but it does so within the basic force field of pressure acting on the individuals who are to wear the suits.

Thus, any behavior that can be viewed as having a "level" or a "flow" or "an average amount over time," can be regarded as held in place by forces that are driving in an upward direction and by restraining forces preventing the behavior from moving higher, or pushing it lower.

Tradition is a "level," a characteristic way of doing things. It is subject to change by changing the forces in the field, either adding driving forces, removing restraining forces, or doing some of both. Take smoking again. How do manufacturers of tobacco deal with changing the level? They advertise, showing the sophistication of smoking; that is, they add a new driving force. Yet they also try to remove restraining forces, such as putting forth long cigarettes with filter tips which might possibly reduce fear of cancer. In other words, advertising sensibly takes the total force field into account. And the bathing suit makers have recently announced a swim suit so designed as to be seen as a "regular," or by the flip of a button it miraculously turns into a "Bikini." Here is a new idea. It tells the girls, "Have your cake and eat it too."

Force Field Analysis of Acceptance of New Ideas

Is rate of acceptance for new ideas in an organization different than a force-field analysis applied to other situations, like smoking or bathing suits? Indeed no. Acceptance rate is a level, one that remains constant over time as long as conditions don't change. For some company situations, the rate is low; for others it is quite high. For some it is high for a few years and then goes down; for others the reverse is true. Gaining acceptance of new ideas—change in other words—is a matter of analyzing the field of forces operating in a situation, and of changing these forces so as to bring a new "level" into effect. I want to spend the remainder of my time spelling out some of the more central driving and restraining forces that act to influence the acceptance or rejection of new ideas.

Most of what I am going to say is based on a program of research in intergroup relations which is now in its fourth year. Groups have been studied in relationships of competition, conflict, and cooperation; before and after victory and defeat; college students, managers, and executives, in temporary and permanent groupings, have served as subjects and so on. Rather than reviewing this work, which I think to be central if one is to understand change and resistance to it, I am going to tell you what it means to me by citing examples taken from the work place.

Restraining Forces that Block the Acceptance of New Ideas

What are some of the restraining forces that block the acceptance of new ideas? Two are given below as examples of the types of psychological blocks that impede the introduction of change into organizational life.

Violation of Legitimacy. One on every corner, you hear phrases like "management's perogatives," or "the rights of workers." Such phrases carry no *inherent* meaning: they only make sense against a background of traditional routines that people have become accustomed to. When either side in the cleavage splitting labor and management introduces ideas for change that go against the "legitimate" rules of the game, the other side screams "infraction" or "foul play." If it's a management proposal, it's "high-handed;" if the proposal is by labor, it's "brazen" or even impudent. Under these conditions battle lines are drawn, as though a life and death struggle had been joined.

Let's take a concrete example. One company after another is striving to exercise it's "rights to manage," by negotiating changes in the "rules" of work. An important rule is the one involving respect for craft specialization. Each man is a specialist: a pipefitter fits pipe; a welder welds, and an electrician works with problems of generating, transmitting, and applying electrical power. "Legitimacy" is defined by specialization.

When management, acting under the driving force to increase efficiency, proposes a "new" idea called *work* *flexibility,* so that individual effort can be assigned in line with the requirements of the situation, the union reacts with strong resistance. To the union, the idea of flexibility of work distribution provokes strong restraining forces against acceptance. The union says, "Rights of the worker are about to be violated through exploitation," Its members say, "We" be jacks of all trades, masters of none." *Everyone* fears "layoff." "Legitimacy" as seen by labor springs from specialization in the modern world, yet it's not always been that way. The village blacksmith would have been violated were his "legitimate" activity limited to hammer and anvil. And so too with management. Its "rights to manage" are in jeopardy when work distribution is required to follow what are seen as inefficient lines.

The solution? There is no solution short of management and labor sitting down and developing a force-field analysis along the lines, described here, and then working clowly towards a definition of the situation which makes it understandable from both sides of the fence.

A number of concrete steps can be suggested which go against present day ways of doing things. One, for example, is, "Don't take a position in advance." Develop it with the other side, so that both groups are changing together. Another is, "Avoid newspaper or other types of accusations and counter-accusations." They only serve to inflame; they don't persuade. A third is, "When people start resisting, analyze why." They're not stupid. Chances are you'll find some very real reasons for resistance you do!"

It would be difficult to overestimate the role of "violating legitimacy" as a reason for resistance to change, particularly when group lines are drawn and the new idea is the property of one group. The groups don't have to be management and labor, they can be functional grouping, levels within management and so on. Yet there are many other sources of resistance. Let me give another.

Long Continued Success. Every organization works for success, yet very few know how to live with it once attained. Success is a narcotic! It is capitalism's most dangerous product! Success breeds complacency. Disaster, or the brink of it, seems to be about the only antidote for success that we react to today.

While we have studied success and failure groups under laboratory conditions, there is no better way to tell this part of the story than to quote Sylvia Porter in the New York Post, December 3, 1959.

"There isn't a half-awake American who needs to be reminded of the prolonged and at times bitter struggle preceding the introduction of the small cars by the "Big Three."

"We're an exceedingly car-conscious nation and you know how the auto magnates at first scoffed at the soaring popularity of the little foreign cars here, then frowned, then went into action and placed stakes running into hundreds of millions of dollars on their own competitive models. You know how mightily the "Little Two"—American Motors and Studebaker-Packard—have prospered because of their hot-selling Rambler and Lark. You know how excitedly enthusiastic was the public's initial appraisal of the new models this fall and how decisive is the general approval of the return to a wide variety in auto styles and price ranges. You know that auto sales would be zooming right now were it not for the temporary shortages created by the steel strike."

Two additional remarks will complete the story quoted above. The first is a question: Why were the Big Three unable to forecast future events? Was it because they had been so successful in 1955 and the years before? I think so. The second is even more interesting. Recall that Ford introduced another "big car," the *Edsel,* at a cost of 250 million during the same period that little cars were beginning to dot the American highways! And notice the announcement by Ford in November 1959, "The Edsel line is to be discontinued!"

Success builds its own resistance to new ideas, to change; it breeds complacency, even contempt. Perhaps I can close this section on the damage to progress contributed by success by a reference to modern social science. The "successful" institutions of Europe in the last few hundred years—Cambridge, Oxford, Sarbonne and Heidelberg—are quiet today: they give little promise of springing up from the complacency which grips them. The "big five" grand old Universities of the east coast are not much farther ahead in the modern segments of the school sciences. I will limit my remarks regarding West Coast institutions to private discussions!

Let me put in a final hooker, a test question: "Why is the USA on the short end of the stick in the field of exploration? What can be done to help successful organizations? A lot, but only when successful institutions learn to tolerate deviation, to excite internal criticism; to look towards tomorrow and to forget yesterday. How can this be done? I'll suggest how later.

I've dealt with only two of the stronger sources of resistance to change. Yet perhaps these are sufficient to point to the kinds of factors a force-field analysis needs to take into account if a realistic approach to acceptance of new ideas is to be accomplished.

Driving Forces That Lead to Change

Now lets deal with the kinds of psychological forces that lead toward change. Again I will take only two, just enough to indicate what I have in mind.

Crisis. Many organizations—successful and otherwise—are confronted with unanticipated, disturbing, or alarming situations. They don't know what to do to solve a dilemma. The situation is conducive to change. *Crisis,* in other words—even though unattractive—does "loosen" an organization, free it to reexamine its automatic assumptions, and to see how it must act if the dilemma is to be resolved. Although some of our worst social engineering occurs under crisis conditions, unfortunately, it is one of the few social conditions which motivates change.

I need cite only a few examples: The great Depression and World War II can be taken as typical in the international field. Those two crisis situations produced as much change, in terms of acceptance of new ideas, as any event of history. Sharp defeat in the market place of new products has the same effect: it generates an analytical attitude; a readiness to change.

"Why is "crisis" a source of social injection? I think at least three explanations are possible. One is that it brings out *new* leadership; a second, is that it motivates effort; and a third is that it unblocks blind allegiance to old ideas which the crisis proves to have been wrong.

Now I'm sure no one wants to propose a program of "change by crisis." It's disturbing, disrupting and dislocating; it breeds insecurity, anxiety, and doubt, and all are repugnant in a 20th century world view. What I am saying is that crisis—a sharp, clear discrepancy between what was anticipated and what turns out to be actual—is a major force towards acceptance of new ideas. The real question is, "How can change be accomplished without *crisis* as the motivation?"

Only one answer is clear to me. I will present it after discussing another driving force which increases readiness to change.

Brink of Disaster. Closely related to crisis is the "brink of disaster." An organization usually gets to the brink slowly. It is a gradual process. You sense that something has to be done but the brink may remain unrecognized for some time, whereas a crisis is more dramatic, more easily recognized.

The following remarks are generalizations based first in the laboratory research program and then "tested" in four different company research organizations. Incidently an applied research organization is a good one to study if one is interested in the acceptance of new ideas. Why? Because a research facility can only be successful if it sells new ideas, in other words, if it can induce change!

What is a research organization? A research organization is intended to contribute new ideas, new processes and methods, or new products. All four units described here are physically separated from the operating segments of their parent companies. These research units have been studied in regard to the issue, "Describe the units of the company where you have had best success in getting your research results used." Results are complicated by extenuating circumstances (like having a foreman research man who takes a line position, thereby automatically opening the doorway to new ideas), but the main trends are clear.

All four research units *agree* that segments of the company that are "in trouble" are more responsible to new ideas than those that are "doing well." All agree that new sections are more responsive than older, "established" parts. Generally they agree that parts of the company that are "aggressive," and "on the make" are easier to approach with new ideas than are ones which have become accustomed to long continued success.

What do these statements mean? They mean that openness to new ideas is most present among the young, the aggressive and the troubled.

Yet I want to limit my remarks here to the "troubled." Why should the troubled be more open than those who are doing well? We have seen this many, many times under laboratory conditions. Troubled groups are searching for solutions, new ways of doing things, new patterns, new approaches which can lead to success. They are "open," ready to change; in a word, "driving forces for change are high, resistance towards change is low." Pathetic but true.

Recapitulation

I have said that change—the introduction and acceptance of new ideas—is a "level," more or less constant over time, as long as conditions remain stable and fixed. The "level" changes, up or down, with changes in the field of forces acting on it. Some forces impel acceptance, others restrain it—preventing new ideas from being bought.

Examples of conditions leading to resistance towards new ideas include violation of "legitimate rules" and organizational success. Circumstances leading toward acceptance of new ideas are crisis and brink of disaster situations. None of the four are "healthy."

An Approach to Planned Change

Now I want to propose that these four forces are essentially unplanned. Organizations don't plan to be complacent and resistant when struck by success, nor do they plan to be open and accepting when faced by crisis or a brink of disaster situation. The real question is, "How can change which is *planned* be accomplished? The question might be put another way: "Can success and flexibility go together?

Earlier I delayed dealing with this question, but now I want to. My position is that planned change is only possible through much richer, widespread, more personal systems of data collection, analysis and interpretation within organizations than anything we know today.

The tools of planned change are perhaps known to you. Among others they include an electrographic pencil, an IBM mark-sense card, and a 402, 604, 705, or equivalent equipment for the rapid digestion and analysis of information.

First here is an example of gaining acceptance of new ideas through a program of planned organizational change in a large organization. Four different groups, each representing a different level of management, initiated the program. Each conducted a problem census. Fifty-four problems of a general sort—those appearing in the lists identified by 3 of the 4 special study groups—were then placed on a 9-point scales, and 350 managers, assembled in an auditorium, indicated how serious to the progress of the organization he considered each to be. These data were immediately fed to electronic data processing equipment, which summarized reactions to each question in a twenty cell table, subdivided so as to show localized reactions within each of 4 departments by each of the 5 levels within the hierarchy of the organization. Summarized data were available within 24 hours and returned to all managers to study, to interpret and to design solutions for. The next year in this company is to be devoted to the implementation of solutions for these problems. Already tremendous progress is evident!

Based on incontrovertible data of the kind described here, data which are "neutral" and which command attention and respect, many new ideas have been proposed; some already have been adopted, others are being evaluated further and will be adopted. Some, of course, will never find application. The point I want to make is that what we have seen in this organization is a rebirth of creativity, a fresh approach to problem-solving and a new respect for new ideas. The "level" for accepting new ideas has changed dramatically in an upward direction. The change is due to a new respect for data; indeed to the acceptance of the view that well collected data, adequately analyzed and interpreted, can induce acceptance of new ideas within even a *successful* organization. Data *are* an effective antidote to success. They can aid an organization to anticipate and to avoid crisis, or brink of disaster situations. In a word, they reduce restraining forces preventing change, and add driving forces facilitating change.

A second example may help to show what I have in mind. It comes from another company. During December of 1959, after studying the general problem of change each manager reacted to the following: "The XYZ Company's problems in the '60's—what are they?" through giving in rank order the 10 most important issues he saw. Now these problem areas are being summarized and catalogued in much the same way as described above. These data will be studied, analyzed, and interpreted, in preparation for a year of revitalized problem-solving within the Company, with the problem-solving to be done by those who have the problem. Let me point out that both projects described are being done by the organizations themselves, not by outside groups. A general rule can be stated here: The probability of success in changing a level is increased to the degree that those who have to implement the change also conduct the force-field analysis. The old saying remains, "You can lead a horse to water but you can't make him drink."

In summary, my position is simple. The single best antidote to resistance to change—from whatever source—is well designed data collection, with rich data summaries placed in the hands of those who are confronted with the problem. Under these conditions, new ideas find a much higher rate of acceptance. Success doesn't produce complacency, and data can do much to neutralize stereotypes of legitimacy that block progress.

Finally crisis and brink of disaster situations can be anticipated before they become crushing sources of defeat. If you are having trouble getting new ideas accepted I can make only one worthwhile suggestion. Create a climate under which data can be collected and used by those who need to change to plan the changes for themselves.

INDUSTRIAL STATESMANSHIP

F. F. Bradshaw
President
Richardson, Bellows, Henry and Company, Inc.
New York

INTRODUCTION

I will not attempt to apologize for talking seriously at the luncheon meeting. I am sure every newspaper headline, every technical publication, every major corporate financial statement, and every serious professional program today furnishes obvious evidence that underneath all our prosperity, progress and 'peace' there are serious forces at work in our world. Their operation, if not foreseen, moderated and to some extent controlled, can mean tragedy for us and our children and our grandchildren on a scale hitherto unknown in history—and difficult even for us to conceive. I therefore make no apology for accepting an invitation to speak on the subject of "Industrial Statesmanship."

Your own program is full of topics which your committee has assembled with an eye to their mutual implications for challenging the industrial statesmanship of us all. That I could make your schedule and mine mesh is in itself one of the finest evidences of the first point in my sketch of the challenge ahead. That point is that we cannot, in America, get out of the world. I came from New York to California in five hours and fifty minutes and will return from California to New York in four and a half hours flying time. A friend of mine whose company insures jet aircraft said that one of the principal jet aircraft manufacturers remarked that they no longer had jet planes on their drawing boards. The technology of the jet has now reached maturity and what is on the drawing boards at the present time is missiles that will "take you from America to Africa for example in 37 minutes."

Of course it is obvious that such missiles would also return from Africa to America in the same flying time, possibly moderated or accelerated by trade winds. They also can fly from Egypt and China and Russia at the same kind of speed. As President Eisenhower recently remarked (on a TV program witnessed by millions) turning to face President Hoover, "It is no longer possible for a nation to be a fortress." Even as late as World War II behind the shield of Britain and two oceans we were allowed to convert from peace to war. We are now the shield of Britain and the oceans are but seascapes to be scanned curiously in rapid transit.

THE CHALLENGE

In this world, which now includes space and the far stars, we are challenged as we have not been challenged before during the 175 years of our existence. We have competitors of different languages, different ideology, different faiths who meet us word for work; moment by moment; place for place in the contest for popularity, influence, prestige, military alliance and helpfulness to human need. There was a time at the end of World War II, and before that at the end of World War I, and to some extent during the period of America's rise to power from our raw humble beginning when no country appeared on the horizons of the human imagination more beneficient, more admirable, more inspiring and more helpful than America.

But at times since both these wars we have appeared almost in a cariacature as carrying a burned out torch, backing up the reactionary powers around the world and delaying human escape from exploitation, ignorance, disease, starvation, war and colonialism. As unfair and inaccurate as this caricature may appear to us, nevertheless, the large number of human beings of all colors and in all times who actually do see us that way may constitute a fact and challenge us to exert ourselves as never before.

SELF-SUFFICIENCY

At previous times we have won many contests. In most of these as previously mentioned, large factors in our victory were our remoteness and our resources. If we had not been so remote from Britain we might never have won our freedom and those who signed the Declaration of Independence might have been hung or shot as universally happens around the world when people rebel against present tyranny. Britain was busy with European wars and it was hard to get across the Atlantic with troops and supplies; so finally we won out. In World War I and World War II our opponents were amazed at the speed and volume with which our resources were mobilized. We dropped the Mesabi iron range in War II on Germany. We airlifted all kinds of equipment and supplies to Russia. We rebounded from Pearl Harbor to Hiroshema with a sheer force of supplies and manpower that amazed our opponents and allies. But as I have stated in the paragraphs above we are no longer remote.

Any inventory of import and export trade, particularly of scarce raw materials will show that we no longer have the self-sufficiency in resources with which we fought in World War I, or even in World War II. It was estimated during World War I that we had within our borders 98 per cent of the resources required for a modern industrial and military effort whereas our opponents in Germany had only about 12 per cent. This was almost true in World War II but is no longer true today. Increasingly in places where we draw critical materials the "ugly American" is a less and less favored customer. I repeat, we are challenged as never before.

A CRITICAL CONTEST

The game in which we are challenged is a complex game which, like chess, can distract the player who concentrates on one corner of the board and the strategy built around one piece but can suddenly find himself unhorsed and checkmated in another corner of the board by strategy built around other pieces. Our present chess game includes at least five major elements:

Technology.

Productivity.

Strategic Planning.

Speed of change upward.

Political stability and discipline.

You may be able to think of some other factors but I respectfully submit that we have now around the world ample evidence of the significance of these five. Whether we race for distant space or aim at missile targets or strike against polio or improve scientific education or do motivation research or elaborate communication techniques—in each case the curve of technological events is exponential—for example, from vacuum tube to transistor to tunnel diode to "molectronics." You probably saw the prediction the other day from Westinghouse of radios the "size of a pea" and space vehicles whose flight would be controlled by appliances the size of "a button on your shirt."

Technology. This kind of technology is an elaborate structure of interlocking institutions of education, communication, translation, production, engineering, motivation, etc. etc. It is a structure of interrelationships which cannot be built in a day and whose decumulated impact is geometrical. That is, it is geometrical unless it is interfered with by a social matrix out of date and unable to provide economic support or political climate for the magnification of the powers of the society.

Productivity. We are gradually becoming conscious of many of the implications of the industrial revolution followed by the electrical revolution followed by the electronic revolution. They all point to the decisive factor of "capital formation" and the "benign spiral" upward of productivity caused by an increased rate of investment in "machine power for production." The race may be to the swift but the swift may very easily be swift because of an early start and an exponential curve of progress. It is an interesting thing to note today that the rate of increase in capital formation in Russia is faster than in America, and in China faster than in Russia. On the other hand, the Hindu has today 25 per cent fewer calories to eat per capita than he had in 1900. The longer these ratios operate the farther apart the economies get.

Planning. One of the principal characteristics of scientific management has been the elimination of lost and wasted effort rather than the increasing of effort. As more and more of production becomes dependent upon research and development and high rate of capital investment in machinery the lag of time between the steps of invention, development, production, marketing and profit is ever more extended.

This means more foresight, more risk; this makes mistakes more expensive and more likely, simultaneously. As one considers the total employment of resources this could mean more dislocations of manpower, more loss of capital to the extent to which planning becomes less coordinated.

Our opponents makes no bones about ability to plan in long sweeps, at one center through the power and the authority of the government which is not restrained by things like Bill of Rights, Due Process of Law, Habeas Corpus, or any of the other precious freedoms for individual difference that we have achieved in the last 150 years in the free world and do so highly prize. The margin of victory may, however, lie in the coordination of effort, and hence freedom without dedication may be costly.

Change. Speed of the time factor in the exponential race has already been pointed out. Except as some secondary force may upset them we would predict viewing solely sheer speed in competition that Russia and China may indeed bury the free world!

Political Stability and Discipline. Lord Bryce of England writing about the American state in 1905 commented on the fact that we had a remarkable system of government but were very practical people and could make any system of government work. However, he raised the question as to whether the American system would in fact work when we "came to a position of international responsibility." We have come to such a period of responsibility in leadership now, and there is a good question as to whether our march up the hill and march down the hill will work. We win World War I and then pass the Smoot-Hawley Tariff and repudiate the League of Nations. We win World War II and shift back and forth from UNRRA and the Marshall Plan to "military aid only" and "alliances only."

In other words, does this shift back and forth and the inability of our colleagues to predict us not in fact impair our leadership. I was told the other day that our British friends are now hedging against the devaluation of the American dollar. Just a few years ago all these countries were sending productivity teams over here to find out how we had discovered perpetual prosperity. Exactly the same thing happened after World War I in the early 20's after which America led the world into the worst depression in world economic history.

We are a mercurial people. Over half of what we spend our income for we could go without for a year; we are great followers of fads and styles. If we should mercurially turn to a fad of going without we could take the same kind of spin down as we did in the 20's in spite of all the cushions that have been built. If one jumps off the Empire State Building, cushions on the sidewalk are not apt to do much good.

WINNING THE GAME

So much for the five factors in which the game is being played—Technology, Productivity, Strategy, Speed, and Stability. In the winning of this game government, labor, education, agriculture, religion, business and science will all play a part. America being a business civilization and a technological scientific, industrial-based business structure, the issues will probably lie in the cooperation between business and science.

Accordingly, I appeal for industrial statesmanship. It is not enough now for the business manager to have authority of position or ownership. It is not enough now for him to have previous experience in the previous world. As we think back from 1960 to 1940 (we might, if we had time, pause for 10 seconds silence while each of us thinks back over the past 20 years) reviewing the changes made in our whole concept of the world, of culture, of politics and our entire relationship to the other countries of the world, we see rapid and accelerating social change.

If, as suggested earlier, change is taking place on a geometric ratio, and not arithmetic, would it be too presumptuous to suggest that the '80's will be much different from the '60's by an even greater degree than the 60's from the 40's? Is it too much to suggest that responsible managers must review and revise their philosophy and practice of management if we are to win the game that we now are in.

Fortunately, we are not without some help in preparing to do that. We have the history of the management movement in America. The Frederick Taylor defined scientific management as not a method of time and motion study or any other of the specific techniques that we think of in that connection. Rather he described "scientific management" as a "mental revolution in accordance with which both sides take their eyes off of the battle to divide up the surplus and instead put their eyes on a coordinated effort to increase the amount of the surplus." How much of this mental revolution have we actually put in play in American industry as of this date?

Robert Frost of New England pointed out that after the American Revolution all of the best people left the United States and went to Canada, England and the West Indies but that the "second-raters" who remained produced one of the world great civilizations.

This is the spirit of America; the belief in the people below us and the growing of the people below us rather than the emphasis on hereditary superiority entrenched privilege, authority of position, superiority of status, power, greed and all these several forms of resistance to change which in laboratory after laboratory, engineering department after engineering department, factory after factory, drag us back from our own geometrical ratio of advance.

About 1300 B.C. an obscure Central Asian tribe discovered a cheap way of making good iron. This in the hands of the Hittites led to the overthrow of four settled kingdoms one of which was Egypt which is gradually getting on its feet today over 3000 years later. The Hittites had learned to use temperatures of 2,000 degrees Centigrade instead of 1,000 degrees in working iron. Before World War II we had got this up to 10,000 degrees although the Arab civilization had been stuck at 2,000 degrees and in that had very good metal workers.

During and after World War II we have got the working temperatures that we can hope to manage now and in the near future up into the millions of degrees! If 1,000 degrees Centigrade made the difference of technology and power that history reports in the case of the Hittites what can we expect to accomplish from the technological advance that lies immediately at our feet?

But it is not all technology; it's very largely the motivation; the Romans were not conquered by the Huns because of technological advance. Approximately ten thousand Huns conquered the Roman force of approximately a million, the million having the higher economical and military technology. But the Huns had a kind of democratic social system; they had their "heart in their work"; they were not primarily battling over the "division of the surplus." Here again the American institutions contain great assets if we will but use them.

We've hardly begun to use what we know about the influence of motivation on the people. We've hardly begun to appreciate the extent to which we can use accounting to treat education, research, development; public relations as investments rather than as expenses. The opponent's accounting enables them to pay whatever is necessary to educate people for whatever must be done. We cannot play any longer a chess game in which development of skill and morale of workers is treated as an out-of-pocket expense on which there is never any profit!

AUTHORITY OVER THE TECHNICIAN

My final point deals in a much more difficult to present area. This is a question of authority over the technician.

I use the word technician here in a very broad sense to include the pure research scientist as much as the engineer or any others who are scientifically trained. The speed with which all of the sciences and technical fields are spreading, digging in and the range of vocabulary change occurred converts the modern industrial plant into a new form of the Tower of Babel. Obviously, these people must have coordination of effort; obviously, somebody must try to bring this about. But obviously the person who tries to do this cannot be a master of all the technical fields he wishes to coordinate. As a matter of fact, he cannot long manage and still be a master of the one that he used to be a master of.

This calls for a new type of authority. It is an authority not of power, not even of knowledge, but of "function" pure and simply. It is a kind of authority the traffic cop has at the street. He doesn't exist to interfere with traffic; he isn't going anywhere; his importance is solely in his facilitation of traffic; and yet if his authority is not recognized there will be no traffic. He doesn't know where the people are going; he doesn't know where they've come from; he only knows how to handle their intersection. The best traffic cops are humble, considerate, courteous, fair and recognize that they are a means to an end and that the motorists are ends in them themselves.

Similarly the best managers of technical people must be humble, fair, sympathetic and recognize that those managed are the people who contribute added value to civilization and that the manager's value lies solely in fostering that added value.

AMERICA'S FUTURE

As we move from the world in the 1900's into the world of the 2,000's, people will only exist in the world if we are able to hold our own and be considerate and understanding of the opposition. In America, an industrial civilization, our future depends upon industrial statesmanship. America calls in the words of the poet:

> "Give me men to match my mountains
> Men to match my plains
> Men with empires in their visions
> With epochs in their brains."

It is likely that the response to this call can come only from business and science—only from such as those gathered here today!

PRODUCTION AND INVENTORY CONTROL FOR A JOB SHOP WITH A CHANGING PRODUCT MIX

A. A. Cowan
Executive Vice President
Bobrick Manufacturing Corporation
Los Angeles, California

INTRODUCTION

It is generally recognized that small job-shop types of business, in particular those employing approximately 100, find it very difficult to cope with the short lead times and reliable delivery schedules demanded by both the military and commercial markets. These companies are constantly behind schedule, not dependable in their promises, and unpredictable in their re-promises. Because of the great number of small businesses and the fundamental role which they play in our national defense and economy, this situation should be of great concern. Delinquent deliveries are caused by lack of effective coordination of manpower, materials and machinery. Considering the extent and importance of this problem, and the fact that this is his rightful field, it is surprising how few practicing industrial engineers are engaged in this function.

A system in itself is not production control. It is merely a routine which evolves from the thought processes that are applied to existing problems. The emphasis, then, is not on the system, but on the thought processes that produce it. Many of the operations problems of small business can be solved with elementary mathematical analysis. It is the method for small business just as operation research may be the method for big business. In many small businesses, operational or factual data is either scant or lacking, and that precise solutions are, therefore, impossible. As most engineers tend to be conservative, they are reluctant to proceed in the solution of a problem with insufficient data. The problems, however, demand solution. Estimates or assumptions must be made, since an approximate solution is better than no solution, especially since these approximations can be tested in the situations and adjusted as required.

The results which we have attained in our company operations bear this out:

1. Late orders reduced from 60% of monthly schedule to 18%.
2. Percent orders shipped on time increased from 15% to 80%.
3. Reduction of inventories. Ratio of inventory to monthly sales dropped 20%.
4. Reduction in manufacturing costs and overhead because of the better working climate.

Let me tell you our story. You may find it an interesting one in itself or perhaps as a familiar parallel to your own.

COMPANY BACKGROUND

We design and manufacture a rather extensive line of soap dispensing equipment for the commercial market and a broad variety of check valves and other systems hardware for the aircraft and military market. These assemblies are of medium complexity and the components are small enough to be held in the hand. To do this, we utilize a group of sub-contractors as well as our own plant facilities in which we employ about 90 persons. While our current position with regards to customer deliveries is very good—it was not always thus.

When our company first started to manufacture soap dispensers many years ago, we enjoyed a rather exclusive position. The industry which we served was small and our founder had personal friendships with the several jobbers throughout the country. While the product line at the time was limited and production problems at a minimum, it seemed that there was always some part missing, which prevented prompt assembly and shipment. Market demands, however, were not high and delay in deliveries was overlooked in favor of the high quality product and the personal relationship between our companies.

But, as the post war commercial market grew, the company found itself unable to keep up with the demands. In its rush and anxiety to do so, the attendant carelessness in manufacturing down-graded the quality of the product. This was bad and not even the close personal relationship with our customers could salve this irritated market condition. The situation invited competition, and our share of the market took a tremendous fall. Similarly, with continued delinquencies in delivery of aircraft components, it soon found itself with practically no aircraft business. By this time, the then rather conservative management realized that something had to be done! They decided to look into the matter. In typical small business fashion, many of the "home remedies" were tried. First the universal panacea; "raise hell with everybody. That usually gets results." When the staff responded with a deluge of excuses and reasons for their lack of performance, it appeared as though the No. 1 solution would not work. It seemed advisable to try other "solutions." Management looked a little further.

SITUATIONS, REMEDIES AND RESULTS

Situation #1 Lots of urgently needed components were partly finished and gathering dust. *Remedy:* Expedite these "hot" parts through the factory; split the lot if necessary. *Result:* Expedited parts were finally delivered to assembly. But this is not the end of the story, for while the expeditors were busy putting out the fires on the immediate shortages, the balance of the lot and other parts in process or due to be started were often neglected. Soon they too found their way on to the "hot list." And so, the vicious cycle started again.

Situation #2 Stock room was completely out of a particular part, and everybody said, "we always seem to be out of that part." *Remedy:* Run larger lots when this part goes into production. How large? Twice as large. *Result:* Most always the lot was split because of other urgent demands on the machine time. The larger lot was never delivered as such to the stock room. If the large lot did manage to get to the stock room, the sight of a big supply was so assuring that job releases for the next run were almost always late in forthcoming. So, sooner or later, we were back to the same trouble.

Situation #3 Shipments were always several weeks late in promised delivery. *Remedy:* Take our normal promises and increase them by some specific amount, say three or four weeks. This was usually a poor guess, based on customer tolerance rather than on actual shop conditions. *Result:* The placing of a distant delivery date on an order invariably gave the shop a grand feeling of comfort. They would concentrate on the pressing jobs and the approach of the delivery date found them in the same sad state.

In due fairness, it must be said that there was some slight improvement in deliveries and conditions. These were, however, costly and did not provide the solution of the basic production and inventory problems.

The failure of these remedies to solve the situations was due to three things: (1) lack of concept, (2) dealing with symptoms instead of causes, and (3) the basic notion that "if a little does well, a lot will always do better."

THE NEW APPROACH

Now, simply stated, the objective of production control is "Deliver everything on time." In our approach to the problem, we viewed the factory as a mechanism or a system which transforms an input (labor, material and capital) into an output (a product). At any given time, this mechanism has a finite capacity or rate of output. Let us expand this concept into an over-simplified picture and explore it further.

Under ideal conditions a unit of input will work through in some normal time. New inputs must, of necessity, wait until previous inputs have been worked through the mechanism. Any of the increments of input might be accelerated through the mechanism; in doing so, it displaces some previous inputs which will then clear through at some time later than originally expected. Although it might relieve a jam-up, no amount of juggling and shuffling within the manufacturing cycle can add to the total work-absorbing capacity of the machine. To increase the output, we must increase the size of the machine or channel some inputs into an auxiliary. The problem of production control, therefore, can be resolved into knowing the capacity of the mechanism, anticipating the input, translating this input in terms of capacity, providing for a controlled flow of elements through the machine, and follow-up to assure performance. Elementary as this might seem, many companies failed to recognize this in their system installation, and their efforts at control are unsuccessful.

FUNCTION OF PRODUCTION CONTROL

In terms of the specific industrial situation, the functions of production control systems are: Forecasting, Planning and Scheduling, Order Processing, Control and Follow-up.

The presentation will deal mostly with the first two primary functions and touch lightly on the secondary, though no less important ones. Good production control, assuring a minimum delay through the fabricating processes, would not, in itself guarantee the meeting of shipping schedules, if the components are not ordered in sufficient time or in sufficient quantity. This important function is the essence of Inventory Control and it is closely connected to production control.

THE INVENTORY PROBLEM

There are also some other very important reasons for inventory control which should be mentioned in passing. Inventories, both in-process and finished goods, usually represent approximately 60% of a manufacturing company's assets, and prudent management demands control of such a sizeable sum. Poor controls, leading to excessive inventories can readily drain the working capital of a small company; and, also, increase the danger of losses due to obsolescence and cancellations. There is also the high cost of maintaining excessive inventories.

There are two schools of thought on this matter. The one which takes into account such things as warehousing charges, taxes, interest, insurance; in short, the actual costs of maintaining inventories. Figures have been developed to indicate this might mean 15% to 20% of the inventory value. The more current thinking, however, takes the position that monies invested in excess inventories could and should be earning money. Financial statements of manufacturing companies indicate that net profits before taxes are at least 30% of the invested capital of the company. From this point of view, the cost of maintaining excessive inventories is rather shocking.

With the importance of these functions now established, we will proceed with a presentation of what we at Bobrick have developed and applied in inventory and production control. We will offer no pat formula. We feel sure, however, that you will find some of the elements directly applicable to many industrial situations.

A SYSTEM OF INVENTORY CONTROL

We start with inventory control, since it is at this point where the shop orders originate in our system. The foundation of an effective inventory control system is the sales or production forecast. This tells us how many we need and when we must have them.

One type of forecast commercial line of soap dispensers manufactured for stock and shipped on demand in varying monthly rates but having a statistical pattern over the years. Because of this consistency and the repetitive nature of the production, it was felt that our control should be somewhat automatic, requiring no more than ordinary clerical skills. We decided on the "order point" method. The system was designed to release a shop order when the stock reached a specified level. We utilize a Kardex file to which is posted all incoming materials and all disbursements. The individual card shows material at hand so that the stockroom clerk is aware when the ordering point is reached.

THE ORDER POINT

It was felt that the quantity on hand at the ordering point should be sufficient to take care of the assembly requirements until the newly issued lot comes into stock. The assembly requirements were obtained from a simple statistical approach. From an analysis of previous annual sales figures, to which we added a 10% for anticipated increase, we derived average weekly usage. We have found the week to be a convenient unit of time throughout the system.

There are two general classes of parts to be considered in determining the number of weeks required to put parts into stock: (1) purchased parts and (2) parts fabricated in our own plant. For purchased parts, previous experience with deliveries from the vendor is usually sufficient to establish an approximate delivery time. Any major or radical changes in procurement conditions either current or anticipated are transmitted by our Buyer to the production manager who then has the necessary corrections made to the Kardex information. To determine delivery times of parts manufactured in our own facility, we developed a formula from existing production and cost information.

Job data were analyzed to determine the correlation between total manufacturing span (date of job release to date of job close out) and the number of operations required to fabricate the part. These were plotted on a scatter diagram. For the sake of simplicity in scheduling and on the presumption that the establishment of target dates would reduce in-process time (and in-process inventory) in the shop, we arrived at the simple basic formula which, I might say, has worked out well. The total manufacturing span in weeks equals lead time plus number of operations

$$M = L + n$$

The lead time refers to the number of weeks from the release of the order to the start of the first operation. This lead time was verified empirically by taking a tally of the work load ahead of the principle work centers. We did this at random several times during the development and the installation of the new system and found that work load ahead of each center averaged four weeks. While the method described lacks the sophistication and exactness of true statistical analysis, its justification is based on its simplicity.

The variables in a small job shop production situation are for the most part not under relatively good control, and determination of the number of significant variables and the way in which they operate is virtually impossible, with the means readily available. To get at the essential elements of the problem and relate them in a simple workable formula, then, necessitates the assumption of simple constants such as the arithmetic mean, etc.

The choice of "number of operations" rather than total time, in the determination of the manufacturing span is based on the job shop activity. Typically, a medium sized lot of small parts will take the following route. There is usually a primary operation on either an automatic screw machine or turret lathe. Here, the lot can be processed through in a matter of a few days. It is then delivered to other work centers for secondary operations, which are usually much faster than the primary operation. Since the lot must wait its turn, it can seldom get through a department in less than one week, even though the total manufacturing time for the lot is only a day or so. Should the lot be delayed in a particular center, it can be readily expedited since the speed of the secondary operations makes it possible to perform two of these operations in the following week, and so catch up. So much then as to "when to reorder."

THE ORDER QUANTITIES

Formulae for economic ordering quantities have been developed for use in this phase of inventory management. They require data on the cost of ordering and on the cost of carrying inventory. In using the formula, ordering quantities change markedly with changes in these elements, and since we had no data on these factors, we had to take the following approach: We assumed some industry-wide averages and selected some of the higher priced, large quantity, inventory items and applied this formula to them. The results varied from part to part, averaging approximately a three month's supply. We then arbitrarily selected this as a lot-size and checked with the shop and with our vendors as to the feasibility and practicality of these lot sizes. The lower cost, high quantity, items were set up on the basis of lot sizes recommended by the factory, but never less than a three month's supply. You will note that what we have discussed assumes an ideal set of conditions. Let us see what happens if usage varies from the average in any single period.

If the usage is greater, we will run out of parts before the new lot reaches the stockroom. This, of course, is undesirable and the possibility of its happening should be reduced to some practical minimum. One way to do this would be to add a "cushion" so that a delay of incoming parts would not leave us without some supply. This is obviously costly and should be minimized in view of what we said of the high cost of the maintaining excessive inventory.

To give us further protection without increased inventory, we resort to a weekly survey of our Kardex. This is a visual survey and required very little time. It involves the listing of the parts that are in less than one month's supply. It is filled-out by the Inventory Control Clerk and is transmitted to the Shop where it serves as a revised order of job priority. We are usually able to accelerate these parts through the plant owing to the higher production rates of the secondary operations.

So much for first class parts whose usage has a fairly high order of predictability. Now for parts whose usage has a moderate degree of predictability. The custom-built aircraft assemblies which we manufacture for delivery according to a pre-determined schedule, fall into this category. Purchase orders for these assemblies are irregular. The quantities are usually small and we are likely to get several spare parts orders during the term of an original purchase order. Since the airframe manufacturers and the military services try to keep their operating inventories to some safe minimum, these purchase orders call for short delivery times, usually less than the normal manufacturing time. We have solved this problem, for the greater part, by the following approach.

Because of the irregularity of these requirements, we use the periodic "review" method as contrasted to the "order point" method in determining when to order. As regards quantity, our manufacturing lot sizes are figured on quarterly requirements, even though the total quantities on the purchase order may extend for a year or more. This is based on existing practices in the aircraft industry which are designed to minimize the losses due to cancellation, obsolescence, etc. Job releases, based on review of open orders and inventory, are made quarterly, one month before each calendar quarter. To provide for the irregular spare parts orders, the quarter's requirements are better than none at all. An over-guess in one quarter could be shipped as part of the regular requirements in the succeeding quarter. An under-guess would, at least, provide some spare parts for the customers requirements, and the balance could be made up early in the following quarter. I would invite your attention to the long lead time provided by the system. Since it takes approximately 12 to 13 weeks to manufacture parts, we are actually ordering for the following quarter. This automatically insures a "cushion" in manufacturing time. Monthly delivery schedules for the next two months are published monthly and issued to the production control supervisor to aid in the follow-up of parts in process. Changes in shipping schedules between issues are transmitted as soon as received so that the necessary action may be taken in the shop.

Newly engineered jobs for which there are no similar or open orders are made to order as required. We, therefore, make no provision for this in our inventory control system. This type contract, however, does play an important role in our production control system and will be discussed during that presentation.

A SYSTEM OF PRODUCTION CONTROL

The principle function of production control is planning, scheduling, order processing and follow-up. Now, just as the production forecast is the foundation of a good inventory control system, so the estimate of the work load is the foundation of a good production control system. This required the establishment of a job routing and the manufacturing time per operation. The system cannot hope to function successfully without it, and here too, an educated guess is better than none at all.

The high points in the mechanics of the system are covered by following a typical job release through it. (1) Production Control department gets a job requisition either from the stock room or from Master Planning. (2) A job tab is filled out covering job order number, quantity and final due date as requested. (3) The master routing is verified for accuracy or change. This is done by a relatively unskilled production control clerk who uses a marked-up copy of the traveler of the previously run job which has been filed in the master folder. The marking up has been done by authorized skilled personnel; usually production foremen or shop planner. (4) A complete set of forms is run from the one master and distributed to various files, racks, control boards etc.

At Bobrick the basic paper work in connection with the system is as follows: (1) Traveler, which goes along with the parts, (2) Production Log on which the finished operations is posted, (3) Perforated Routing Sheet which is divisible into strips for use on the Machine Loading Board, (4) Shingled set of Job Cards which are individually detached to serve as job tickets. On the job tickets, Operations 10 and 20 are usually purchase or material requisitions and that intermediate operations designating outside processes or key inspections, make use of the job ticket as a requisition. This use of job tickets is somewhat unique in our system. It has been used with great success to coordinate the activities of the several departments usually involved in parts fabricated in and out of the shop.

The Traveler is put into glasene envelopes and distributed to tub files which are set up as follows: (a) Material Ordered, (b) Material Purchased, (c) Material Received, (d) Material Outside For Intermediate Processing, (e) Material Outside for Final Processing. These files provide visual information and assist in the follow-up of parts. The Job Cards are filed by part number and dispatched as needed. (7) The perforated Routing Sheets are separated into strips, each being cut to length proportionate to the total time for that operation, one inch per 8 hour day. Each strip is then hand marked with its individual schedule date. This is determined by marking the last operation to agree with the due date of the original requisition and back dating each previous operation in accordance with the formula of one operation per week. To facilitate this, we use week numbers from 1 to 52.

In addition to this paperwork, the system has a Machine Work-Load Board and a Job Status Board. The Machine Loading Board shows all primary operations and major secondary operations. The Job Status Board is used only for those parts requiring the longest manufacturing time or most attention. By a careful selection of key parts and operations, we exercise a fairly good control, since experience has shown that a minor part which has been delayed or overlooked can be made up in fairly short time.

The Machine-Load Board consists of a series of horizontal tracks into which the perforated strips are placed. These horizontal tracks indicate work centers and reflect the total work load ahead of the shop at any given time. There are several basic concepts in connection with the placement of strips on the board. (1) The lowest date numbers have the greatest priority. (2) If the numbers are equal, or very close to each other, then the one with the longest running time gets highest priority. This is based on the notion that it is probably less harmful to be one day late on a two week job, than it is to be two weeks late on a one day job.

The Machine Load Board is essentially a plan of action. Should these change by reason of stock room requirements, customer requirements, then appropriate adjustments must be made. Care must be taken to avoid the pitfalls of the fallacious logic that says, "if we have to continually change our plans, why bother to make them at all?" The answer to that is, minor changes in planned efforts can be controlled, whereas, effort without plans leads to disorder and chaos.

The little time involved in keeping the Job Status Board up to date is more than offset by the advantages of the visual indicator. Ready information on the status of the key parts helps to assure that they will not be lost due to the daily diverting pressures and possible errors in posting, handling, scheduling etc.

The discussion this far has assumed a set of simple conditions disturbed only slightly by minor variations. Changes in the product mix often result in great variations in the amount of hours demanded of the various work centers. Despite the finite capacity of the plant facilities, provisions must be made so that operations will be performed during the week in which they are scheduled. To accomplish this, we have developed a group of reliable vendors. Since the Machine Load Board provides us with a visual picture into the future, we know where our overload will be well in advance. We can, therefore, sub-contract components in sufficient time to assure their arriving into inventory as required. The decision as to the particular parts to be sub-contracted is made by a committee consisting of the Production Manager, Shop Superintendent and Shop Planner. The *keeping of the weekly schedules is basic to the system* and must be adhered to in order to insure out final delivery schedules.

MASTER PLANNING AND WORK AUTHORITY

The discussions of production and inventory control as presented thus far, has dealt with the factory aspects of the function. You will recall these controls were based on production forecasts. These estimates are part of the master planning function and are developed on the basis of quarterly reviews of open orders and market conditions by a committee comprising Production, Sales and Management. All incoming purchase orders clear through this committee. It is here that delivery promises are made, based on the availability of parts from inventory either direct or in process. If a purchase order or request to quote covers a brand-new job which is not in current production, a master planning sheet is worked out and submitted to the various departments for their comment. At a planning meeting, which is held several days later, target dates are set for the completion of engineering, tooling, production planning, castings etc. At this point, too, it would be well to comment that even a rough estimate on target dates is better than none at all. The best chance for success in meeting the promised delivery is to work toward that plan.

There are some supplementary but very important points which must be made on systems in general. (1) A system comprises procedures, paperwork and the people who function in it. Although we can, with ingenuity, build in check points or signals to protect against mal-function, to assure success, the people must understand the system and their part in it. People are more important to the result than procedures.

(2) People are more effective in carrying out their responsibilities and assignments if these are presented to them clearly and in attainable units. The system as outlined provides for such information, but Management must insist that this information be used or the system is doomed to failure.

(3) Production control can be no better than the other controls in the company at that time. Lack of adequate control in purchasing, tooling, quality and engineering such as would delay materials, fabrication, technical information, etc., will contribute to delinquent schedules. Production control therefore necessitates plant-wide coordination requiring the utmost in perception, alertness to changes and prompt responses to varying conditions. The production control department must never relax its pressure on all departments concerned in order to maintain target dates. They must never permit themselves to think that they can confortably or readily make up for any time lost due to some scheduling slack.

A suitable riddle can best illustrate this point. A driver is to cover a four-mile course. He travels the first mile at 60 miles per hour; the second mile also at 60 miles per hour; he covers the third mile at 30 miles per hour. How fast must he travel the last mile to average 60 miles per hour over the four miles?

With some thought you could all answer this question correctly. Should it be 90, 120, 180 miles per hour? The sad but true fact is that the poor driver can never make up the lost time and average 60 miles per hour regardless of his speed in the fourth mile. In order to go the four miles at an average rate of 60 miles per hour, or one mile per minute, he should cover the course in four minutes. He had used one minute for the first mile, another for the second mile and, in dropping his speed to 30 miles per hour, he has used the remaining two minutes in the third mile. An infinite speed is required on that fourth and last mile in order to average the 60 miles per hour required. It cannot be done. Constant control of production will minimize the possibility of this happening to us.

THE GENTLE ART OF SIMULATION

O. J. Feorene
Supervisor
Industrial Engineering Division
Eastman Kodak Company
Rochester, New York

RESTRICTIONS TO EFFECTIVENESS

The major role of the industrial engineer is to provide assistance to production supervision and to plant management. It should not be surprising to any of us that the demand for assistance of this kind is directly proportional to the effectiveness of the service rendered. The old, old story of the man with the better mousetrap applies to us as well as to manufacturers of mousetraps: If we are to be a part of the broader studies on the industrial scene, our services should not only satisfy the immediate need for which we were called, but we should provide something more --- and that something more should be additional information that will guide the supervisor in making future decisions.

Industrial engineers are told to "stick to the problem" meaning, on occasion, that an answer is wanted in a fairly short period of time and at the lowest possible engineering cost. This attitude, if it prevails, precludes the possibility of an analysis in depth directed at causes and effects, and tends to perpetuate a restricted Industrial Engineering function. When the industrial engineering activity is limited to work measurement, or work simplification, or plant layout, a wall is created that restricts the engineer in the *scope* of the study, the *techniques* he might employ, and most important, the *effectiveness* of the service provided to the operating departments and to the plant manager.

Time studies or methods improvement are specific activities that will only go part way in meeting the problems that we are being asked to work on today. How is the remainder of the problem brought under control? Often the operating head tries to do the work by taking the time away from the pressing daily needs of his own position. This seems unrealistic and even impractical considering the importance of his function as a line supervisor. Or perhaps, other staffs may be called in to complete the study. This may be prompted by a sincere effort to follow organizational lines of responsibility in which, perhaps, the activities of the various staff units have been "clearly" delineated. The inevitable duplication of effort and the possibility of a patchwork solution are certainly matters of concern to the plant management. Of even more concern should be the extent to which either of these approaches falls short of a possible optimum solution since we can not measure what the outcome might have been if the problem would have been tackled in a different manner.

In regard to the point of other staffs doing Industrial Engineering work, it can be suggested that as long as the job gets done --- Who really cares? We do --- and for the following reasons:

1. As more "fringe" areas of interest are undertaken by other groups, it becomes increasingly difficult for the operating head to distinguish between the activities of Industrial Engineering and these other staff departments when he needs assistance. He might well proclaim a "Plague on both of their houses" and do his own industrial engineering thereby further compounding the whole matter!

2. A complete industrial engineering study can be made only when the immediate problem is resolved in terms of the entire operational environment. Parceling out segments of the study presumes a fore-knowledge of interoperational relationships on the part of the requestor that has not always been borne out by experience. This particular point is the one that should concern us the most.

IMPROVING ENGINEERING EFFECTIVENESS BY UTILIZING SIMPLE MODELS

The majority of supervisors would probably welcome a "crystal ball" that would allow them to preview the outcome of their decisions while they still had a freedom of choice. The extent to which we can help the supervisor or manager predict the results of anyone of a series of alternatives may well be a measure of the demand for our services. To accomplish this our assignments must be relatively broad. Instead, assignments to Industrial Engineers are usually stated in the form of a request to study a specific problem. This is not because of short-sightedness - it's a reflection of the nature of day-to-day operating problems. However, as a result, the specific request tends to narrow the scope of the investigation thereby limiting the opportunity to study the problem in all of its aspects.

As an illustration, one of our engineers, Al Shannon, was asked to make some layout changes in one of our departments in order to provide more room for the storage of hand trucks used to carry mixed chemicals. These chemicals are collected by individual order to avoid mixups and are delivered on call to the using departments. There are two general areas located in a nearby building that use these chemicals.

The frequency of demand for mixed chemicals varies from hour to hour. The length of time that any one truck is gone from the mixing departments depends upon the destination of the truck and is one of the factors that determines the number of trucks required to give adequate service.

As a general rule of the thumb, orders for mixed chemicals were to be delivered within one hour of the order time. This was to prevent serious difficulties in the succeeding operations that by pre-scheduling depended upon a specific sequence of activities once an order for mixed chemicals had been placed. As a rule prompt action could be expected on the part of the mixing department; the supervisor made certain that there were a sufficient number of trucks on hand at all times to fill the orders he received. A specific area was set aside to provide a marshalling area for filled trucks waiting a call from the using departments. At any given moment there were as many as 33 hand trucks in the system.

With an increase in production requirements there appeared to be a need for additional trucks and also a need for an increase in the size of the marshalling area. Considerable congestion had already begun to develop in some of the busier aisles and passageways. This was the situation upon which the specific request for a relayout to provide more room was based.

As part of the familiarization phase of the study, Al made a simple flow diagram that outlined the steps in the system. This, of course, would be the normal procedure for any industrial engineer whether making a layout study or determining the operating pattern of the system. As he made his flow charts he listed those variables in each of the steps that appeared to be significant. There were five:

1. The number of orders placed for any given interval of time.
2. The variation of the actual order call time about the order time.
3. The truck destination.
4. A distribution of the time spent by each of the trucks in the using departments.
5. The total number of trucks in the system.

Al's next step was to plot a frequency distribution of the order pattern. This distribution showed him the number of orders placed per half hour periods of time. For example, there were 10 half-hour periods in which no orders were placed; 67 in which 3 orders were placed; 12 in which 9 orders were placed and so on. (Refer to Fig. 1)

He then super-imposed a Poisson distribution on this order pattern. The closeness of the fit was checked statistically and supported his hypothesis that the order pattern was completely random in nature.

Al then examined the data he had accumulated on the order call time. Despite the fact that the orders should normally be called for within an hour of the time actually needed, he found that the calls for the order varied as much as plus or minus three hours from the original time. The calls placed after the order time indicate that operating difficulties such as break-downs or machine down-times delayed the call. These orders probably should have been cancelled and re-ordered. Instead, trucks were unnecessarily held in the marshalling area waiting call. The calls that were placed as much as 3 hours in advance of the order time were not rush calls and should not have occurred. These calls also contributed to the tie-up of trucks since the mixing department personnel began to anticipate early calls by preparing chemicals earlier than normally required.

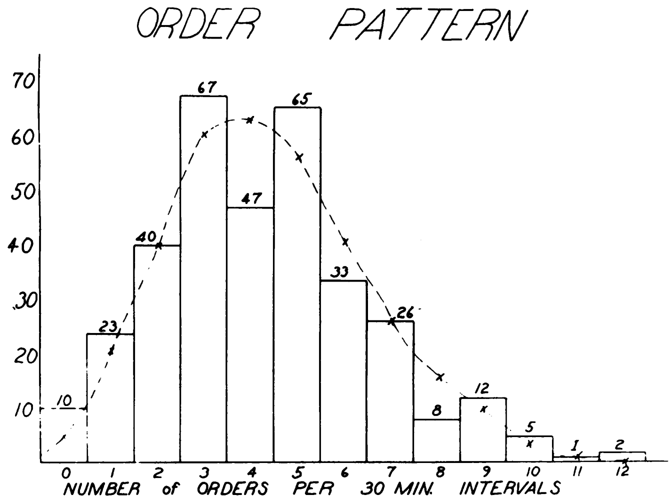


Figure 1

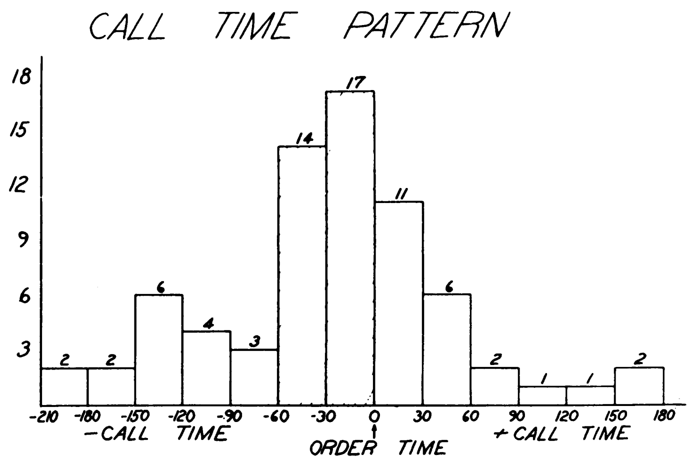


Figure 2

As soon as the department supervision learned what was taking place, they quickly enforced a rule that all trucks would be loaded and called for no more than an hour and a half in advance of the order time. Al then prepared a new distribution chart reflecting this change in the procedure. With this information he was able to establish the probability relationship between the time an order was prepared and the time it would probably be called for delivery. For example, he found that 24% of the time an order would be called within 30 minutes, either way of the order time. (See Fig. 3)

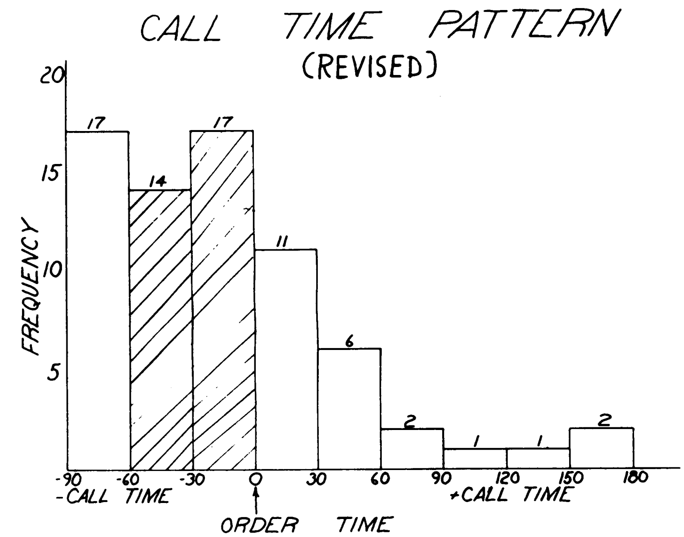


Figure 3

The analysis of truck destinations revealed that 42% of all the orders went to one area and 58% to the second area. The probability of any order going to a given area would be the same as these percentages since the same operations were carried on in both areas and since the order pattern was random.

The length of time that a truck was gone while delivering an order depended on the location of the using area. An actual distribution of the elapsed truck time was prepared for each area and from this information the probabilities of a truck being absent for any given amount of time on a trip was determined. (See Figure 4)

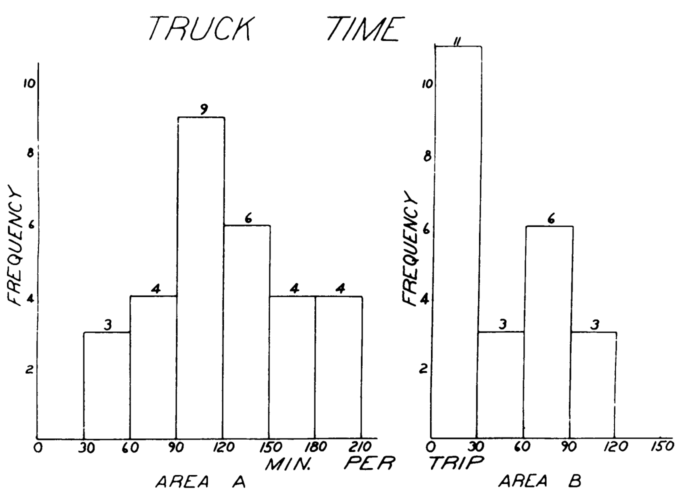


Figure 4

Al now had enough information to construct a model of the system that he could manipulate and which would reasonably predict the behavior of the system for any one of several methods of operation. Since the order pattern upon which the system depended was subject to random behavior, he utilized a Monte Carlo type of simulation that allowed him to evaluate the effects of changing the total number of trucks in the system, altering the demand for service, or changing the location of the using department. This additional information was made available simply by broadening the scope of the study.

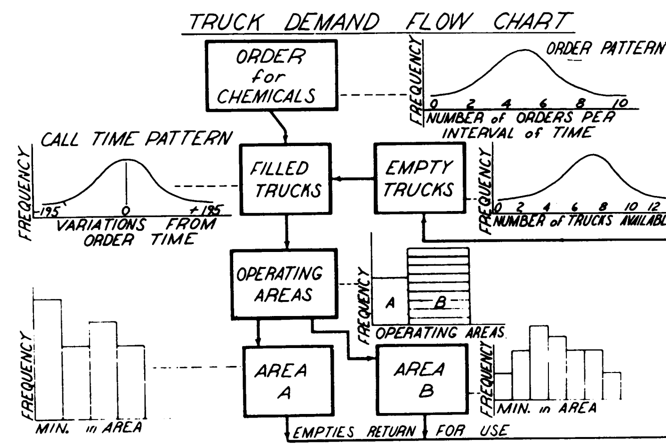


Figure 5

In setting up the Monte Carlo model, Al assigned numbers to each of the elements in each of his significant variables. These numbers were assigned in accordance with the probability of that element occurring. For example, the probability that an order would be called for within a half hour of the order time was .24. Therefore 24 numbers were assigned to this element. The remaining 76 numbers were similarly assigned to the other elements so that the total sum of the probabilities involving order call time added up to unity.

The actual synthesis was carried out by selecting orders from a table of random numbers. The times that the order would be called for was determined in the same manner, as was the area to which the order would go and the time that would elapse before the truck would return empty for its next order. In each "run" or simulated trial, the number of trucks in the system was changed. By keeping a log of each truck he found the minimum number of trucks required under a given production schedule that would assure the production supervision of always having an adequate number of trucks and what the probabilities were of not having an adequate supply of trucks on hand. (See Figure 6 on the following page)

The simulation indicated that with the enforcement of the call time procedure, the existing production level could be met with 24 trucks in the system—nine less than currently in use. This reduction eliminated the congestion in the passage ways and marshalling area.

Of even more importance and value, is the ability the production supervisor now has to quickly predict operating conditions if any of the variables in the system are deliberately or unintentionally changed. Neither mechanical

DATA SHEET FOR MONTE CARLO

Start Time	No. Orders Per Time Int.	Truck No.	Destination A	Destination B	Call Time	Truck Return Time	No. Of Trucks Available (36)
8:00	1	1	1				35
8:15	0						35
8:30	1	2		2			34
8:45	1	3		3			33
9:00	5	4,5,6,7,8	4,5,6	7,8			28
9:15	0				4,2		28
9:30	2	9,10			3		26
9:45	4	11,12,13,14				3	23
10:00							
10:15					1		
10:30						4	
10:45							
11:00							
11:15							
11:30						2	
11:45							
12:00							
12:15							
12:30						1	

Figure 6

calculators nor electronic computers were used or would be needed for future simulation of this particular system.

In this instance, a progressively-minded production supervisor left the scope of the assignment open even though the original request pointed towards a specific solution. As a result the engineer, in turn, delivered information of far more value in planning future operations than would have resulted from supplying an immediate and perhaps even obvious answer by recommending a relayout. However, open-mindedness on the part of supervision or management is not enough. The engineer himself must be trained to think in terms of broad concepts that will permit the use of more powerful analytical techniques.

The use of abstractions in the form of physical or graphical models is certainly not a new concept to Industrial Engineers. Two and three dimensional layouts, process charts, Gantt charts, and alignment charts have enjoyed a wide range of applications for almost a half century. Mathematical abstractions have also been used by engineers when the calculations involved were simple enough to be handled by humans. There seem to have been two practical reasons why engineers have resorted to graphical simulations or to mathematical approximations:

1. There just wasn't enough engineering time to quantify all the variables and perform the calculations involved.
2. Answer's were usually wanted within a "reasonable" period of time that by definition precluded the possibility of a refined simulation.

IMPROVING ENGINEERING EFFECTIVENESS BY UTILIZING A COMPUTER

The information obtained through a probability model such as the chemical truck simulation I have just described permitted the engineer to do a better job of industrial engineering. However, there are simulations that involve complex relationships between the variables that do not lend themselves to human manipulation. For these problems we need the versatility and speed of the electronic computer.

Today, any company regardless of size has access to a computer. Those who can not or choose not to buy or rent computing equipment can rent time from universities or service centers such as the I.B.M. Datacenter or the service bureaus of Remington Rand, Burroughs or RCA. Libraries of programs have even been established by some of the companies that manufacture data processing equipment which with modifications can be adopted to a variety of related manufacturing situations. A brief view of a maintenance problem will illustrate a case where the simulation was sufficiently complex to justify programming on an IBM 705 computer.

In this particular study an operating department had 20 automatic machines that were serviced by a crew of 6 mechanics. These machines operated continuously - 24 hours per day. Production forecasts had gone up and two more automatic machines were to be added to the battery. The production supervision was interested in knowing whether more mechanics should be added to the maintenance pool.

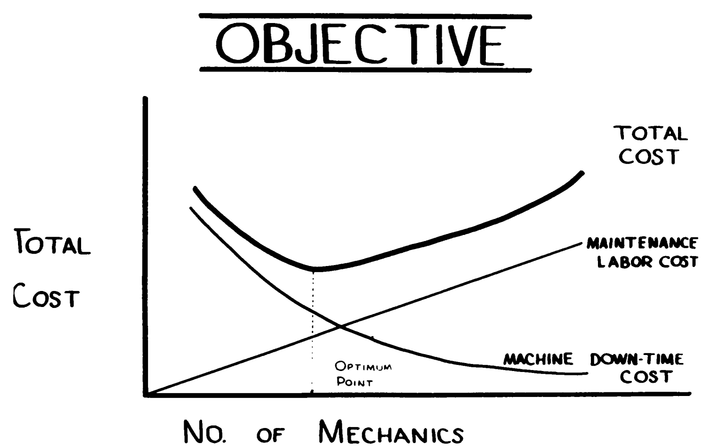


Figure 7

Mel Witmer, the engineer on this study, compiled data from the maintenance and downtime records kept in the production department and plotted frequency distributions of the 4 significant variables in the system:

1. The length of time that a machine would run before it required service. (See Figure 8)
2. The length of time a machine was down while being serviced by a mechanic. (See Figure 9)
3. The mechanics "run-in-time" before returning to the maintenance pool for further assignment. (See Figure 10)
4. The amount of mechanics' service time in those instances in which the machine could be serviced while it was still operating. (See Figure 11)

ARRIVAL RATE

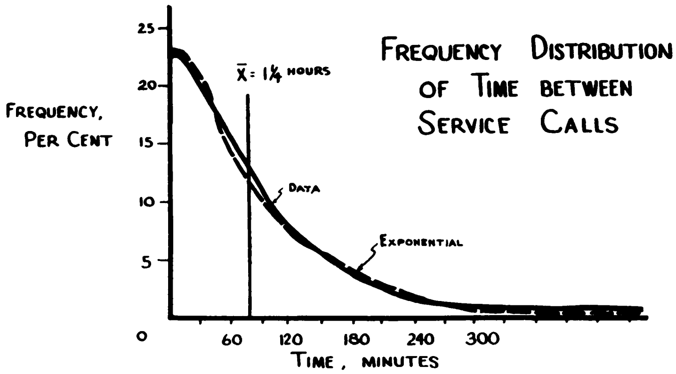


Figure 8

MACHINE DOWN-TIME

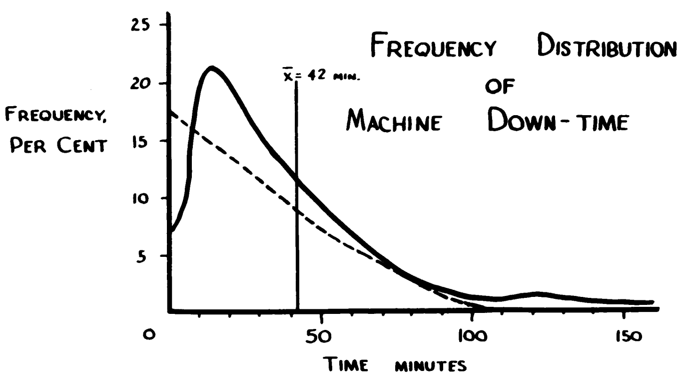


Figure 9

MECHANIC'S "RUN-IN" TIME

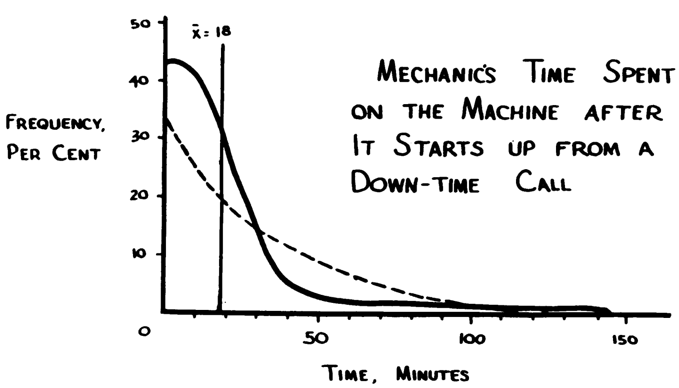


Figure 10

MECHANIC'S RUN-SERVICE

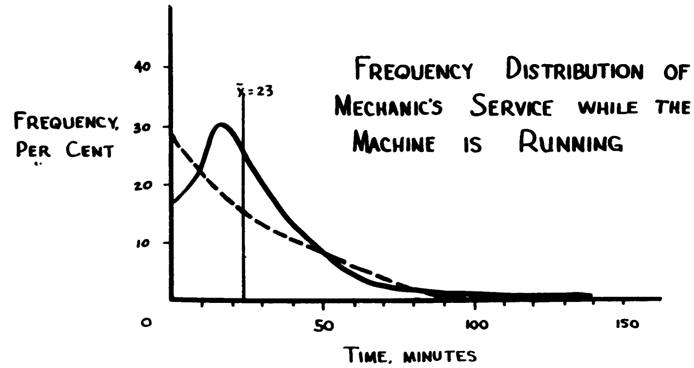


Figure 11

Mel also noted that two thirds of the time these machines could be serviced while they were operating and turning out product. The other third of the time the machine had to be shut-down while the repairs and adjustments were made. In this latter event the mechanics remained at the machine after servicing to make certain it was functioning properly.

In order for the production supervision to minimize downtime it was only necessary to add more mechanics. Maintenance costs would, of course, go up proportionately. On the other hand, if economies were made in maintenance labor by reducing the maintenance crew, then downtime would increase and a relatively high capital investment would not be utilized to its fullest extent. Since the possibility of any one machine requiring maintenance was entirely random, it is easy to understand the complexity involved in determining the number of machines that would require simultaneous attention and the possibility that a mechanic would be available at that particular moment. However the probability of any particular series of events taking place could be completely and quickly examined by a computer.

The decision instruction pattern for the programmers took the form of a flow chart. (See Figure 12 on the following page) The four frequency distributions were fed into the computer along with the "run-time - downtime" ratio. As you would expect the instructions and information supplied the computer had to be a complete and accurate representation of the way in which service calls were generated and handled. The computer then simulated operating conditions with a pool of 6 mechanics and 20 machines operating. The result was a faithful reproduction of actual downtime experience. The number of machines and the number of mechanics were varied at will and the computer printed out the total lost time for any of these combinations.

With this information Mel could now assign a dollar sign to the factors upon which a decision could be made by the production supervision. The significant cost factors were those of maintenance, machine operators, equipment depreciation, and overtime labor made necessary because of lost production time. A series of curves were prepared showing the number of mechanics necessary to operate at

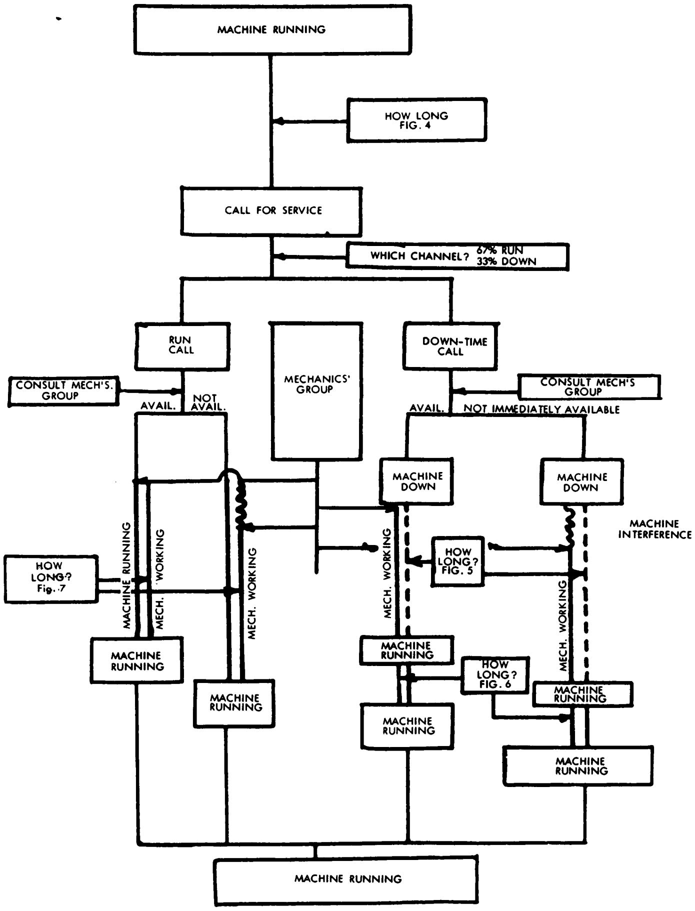


Figure 12. "Monte Carlo" Model

the lowest possible net cost for any one of several levels of production.

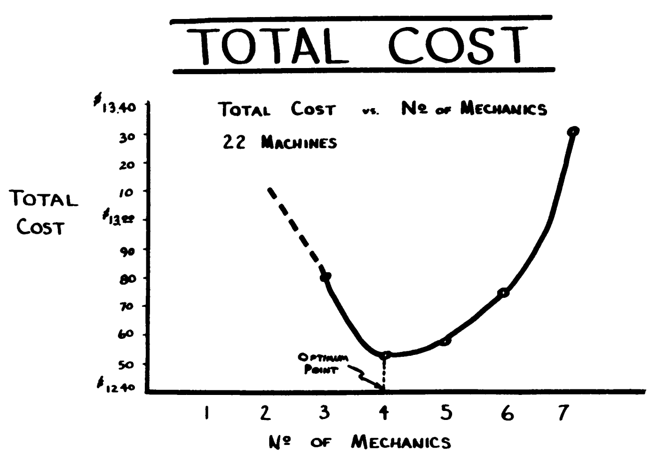


Figure 13

In addition to this valuable information, the curves were also useful in determining the point in time when it would be economically justifiable to build and add more automatic machines. The production supervisor could also use the data generated from the simulation for comparing the alternatives of mechanical changes to the existing automatic machines versus the possibility of completely new machines. This type of information could be used by the supervision to either prevent costly modifications or to encourage minor changes since the alternatives could now be quickly and more completely evaluated.

This study took time: about 150 Industrial Engineering hours and another 150 hours of pro ramming time. The IBM 705 took only 15 minutes to simulate all the possible alternatives. However, consider the value of the information the production supervision received in exchange for allowing the engineer the time necessary to construct a model of his maintenance operation. His "crystal ball" cost him less than $2000 and allowed him to exercise much better control over hundreds of thousands of dollars in terms of labor costs alone.

EXTENDING THE CONCEPT OF A MODEL FOR TESTING HYPOTHESES

The production supervisor or plant manager is continuously exercising all the judgment and all the managerial talent at his command in an attempt to make the best possible decision with the information he has. We can be of valuable assistance in improving his ability *to make decisions* by improving his ability *to predict.* By manipulating a model he can generate experience without interfering with production. As his ability to predict improves so will his ability to control a complex system of operation. This concept must be recognized by all of our engineers if we are to improve our effectiveness.

We are told by historians that theoretical science was born about 600 years BC when the Greeks, chin in hand, arrived at certain conclusions by just thinking about the world in which they lived. This process is defined as cerebration and has been, on occasion, highly espoused. As philosophers, we are also told, the Greeks were superb. It may be that some of their contemporaries - perhaps more practically inclined - may have unkindly noted that despite all this thinking the philosophers couldn't consistently tell the time of day!

The first real scientists then may well have come much later and in a different country where by observing natural phenomena, and devising ways of measurement that tested their theories, these men learned how to make predictions that could consistently be relied upon - (such as telling time) - and which could be repeated by others with the same end results. It is probably for this reason that prediction has been described as "the very essence of science."

As most of you know, the technique of obtaining information from a model is one of the oldest analytical tools known to man. Primitive man probably first used symbols to represent the real world around him when he accidentally discovered that pebbles or sticks and later on - scratches on stone could be used to represent sheep, cattle, or spears. Even in literature we find reference to the wisdom and practicality of this concept. Shakespeare, in one of the passages in King Henry IV said: "When we mean to build, we first survey the plot, then draw the model; and when we see the figure of the house, then must we rate the cost of construction."

For over 150 years engineers in their role of applied scientists, have used physical models to gather data and information in the study of mechanical contrivances and in the field of hydraulics and aero-dynamics, to name a few general areas. As engineers we have carried this concept over into our own particular profession as a logical extension of engineering methodology. The continued emphasis on the use of abstractions to simulate the operating conditions surrounding a problem will help to keep our services in constant demand. However, the scope of our studies must extend beyond the so-called traditional functions of Industrial Engineering. There must be no fences around the problem if we are to do a really effective job of Industrial Engineering.

ADMINISTRATION OF THE INDUSTRIAL ENGINEERING ACTIVITY

R. A. Forberg
Director of Industrial Engineering
The Procter & Gamble Company
Cincinnati, Ohio

The nature of a business and the primary organizational form influence the form and functions of the industrial engineering organization.

To present the administrative practices of the industrial engineering function within The Procter & Gamble Company, it is necessary to describe first: the nature of the business, the organizational form, and the objectives and functions of the industrial engineering staff.

NATURE OF THE BUSINESS

The Procter & Gamble Company is largely a consumer goods manufacturing and merchandising organization. The Company operates sixty plants, the majority of which are in the United States with a growing number overseas.

The principal consumer products are soaps, detergents, shortening, dentifrices, shampoos, liquid bleach, and paper products. Annual sales are approximately $1,400,000,000. Manufacturing operations are of the process type and packaging is highly mechanized. There are approximately 31,000 employees, world-wide.

ORGANIZATIONAL FORM

Procter & Gamble has recently completed the transition from a typical functional to a divisional organization structure. The present form is shown in Figure 1.

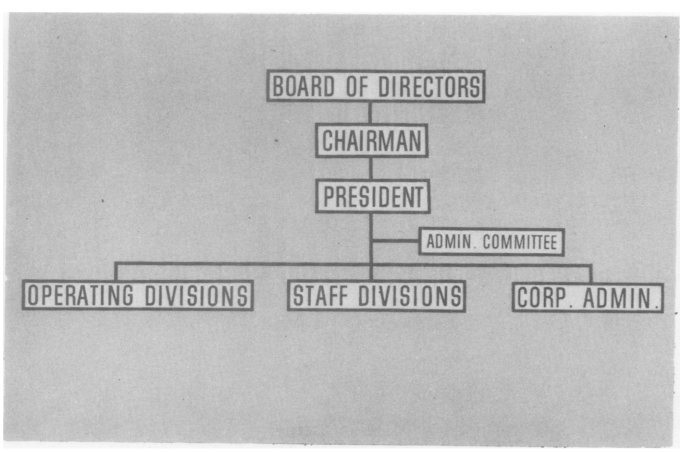


Figure 1

Below the executive level, the corporate organizational structure divides into three principal groups; the operating divisions, the staff divisions, and corporate administration. Only the first two of these groups contain industrial engineering functions. There are seven operating divisions, organized, with the exception of the Overseas Division, on a product basis. The Soap Products Division (Figure 2), a typical operating division, is divided into Sales, Advertising, Product Research and Development, and Manufacturing functions.

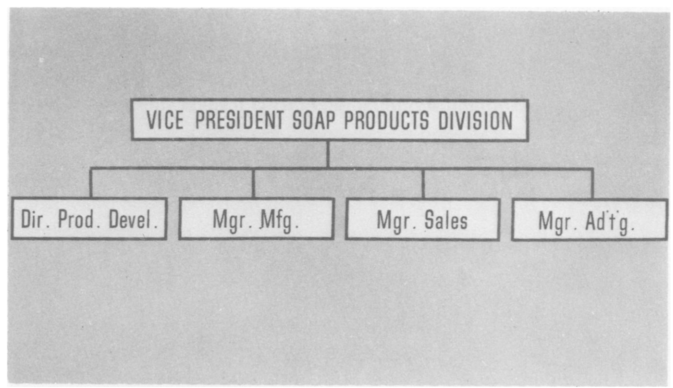


Figure 2

Manufacturing operations in the Soap Products Division are geographically divided under a Manager of Manufacture (Figure 3).

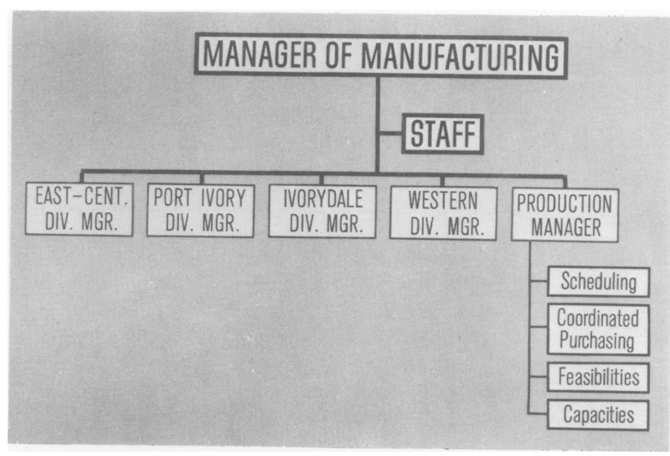


Figure 3

The Western Division Plants, for example, include the Sacramento Plant (Figure 4).

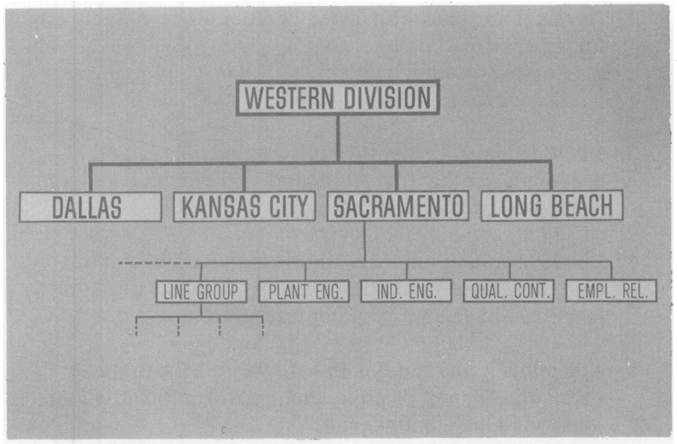


Figure 4

The Plant Industrial Engineering Department reports to the Plant Manager (Figure 5).

A typical Plant Industrial Engineering Department consists of a group under a Chief Job Study Engineer who specialize in wage cost performance standards, a group of specialists on other costs, and a methods engineer, who may also be a statistical specialist.

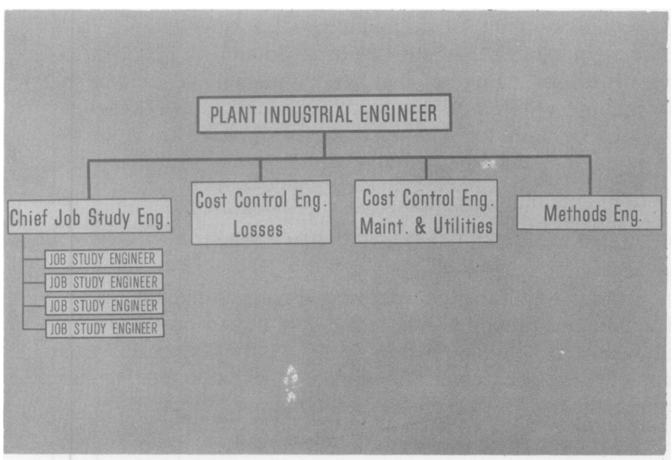


Figure 5

In the second principal group below the executive level are the staff divisions (Figure 6).

Each staff division is headed by a vice president in the functional areas of the business: Sales, Advertising, Research and Development, Purchasing, and Manufacturing. The corporate industrial engineering staff reports to the Vice President - Manufacturing and Employee Relations. He has responsibility for policy formulation and authorization for the manufacturing portion of the business and corporate-wide responsibilities for Technical Staff Division services.

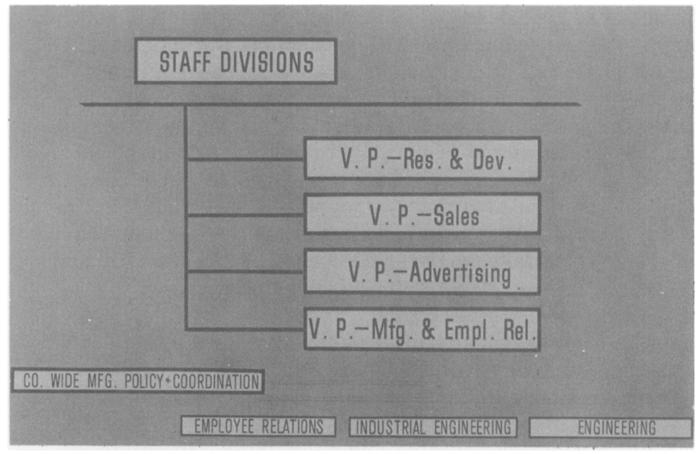


Figure 6

The Industrial Engineering Division, which is the corporate industrial engineering staff, is an organization of about eighty people of which more than half are professional personnel. The Division is specialized by function in four departments: Incentives and Standards, Methods Development, Systems Analysis, and Mathematics and Statistics.

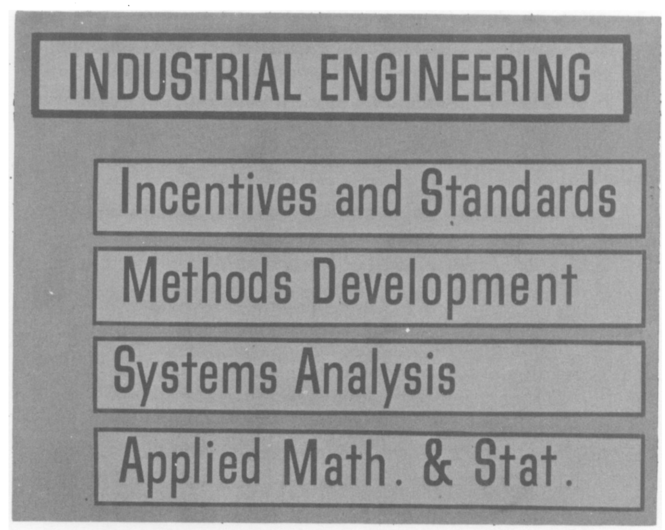


Figure 7

OBJECTIVES AND FUNCTIONS OF INDUSTRIAL ENGINEERING

The various industrial engineering organizations in the Company have a common set of objectives.

The first objective, is that the design of the job and the industrial environment recognize the needs and capacities of people. I put this first because I believe that is where it ought to be. Other groups have design responsibilities that also bear on this objective. In a business such as ours, Research and Development (i.e. chemical engineering) has design responsibility for product and process. The Engineering Division has design responsibility for process equipment, services, and structures. The line organization of manufacturing is very much involved as the user, and contributes to design decisions, as do the medical and safety groups of the Industrial Division. The effective collaboration of all these groups is necessary to attain our first objective. With start-up and operation, this is a continuing responsibility.

The second objective is to assist the line and other staff in finding and evaluating ways to reduce costs by changing methods and materials, while maintaining or improving quality and job satisfaction. This is our hunting license to question anything and everything. In our thinking, we consider the cost horizon to extend from the suppliers' operations to our customers' docks.

The third objective is to provide management with information to evaluate and control performance on operating expense and other costs. This means to establish and maintain performance standards and to use these in evaluating performance, for the payment of extra compensation, and for recommending control action.

Industrial Engineering Division Functions

At the present time, the functions performed by the Industrial Engineering Division to achieve the common industrial engineering objectives are to:

1. Analyze management methods; aid management in determining information requirements for planning, organizing, and controlling operations; and design methods for representing and evaluating decision alternatives.

2. Develop methods or integrated systems for:
   a. Handling and storage of bulk and packaged materials.
   b. Appearance and process cleaning operations.
   c. Clerical or data processing operations in manufacturing.

3. Administer the corporate:
   a. Methods Change Program.
   b. Cost Performance Standards Program.
   c. Financial Incentive Plans in Manufacturing
      (1) Wage
      (2) Supervisory

4. Provide consulting service on mathematics and statistics.

Plant Industrial Engineering Functions

The Plant Industrial Engineering Departments have the following principal functions:

1. Develop new and improved operating methods - manual, man-machine, and clerical; to eliminate or reduce costs.

2. Develop and maintain cost performance standards for operations:
   a. For individual jobs
   b. For departments

3. Provide management with information on actual performance against standard and recommend action to improve performance.

4. Provide management with information to permit assignment of operating work and aid in the administration of the wage incentive plan.

5. Aid plant management in efforts to eliminate or reduce all types of cost, and coordinate the Plant Methods Change Program.

6. Train line and other staff personnel in methods of analysis for cost reduction.

7. Maintain a current analysis of plant capacity, by processes.

MAJOR PROGRAMS AND RELATED ADMINISTRATIVE PRACTICE

Having described the organizational form of the Company and the objectives and functions of industrial engineering, the administrative practices can now be considered. The relation of administrative practices to the program or project being administered is such that one cannot be easily grasped without a knowledge of the other. No attempt will be made to cover all administrative practices. Four of our programs will be briefly reviewed and related administrative practice described. These programs are: Performance Standards, Methods Change, Systems Design, and Mathematics and Statistics.

PERFORMANCE STANDARDS PROGRAM

Plant industrial engineering develops operating methods and performance standards based on these methods where it is economic to do so. This program represents two major areas of activity; Operator Performance Standards and Department Performance Standards.

Operator Performance Standards

The administration of a performance standards program and associated wage incentives has been frequently reported. If there is anything that is unusual about our administration, it is the attention given to precise and detailed description of methods and equipment and careful and frequent audit of both the standards and the administrative procedures. I will briefly describe some of these activities.

As early as 1920, Procter & Gamble used financial incentives in manufacturing; piece work incentives for operators and supervisory incentives based on managerial evaluation of job performance. An industrial engineering staff was established in 1928. The first objective of this staff was to establish performance standards for wage cost control. The piece rate standards which had been largely based on experience were replaced through a program of work measurement. Compensation was then paid on a standard-hour basis, with a guaranteed base wage.

Due to the chemical process nature of operations, it was necessary to use multifactor performance standards on many jobs. Other costs than wage costs were under the control of the operator, and in some instances were more significant than direct wages. Examples of some of the types of factors used are: material losses, equipment utilization, reaction yields, and control of quality variables. At the present time 108 factors, other than measured work, have been used in designing operator performance standards.

Standards must be changed as frequently as changes are made in job conditions or methods. Controls to insure that necessary and timely changes are made are vital to wage incentive administration. Manufacturing Standards for Industrial Engineering specify the following minimum audit frequencies for operator standards:

Hours Used Per Year	Frequency of Audit
0 - 10	Once per 3 years
10 - 50	Once per 2 years
50 - 600	Once per year
Over 600	Twice per year

Written reports on the audit findings, indicating corrective action to be taken, are required by Industrial Engineering Standards. Records are maintained by the engineer to demonstrate that the auditing has been done at the required frequency. Over 35 per cent of standards are corrected each year.

Auditing is the last resort in maintaining standards. When methods are changed, the department manager should have authorized the change. He is expected to give the engineer information on changes. The engineer, notified of the change as soon as it occurs, or before if possible, is able to better maintain standards. Currently about half of all standards revised for methods changes have been reported by the department manager. We are working to increase this ratio.

During the 1930's and 40's, performance standards were extended to permit offering wage incentives to approximately fifty per cent of total plant personnel. The present pattern of coverage is shown in Figure 8.

Applications have been made in most of the areas where it is of benefit to both the Company and the employee. The areas where application is low are maintenance, clerical and service jobs, where we have been unable to meet these criteria.

Uniform practice in plant organizations is maintained by the distribution of written corporate policy. The central staff audits plant practices for adherence to policy.

An audit of an average plant usually requires from three to five man-days. We use a random sampling procedure in auditing anc check further into those areas where deviations are disclosed.

Audits are conducted to be helpful, not merely critical. From his broad experience, the auditor is usually able to make suggestions on how situations can be best corrected.

Deviations are reviewed with plant management first and described in a written audit report. A rating factor is calculated, based on the deviations found.

Department Performance Standards

Engineered performance standards for the department or cost center level are also developed by Plant Industrial Engineering. The criteria used in developing the standard is perfect performance. This means perfect performance with present methods; (no scrap or loss, perfect machine operation, full operator utilization, etc.). We have been able to apply this principle quite successfully to the control of wages, process steam, reaction yields, and material losses. Our inability to define maintenance and frequencies precisely has forced us to resort to historic cost comparisons in this area.

Performance standards now exist for over 85 per cent of costs under plant management control, or about 65 per cent of total plant operating expense. These standards are revised as accumulated methods changes exceed 4 per cent of the standard, and are subject to review and revision if performance exceeds the standard. (Refer to figure 9 on the following page.

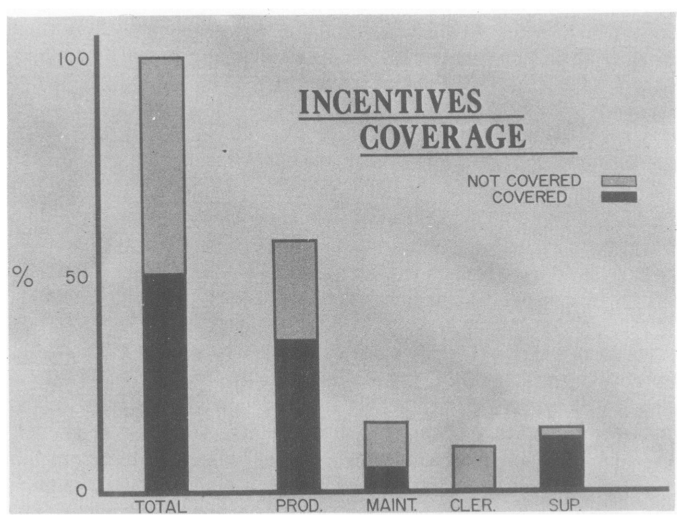


Figure 8

Initial performance in the average department was 66 per cent where 100 per cent represented perfect operation, as shown in Figure 9.

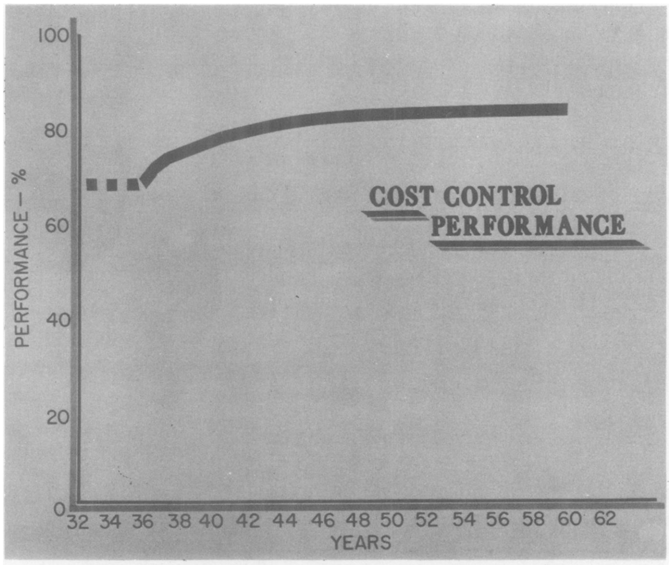


Figure 9

Early work to improve performance was most rewarding. Performance increased rapidly into the high 70's. Additional effort carried performance into the 80's but at a decreasing rate of increase. By 1946, we were getting diminished returns for our efforts at performance improvement in the areas of initial application. It is important to remember that this curve measures performance against current methods. No part of this improvement reflects the changes introduced by Research and Development or Engineering in the product or process. Performance standards revisions were made as changes occurred. It became apparent that if the rate of cost reduction, which had been achieved, was to continue, methods changes would have to be made at an increased rate. A substantial improvement in performance could not be anticipated.

THE METHODS CHANGE PROGRAM

Major emphasis on methods change was introduced as the savings from performance improvement diminished in the late 1930's. During the war years staff was not available so that most of the program has developed since 1946.

It is not only effective but essential to sell major changes in management practice from the top down. The methods program was begun by giving manufacturing management appreciation sessions in the concepts and techniques of work simplification. We proposed to begin by adding one methods engineer to each major plant industrial engineering organization. After obtaining management agreement a series of training courses was begun in work simplification for methods engineer candidates. These men were usually engineering graduates with one to five years of Company experience. After completion of a one-week training course they returned to their separate plants to begin work as methods specialists.

The Transition from Specialist to Coordinator

As projects were completed the results were summarized in short reports. Results were encouraging and additional men were trained and the program extended to more plants. Between 1946 and 1949 it became apparent that this organizational approach had some limitations. When the methods engineer worked as the expert, the department manager participated very little in the development of new methods. Selling the methods change to the manager was difficult because he hadn't participated. He was inclined to take the suggested change as criticism. This picture had become so clear by 1949 that we revised the approach. The role of the methods engineer was changed from specialist to coordinator. He was asked to spend about two-thirds of his time helping plant management on their projects. The other third of his time would be spent on special plant projects on which he would work as an individual. In this approach each member of plant management had several selected costs to be reduced. He worked on these himself and requested help from the methods engineer as required. The methods engineer also conducted training courses at his plant for the line organization and other staff.

As the program grew and developed, a bi-monthly bulletin was published to promote the reapplication of successful methods changes in the other plants and to summarize program achievements. Plants of different sizes were put on a comparable basis by calculating the annual average dollar effect of the projects completed per member of plant management. This measure makes no attempt to differentiate between one time savings and continuing savings. It is conservative in that no credit is given for savings which continue beyond the first year. The Company intends that all members of plant management will participate - line and staff. Figure 10 shows the average annual dollars saved per member of management for each year in the program to date. The average level of achievement in all participating plants in the years 1946 through 1949 was less than $700 per member of management per year.

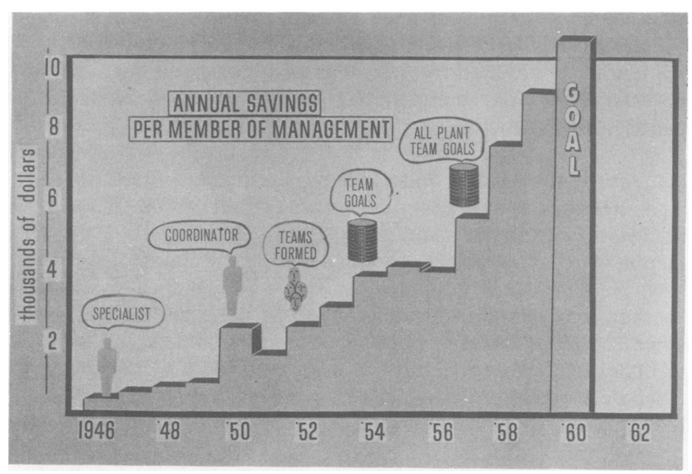


Figure 10

In 1950, the changes that had been made in the organization of the program began to pay off. With a broader participation of plant management, the rate of annual savings tripled, from less than $700 per year to $2300 per year. In the beginning, any project which seemed to be productive of savings was selected to get the program going. Some of these had been small. It was important to encourage men to work on projects that interested them, to obtain confidence in their ability to regularly carry out savings projects.

Development of the Team-Goal Approach

The plants were experimental in their organizational approach. About this time one plant organized the management group into teams of four to eight men. Group questioning of operations tended to build a backlog of more significant projects. Projects were ranked according to estimates of effort and potential savings, with consideration for the rate of return on any capital required. The team approach also had other values. Opportunities for recognition for good work were increased. Individuals who were having difficulty in showing results were aided and stimulated by the example of the more successful men on the team. Between teams there was a friendly rivalry for first place in plant standings. Display boards were set up in the plant office to show team standings.

Another plant experimented with a different approach. They found themselves in the position of being a high-cost plant, motivating them to take a total approach to cost reduction. Previously plants had usually only concerned themselves with costs under their control. This plant began to review all of the product costs; materials, inbound and outbound freight, insurance, taxes, as well as the more direct aspects of operating expenses. Their cost position could only be corrected if substantial cost reductions were made. So the plant manager established a goal of $500,000 for the year. This goal represented over $5000 per member of management. With the participation of the Buying and Traffic Departments and considerable plant effort, the goal was achieved. This opened everyone's eyes to the savings potential.

The central staff analyzed the strengths and weaknesses of the separate plant programs and recommended the most successful to the other plants. Our recommendation was that the team and goal approaches be combined.

All-plant achievement in 1954 began to reflect these changes in approach. Savings increased to an average of approximately $4000 per member of management. Success gave the plants confidence that a high rate of methods change could be sustained.

Setting Plant Methods Savings Goals

After two or three years of experience in setting goals, the value of a goal for cost reduction was clearly shown. There were a number of ways in which it could be done. We analyzed plant experiences comparing different goal-setting procedures. There seemed to be more acceptance of the goal, more feeling of responsibility to achieve it, in organizations where the goal was set by each team. Where the plant manager established a plant goal and divided this among the teams, savings were not as high.

Early in the program, plants tended to think that they had "skimmed the cream." The easy projects had all been picked off. Next year would be harder they thought; consequently a lower goal was in order. We had to sell some people on the reasonableness of a higher goal each year.

Higher goals were reasonable because of increased experience at cost reduction. The growth in business was another factor. Getting the less active team members to do more offered real potential for increased savings.

Although we had concluded that the goal setting process should be democratic, some guides were useful. The teams were encouraged to compare themselves with others on a dollars saved per member of management basis. Comparisons were also made in terms of goal as a per cent of operating expense and as a per cent of production value. The desire of plant management groups to show up well in all-plant comparisons was a strong factor in motivating teams to choose goals which required their best efforts for attainment.

In the five years since 1954, the level of achievement has more than doubled. During this period, extension to all manufacturing operations world-wide has been accomplished, with cost reductions contributing to a corporate goal. The goal for 1960 is $10,200 per member of management. This is fourteen times the level of savings realized ten years ago, and we know we are just beginning.

Extension of the Methods Program Beyond the Plant Organization

In the last few years, the Industrial Engineering Division has been in the process of extending the Methods Change Program to the technical staff groups and the functions other than manufacturing. For example, the Technical Packaging Division is establishing cost reduction goals; the Buying Department has a very comprehensive program; office building operating managers have added industrial engineers to their staffs and are developing a full Methods Change Program. In a number of instances, the plant and one or more staff groups will participate in the same project. When this occurs, the plant is given full credit for the savings accomplished, and the corporate staff group is given credit for the savings in the initial plant and for reapplications in other plants. The reports submitted enable the corporate industrial engineering staff to show savings to management without duplication. Giving full credit for savings to all participating groups enables us to handle recognition of achievement with a minimum of conflict. We hope to be able to extend this program to include the entire management of the business.

Important Points in Organizing a Methods Change Program

Let me suggest what our experience with a Methods Change Program should mean to you.

First - make certain that the groups have surveyed all the dollars in their areas. There was a time when most cost reduction thinking related to wage costs. We have broadened our horizon to include inbound and outbound freight, the cost of materials, rent, taxes, insurance, as well as losses, yields, and degradings.

Second - plan to use your entire management group. Cost reduction is possible wherever dollars are spent. No function should be above participating in cost reduction.

Third - be sure that goals are established. We find that building them democratically, from the first level up, works best.

Fourth - to get a high return for management effort, requires careful project selection. Projects with small returns often demand as much management time as those with handsome payouts. So make sure that sufficient time has been spent on developing a supply of good projects from which to make a selection.

Fifth - be sure that some person - we call him a Methods Engineer - is assigned to give the program the kind of continuing follow-up that means meeting the goal. He will help with ideas, work on reports, get answers from the other technical organizations, and keep the record of achievement.

Sixth - keep the responsibility for success where it belongs - on the line organization. The line should retain responsibility for project selection, follow-up, evaluation of progress, as well as the obvious points of final decision and installation.

Seventh - take positive steps to provide recognition; taking good methods work for granted will not produce outstanding results.

And last - fight the delusion that occurs to some minds that cost reduction is "cream skimming"; the misconception that the next year will be harder because of success this year. Encourage instead the idea that you are just starting to work. Past success points the way to better performance; more cost reduction.

Employee Relations Aspects of Methods Change

What were the personnel relations aspects of this program? How did we get the acceptance of operating personnel for a high rate of chance? First, we recognized the necessity for adequate explanation ahead of the change. Management planning to eliminate or minimize unsatisfactory employee experience was strongly emphasized. We found that acceptance of change was best in those organizations in which it occurred frequently and was well handled. Our efforts were greatly aided by the Company policy of "Guaranteed Employment" which is in effect at most of the soap, food, and toilet goods plants in the United States. This policy, which has been in effect since 1923, assures hourly employees with two or more years of service at least 48 weeks of work each year. Over 85 per cent of operating personnel, where this policy is applied, qualify for the Guarantee.

Employee acceptance of change is also influenced by the existence of a profit sharing plan. Where this plan is in effect, employees become shareholders by personal and Company contributions, and share directly in the success of the Company.

Summarising - our success in obtaining a high rate of change while maintaining good employee relations is due to good face-to-face communications; adequate consideration of the effect of change on people; a concern to maintain steady employment; and a policy of sharing our financial success.

SYSTEMS DESIGN

The efforts of Plant Industrial Engineering are supplemented by the development and design programs of the corporate industrial engineering staff.

In the 1920's, a methods development laboratory was established in the Industrial Engineering Division. This group provided training and direction for the Methods Change Program and engaged in work on projects of major corporate significance. Projects were selected where corporate spending was over $100,000 on a class of operations; for example, case product material handling, bulk material handling, or appearance clean-up. These projects have provided well developed ideas for cost reduction which the plants have appropriated and used in their Methods Change Programs.

In recent years this job or operation analysis approach has been supplemented by a systems approach. We recognized the need for a broader approach as we worked on finished product case handling operations. Cost of warehousing and shipping were influenced by other factors than material handling methods. Inventories fluctuated, requiring periodic use of public warehouse storage. Handling costs to storage were different in various areas of a warehouse system. The product mix produced influenced the pattern of warehouse operation. Age requirements on warehouse stocks set limits on product turnover intervals. These situations interacted in affecting shipping unit costs.

Production Scheduling

In 1953, with consulting help, we started a research project on production scheduling and inventory control. After about a year of investigation and analysis, a plan was developed to improve the control over the balance of stocks in inventory. This plan was introduced in major United States plants after testing by simulation and a one-plant pilot experiment. The balance of product brands and sizes in inventory with reference to their shipping demands was significantly improved. No solution, however, was provided for plant management's problems in balancing costs of changeover in product mix and volume against warehousing costs and customer service considerations.

Work on these problems has been the principal activity of our Systems Analysis Department in recent years. It has been our experience that on this type of work each investigation discloses new opportunities for improvement. The development of an adequate backlog of work has been no problem.

Warehouse Mechanization

Material handling development work has gone through a similar evolution. Our early efforts in this field were on a job analysis basis. Hand trucking and stacking operations were converted to fork lift handling. The costs of wood pallet handling methods were reduced by developments, with the suppliers, of fibreboard pallets and the Pul-Pac truck. Over the last five years we have completed the conversion of most Pul-Pac operations to clamp truck handling, and eliminated the pallet.

During this period the components which will permit building highly mechanized warehouse handling systems have become available. These components are machines which will stack unit loads of finished product cases, sensing devices which identify cases and actuate switching equipment, and controls to permit an integrated design with efficient coordination of many of these elements. A mechanized handling system designed to the requirements of a typical plant would cost upwards of a million dollars. In such a system there are sequential queuing problems, decisions on brakpoints between mechanized and manual handling, justification problems for components and the system as a whole. Methods of shipping order data processing and inventory control procedures interacted with the material handling system design and were included in project scope. We recognized that the design approach must consider the total handling and control system.

Data Processing

For the last two years we have been responsible for a part of the Company's data processing design effort. The leadership role in this effort is the responsibility of the Data Processing Systems Department. We have participated in the manufacturing phases of this development effort. This is another area where systems concepts are essential.

We have trained our own employees for systems analysis and programming assignments and have relied heavily on the manufacturers' schools for training in data processing techniques.

MATHEMATICS AND STATISTICS

In 1954, after our first year of efforts on production scheduling and inventory control, we were acutely aware of our need for competence in statistics. We were fortunate in recruiting an experimental statistician with academic experience at the post-doctoral level. He acted as a consultant and undertook a training program for members of the organization.

Over the last five years, his efforts have resulted in the establishment of a Department of Mathematics and Statistics. This Department promotes the development of statistical competence in the plant organizations, Research and Development, Engineering, and in such commercial activities as Market Research. Much of our training of plant personnel has been done in intensive one-week short courses. A basic course and an advanced course are offered. The courses combine theory and laboratory practice on practical problems. Graduates of the advanced course frequently serve as statistical specialists in plant and other organizations. They are competent to present basic course concepts to local management and to provide consulting services on statistical procedures.

The Mathematics and Statistics Department follows developments in these fields for concepts and techniques which might be useful in our operations. Close cooperation with our data processing groups have resulted in programming a number of types of statistical analyses on the high-speed data processing equipment.

The value of a highly competent mathematical and statistical service to industrial engineering is well established in our experience and can be expected to increase as problems of large scope are attacked.

SELECTION AND DEVELOPMENT OF PERSONNEL

Many of our general administrative practices in recruiting, training, and the professional development of personnel are typical of modern industrial organizations.

For over 40 years, Procter & Gamble has used college recruiting as a primary source of managerial personnel. Most of the men in responsible positions today have entered the Company in first-level starting positions from college recruiting. The recruiting, selection, and training of new managerial people is a prime responsibility of the manager of any organizational unit. Each recruiting year quotas are established at each plant and in each of the commercial and technical operations. It has been our practice to start about one-third of our college recruits for manufacturing in plant industrial engineering starting assignments.

We endeavor to select men who have development potential for major management positions. Many of these men move through industrial engineering to responsible supervisory positions in departmental management within their first two years. Although this practice increases the training responsibilities and supervisory workload of the Plant Industrial Engineers, we have found that the cross-training makes it much easier to carry out our function. Generally, we seek men with technical competence and a desire to work in production operations rather than requiring a specific engineering background. Consequently, the personnel in our corporate industrial engineering staff is divided as follows among engineering and other academic experience.

	Baccalaureate
Industrial Engineers	9
Mechanical Engineers	11
Chemical Engineers	8
Electrical Engineers	2
Other Engineers & Scientists	4
Business & Economics	8
Mathematics & Statistics	5
	47

In addition, nine of these people have advanced degrees of which one is a Ph.D.

Losses are low but growth needs for the Industrial Engineering Division and aid in establishing new industrial engineering organizations in the Company keep recruiting quotas at levels approximating ten per cent of enrollment.

As Director of Industrial Engineering, I have a responsibility for meeting my recruiting quota with people who have real development potential for the Company. Our plant managers and the responsible personnel in other technical divisions aid by referring applicants. In this way, we are represented, as a Division, on most of the major college campuses in the country. Final selection is usually made only after a day visit by the prospective employee to our operations in Cincinnati.

The opportunity to work in the central Industrial Engineering Division exposes a man to some of the problems of general management and tends to give him a broad view of Company operations. It is also important in the early years of his Company experience to have close association with production operations. This is best achieved by assignment to a plant operation. It is our intention that the men who start in the central Industrial Engineering Division be transferred to the plants or other operating organizations within their first two years. A number of promotional alternatives are available to them. If they are qualified and interested, they may become department managers, and progress in the line organization. If their interests lie in industrial engineering, a variety of experiences are available, leading to Plant Industrial Engineer. Or, after sufficient Company experience, they may return to the central Industrial Engineering Division in technical or administrative capacities.

In the plant organizations men are regularly promoted from operating or clerical jobs and trained for methods and work measurement assignments. Industrial engineering training is used effectively to develop a managerial point of view as well as to familiarize the new member of management with the nature of this staff service.

SUMMARY

Summarising, Procter & Gamble has a decentralized industrial engineering staff, primarily related to production operations. This activity is coordinated by the Industrial Engineering Division acting under the authority of the Vice President - Manufacturing and Employee Relations. The corporate staff is in the process of demonstrating the values in an industrial engineering approach to the managers in all functions of the business.

Close cooperation between line and staff for a high rate of cost reduction has been achieved by project selection and goal setting at the first management level, as a line-staff team effort. Supplementing this are projects of larger scope conducted by the central staff.

Outstanding employee relations have been maintained by consideration of the effects of change, adequate explanations before changes are made, a policy of guaranteeing employment for a high percentage of hourly employees, and considerable effort on the maintenance of operator standards.

Industrial engineering is regularly used as a development assignment for new managerial personnel which has resulted in increasingly effective use of industrial engineering staff by the line organization.

MANAGEMENT INFORMATION SYSTEMS

M. O. Kappler
President
System Development Corporation
Santa Monica, California

In the application of computers to management control systems there is a real opportunity to make a big step forward in the next few years. In order to see how big a step this is, let us trace the history of data processing for business and for management.

We might start by considering past uses of record-keeping machinery and simpler forms of data-processing equipment in connection with accounting activities. These initial efforts were toward mechanization of jobs that had previously been done by manual methods. Although preparation of payrolls and tabulating activities are fairly complicated, introduction of data-processing equipment was simply the mechanization of those processes. We then moved step-by-step into summary accounting records and similar areas. These advancements presented management with summaries of actions that had previously been taken, but they were still primarily accounting-type displays. The next step was to use electronic data processing machin s for control purposes. An illustration is what was done at the Home Laundry Department of the General Electric Company at Louisville, Kentucky. They employed automatic data transmission from outlying distributors and warehouses which were then consolidated in the factory headquarters. Using this information, the next day's manufacturing of appliances was determined. This was a big step forward—this was actual management control. This control was recurrent in that the process happened day after day, with the system solving essentially the same problem but reacting to different input information.

COMMAND CONTROL SYSTEMS IN THE MILITARY

While progress has been made with the use of data-processing equipment in business management, the military has been trying to achieve control in a different manner. They embarked on a project to establish an integrated command control system. Recently there have been rapid advances in this "live" management control system or command control system technology - probably more rapid than in any other technology. At present, the Air Force is considering the implementation of at least 25 or 30 control systems. Several of these will cost up to 100 million dollars to implement. All of these systems are based on large, high-speed computers, on automatic input of information, and on automatic displays and automatic communication of control action as outputs. All are world-wide in scale. This is a tremendous effort and the understanding of these systems and how to implement them has grown explosively in the last few years. A description of a few of these will help in visualizing this class of control systems.

The SAGE (Semi-Automatic Ground Environment) Air Defense System was the forerunner of all of them. Next came the SAC (Strategic Air Command) Control System, which is designed to provide information about SAC, and to control action to send it on its way. There are at least two types of military intelligence systems now under development that are "control" only in the sense that they gather information, process it and suggest new avenues for exploitation. Then there are two other typical control systems. One of these is intended for Headquarters North American Air Defense Command and the other for Headquarters USAF. Both of these will be based on very large computers and on world-wide communication systems with automatic data inputs.

All of these command control systems have the property of being recurrent in their operation. As a matter of fact, they will complete a cycle within a minute, perhaps in fifteen seconds or less. To clarify some other semantics: these systems are "on-line" in the sense that they are connected to and operate on automatic data inputs. They are also on-line in the sense that they affect the operation while it is in process, rather than merely collecting historical information, tabulating it, and presenting it for someone to cogitate about for possible influence on future operations. They exert their influence before the operation is complete. The numerous functions to be performed require time-sharing of computers. This last may not be a necessary property, but is common to all the command systems mentioned.

Turning to the kind of functions that are performed in these systems: some are straight-forward—tabulations for the commander so he knows how many airc aft he has, or how many are ready to go, or some similar information. There is no sophisticated mathematical analysis made; items are simply summed up and displayed. Making a display, especially one that is updated during the operation, requires considerable computer capacity and sophistication.

*To be published by John Wiley & Sons, Inc., as a chapter of a book on management control systems.

Three Levels of Control Automation. Another typical operation (as for example in SAGE) is aircraft tracking. This represents a major class of operations performed by a control system. There is automatic data input that flows into and is processed by the computer. This results in a display only; there isn't necessarily any action by the crew and there is no control action as a result of the tracking function itself. It is an "open loop" activity. Next is a variant of that activity, which is a little more sophisticated. It is the indentification function in air defense, wherein the tracking results in a display and the display is matched with a flight-plan (the airplane pilot's prediction of where he would be) to distinguish a particular radar track from others and decide whether it is friendly or is one to be ejected from the controlled area. This is an example of a "semi-open loop" control. There is a further variation in the tracking function that might be called "closed-loop". This is one that controls the interceptor in the air defense system. Radar information is processed in the same way as it is in any tracking operation; however, it not only appears to various monitors along the way for monitor action, but it is also used in a logical and mathematical operation in the machine to compute the position of the interceptor aircraft at some later time. This information when coupled with tracking data about the path of the target aircraft is used to determine an optimum intersection point for the two tracks. On the basis of this computation, orders are issued to the interceptor aircraft to bring it into the locale of the target aircraft. (In terms of classical servo theory, this is a typical closed servo system; and, it has to have all of the properties of a stable servo system.) This is the most sophisticated control element in SAGE.

Top Management or Command Control System Pyramid. One way of thinking about this kind of control system is to consider it as a many-sided pyramid. This pyramid has sides that all come up to a point at the top, and command or management is located at this top. On each face, there's a control activity taking place; there might even be a completely automated control loop on each facet of the pyramid. We may not reach that point very soon, although in the SAGE interceptor program it is pretty thoroughly automated. Where control functions cannot presently be formulated mathematically, or where they require judgement, current military systems use automation to the extent possible, or at least utilize data processing as an aid, and then introduce men. People do the decision making and put information based on their decisions back into the computer which either closes the command loop or forwards the open-ended type of information up toward the command at the top. This represents a somewhat different use of people; these are not the command people themselves but they are people who are in the system as mechanisms because a real decision making mechanism to do a good job cannot now be designed. However, these people need the same matching with the machine as do the people at the top of the pyramid who receive the displays and make the final decisions. From a man-machine standpoint, some of the jobs that they have to do may be extremely difficult. In the design of displays for these jobs, the decisions as to just where to put the men and how to present information to them may also be very difficult.

The Use of Simulation. In designing command control systems, simulation is a valuable tool. At SDC we think of simulation as the simulated environment with which we can surround a control system for test or training purposes. A model of the control system is designed as we think it will operate. Mechanized elements are provided wherever possible and other provisions are made for people in those areas where mechanization is not possible. Simulated inputs are then provided and made to flow in the regular data channels. We can also man the system with people and examine the match between the people and the system imputs and outputs. This, also, allows us to be sure that the operation looks reasonable to experts who may have done the job manually.

We use simulation for three purposes. First, we use it for system design by bringing in experts to operate in the positions and to give us their reactions to the adequacy of the operations. Then, simulated inputs are used for training. Finally, we use simulation to demonstrate feasibility. To enlarge on this last point: A new system is not always readily acceptable to people in the field because of lack of confidence—they can't immediately see and understand the mathematical formulation that underlies the operation. They need to work with the system and gain some confidence, by seeing it yield the proper results, before it is acceptable to them. This will continue to be true as we go to more sophisticated systems because it doesn't seem reasonable to assume that either the managers or the people who are in the system as linkages will be able to confirm mentally the complex calculations and logical operations that were formalized and rationalized in the design stage.

An example from our field experience may serve to illustrate this point. The early version of SAGE fighter control was not quite as completely automated as it is now. The fighter-interceptor controllers gave voice commands to the fighter pilots, on the basis of computer-processed information that was displayed to the controllers on their consoles. These controllers had all had experience in directing fighter-interception from the radar control position on the ground. Initially, when they sat down at the SAGE consoles they didn't believe the mathematics that were involved. They had a great tendency to do as they had done before—estimate intercept by eye and then override the computer. They gradually began to discover that the mathematics (which weren't at all obvious) really did work and they accepted the system. Now they are enthusiastic about it. This may also be required to sell sophisticated control concepts to business.

APPLICATION OF MILITARY EXPERIENCE TO BUSINESS

Turning now to the question of carry-over to business. The work that has been done in the management controls field in industry is probably more advanced than some of the individual parts of the military control systems that are in use or under development. If the integrated control concept is useful for business management and if it can be applied, then we would want to take advantage of the work that has been done in the business field. On the other hand, those of us who have had experience in developing integrated military control systems may have views that do not exist anywhere in the business field. This is the basis of our proposed research project at SDC: We will attempt to capitalize on what has been learned from the military systems and to call on others for advice on the work that has been done in the active management control field. As a whole, military command control system technology is advanced beyond that of management control systems. However, the opportunity exists to catch up. We can explore the status of these various classes of control systems and work out what we think are the possibilities for combining them into an integrated control system for business management.

MOTIVATIONAL TOOLS FOR MANAGEMENT

Karl R. Kunze
Manager, Training Department
Lockheed Aircraft Corporation
Burbank, California

INTRODUCTION

It has been said that a worker, if he is not pressed for time, is apt to drive home faster than he drives to work; and that a boy has two speeds, one when he is running an errand for his mother, and another when he is running to first base. At least a partial explanation of these speed differentials can be found in the study of motivation.

Some motivations apply pretty much to all of us. Most of us work essentially for the money we receive. But money is not all—we are motivated by the expectation of approval for doing a good job. We work hard to achieve the status we have established for ourselves.

Although we possess similar motivations, we have them in different degrees of intensity. Many college professors would be in other work if money held the appeal to them that it does to others. Greta Garbo has been showered with so much attention and admiration that she now claims she "vants to be alone." Her need for attention apparently has reduced in intensity.

There are significant differences between people and groups of people in kinds of motivations that affect them. One machinist may stay with a company because of the quality of the machines and equipment; and another because his uncle, the owner, wants him to learn the business. In one study of women at the Lockheed Aircraft Corporation, the younger women seemed to be most impressed with their boss's "personal relations" and the older women with his "administrative ability." Men and women working together under an attractive feminine supervisor may be high producers, but for quite different reasons.

MOTIVATION

The theory of motivation proposed by the writer is simply: of the many choices available to a person in his reactions to situations the one selected is the one that gives him greatest need satisfaction. Although a person may be quite unaware of the process taking place (because it is so rapid and is often accomplished unconsciously) it consists of perceiving situations in terms of the amount of need satisfaction it will yield and of reacting in a way to maximize this satisfaction.

For example, let us say a worker who gets little need satisfaction from his job wakens Monday morning with a mild headache. While daydreaming in bed he imagines himself at work, and something inside him, a sort of *need-satisfaction indicator*, fails to register. He then switches his imagination to a nearly-completed workshop job in his garage, one that has challenged his ingenuity, and the *indicator* suddenly rises. He leaps to the telephone, and a department clerk posts "absent—illness" to his attendance record. An illness? Not really. Simply one need satisfaction fighting a losing battle with another.

When we talk of motivation we are referring to what people want or need, and to how they go about getting the things they need. People want things for a lot of reasons. They drink water to satisfy a thirst, but even more, to live. They work for money that provides for many wants. They marry to enjoy sex life, to get children, to achieve status, and also to do what is expected in this society. People do many things simply to comply. Otherwise a business man would not feel compelled to put on a full suit in summer weather. Some work extra hard to overcome feelings of uncertainty or inferiority. Others do things to avoid feelings of dissatisfaction, fear, or anger. Some, because of a kind of complex, are moved to wash their hands incessantly. We do things for various forms of self-satisfaction--to make us feel good about ourselves.

All of these reasons for doing things in a certain way are motivations. We are aware and understand some reasons why we act the way we do. Let us say we saw two men walk into a restaurant, and noticed that one of the men eyed the waitress and the other glanced at the menu on the wall. If we went to these men, informed them of our observations, they might readily tell us the reasons for the differences in their interests at the time.

However, we are unaware of the reasons for many of our reactions. Many of our motives have been repressed or forgotton and are a part of our unconscious. Fortunately we don't have to trace these tendencies back to an origin in order to use them. All we really need do is study them on a behavioral level, find out how people react to different work situations, and use the situations that offer the strongest motivations to accomplish the end result we have in mind. We place names on those aspects of the situation that seem motivating so that we can use them over again or measure their strength. We say that Worker A responds best in a competitive setting and Worker B in a cooperative one; that authority is effective in this instance, or that group participation is best in that one.

However, a motivating situation requires more than simply the presence of personal needs within the individuals concerned. There must be some opportunity to externalize and to realize a satisfying of these needs. For this reason a motivating situation is usually considered to have two necessary aspects:

The Subjective Aspect, the Need (Desire or Want).

The External Aspect, its Opportunity for Need-Satisfaction (Incentive or Goal).

Whether the opportunity for need-satisfaction actually exists is of less importance than the impression workers have of the presence or absence of such opportunities. There may be very little difference between a highly stimulating and an intensely frustrating work situation, and the difference can well be in the way in which it is perceived. A manager can raise the probability of his success in motivating others if he (1) knows something about the theory underlying motivation, (2) uses some of the motivational tools available to him.

It is not necessary for a manager to be a psychologist and to attempt to identify with high accuracy the needs being elicited by his people. Knowing some of the most frequently active needs among people in a work situation helps a manager to organize his thinking and to remember what people respond best to what kind of relationships and situations. These needs have been studied, labeled, and categorized by many authorities in the field. Knowledge of these categorizations is not necessary. Suffice to say that most of the needs of interest to us have much to do with (1) the protection and enhancement of a person's ego (the continuance or improvement of his self-conception) and/or (2) the relationship of a person to his social environment (his status with others). Some of the needs of most importance in the work situation are:

The Need for Achievement. Did you ever see the look on a boy's face after he rode a bicycle unaided for the first time? The statement "I want to be a manager" is evidence of the need for achievement. This need is expressed in efforts to overcome obstacles and to accomplish something difficult.

The Need for Recognition. This need is closely associated with the need for achievement. However, some people want recognition whether they achieve anything or not. Sometimes a highly-developed need for recognition becomes a need for power or prestige.

The Need for Security. The need for security manifests itself in many ways. Someone may strive for promotion for security's sake, yet someone else may avoid promotion for the same reason. One may feel secure when always called upon to "put out fires" and another when he is in a work situation devoid of unexpected change.

The Need for Acceptance, or of Affiliation is a desire to join groups and be accepted by them, to be a part of a team. It is contrasted by the need for automony, to act independently, to be removed from the influence of others, to shake off restraint. Both of these needs may exist within a worker so that he is accepted by his work associates but also enjoys a certain latitude in what he does.

The Need for Understanding. Workers seem to want to be "in the know," to have a good conception of what they are supposed to do, and to understand the extent of importance of their work. The tendency to ask questions, analyze events, and determine the meaningfulness of situations are evidences of this need. The need to be understood may be a counterpart to the need to understand.

The Need for Consistency seems to be present in most people. Expressions of this need may be in the form of a desire for a stability in the work situation, an absence of uncalled-for or unexpected change, the presence of guideposts and regulations, and a consistency in treatment, including disciplinary treatment.

The needs above are examples of those that find expression in a work situation. You may observe one person who has a need for order in his surroundings, another a need to dominate a situation, another to be creative, another to be creative, another to defend himself at every turn, and another to conform.

Needs are not specific entities within a person. You cannot operate on someone and remove his need for achievement. Needs are simply descriptions of strong or persistent desires that find expression in thoughts and actions. When we know about someone's major needs, we have a hint about what kind of external settings will activate his needs to bring about for him a motivating situation.

At this point the problem becomes one of utilizing an individual's needs to further a work objective—or you might say, to satisfy a company need. Sometimes this is not easy, for a worker may have a strong need to play, to socialize, or to show off when a company has a strong need for production. Fortunately, every person has many needs, although some will be less active than others at any particular time, all capable of responding to a situation.

The "motivational tools" to be described are ones that attempt to bring into play employee needs that, in one fashion or another, overlap with those of the company. In some cases the relationship of a *tool* to an *employee need* is obvious. For example, the relationship of the need to *achieve* with the tool *knowledge of results* does not require explanation. Neither does the connection between the needs for *security, recognition* and *achievement* with the tool *money*. But what about authority? Through our lives we have all acquired a need to be dependent upon the authority of others. We are or have been dependent upon the authority of our parents, teachers, and, later, on people in a supervisory capacity. There is ample evidence that if authority is in the right hands and is exercised effectively those subjected to it depend upon it and are motivated by it to the extent that it satisfies their personal needs. The correct use of authority simplifies, makes orderly, and stabilizes aspects of a work situation. The end result can be a raising of effectiveness of a work situation, and it is not inconceivable that such a result can facilitate the expression among workers of the security, achievement, consistency and other work-related needs.

MOTIVATIONAL TOOLS

Money. Studies attempting to measure the relative strength of work motivations give conflicting results when it comes to the importance of money (wages and salaries). Some findings place money high in the list. In other studies, workers rated security, chance for advancement, kind of work, and other goals higher than money. Of course it can be contended that a common denominator of all these goals is money. Although workers may not be prone to admit the importance of money to them, there is evidence that it influences their feelings about their work and the company employing them. A series of investigations on employee attitude conducted by Lee Stockford and the author at Lockheed revealed that:

> Women who were earning more money on the last jobs than they earned on starting at Lockheed were more apt to have an unfavorable attitude toward the company than those who enjoyed increased earnings on coming to Lockheed.[1]*

TABLE I

Relationship of Expression of Sentiment Toward the Company and Relative Value of Starting Wage Rates

GROUP	Percentage Expression of Sentiment		
	Favorable	Neutral	Unfavorable
Total—All Women	51%	20%	29%
Women Receiving Favorable Starting Wage Rates	52%	24%	24%
Women Receiving Unfavorable Starting Wage Rates	45%	13%	42%

The differences in the percentages above are reasonably significant statistically. When converted to a correlation, the coefficient +.31 indicates a low positive but significant relationship between "favorable" starting wage rates and favorable attitude toward the company.

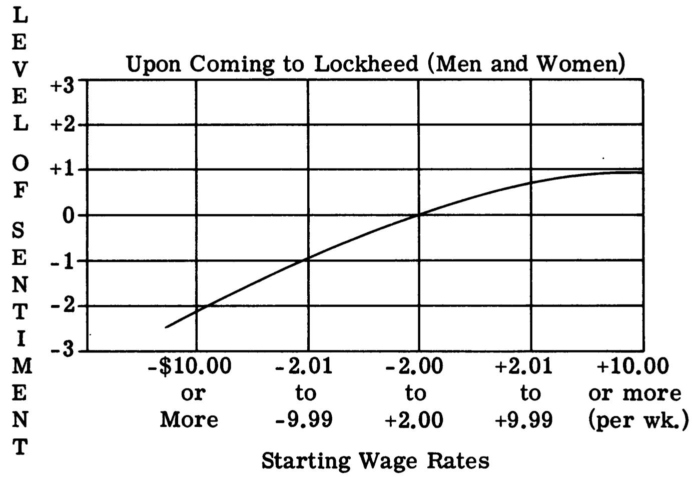
It is interesting to speculate on the value of money as a motivating force conducive to a good attitude. From the foregoing table it is possible to conjecture that if starting wages have any relationship to attitude it may be of a negative value. That is, when women were accustomed to earning a given amount of money prior to coming to Lockheed and received a substantial increase in earnings on coming to Lockheed, they did not show a better level of attitude than that shown by a cross-section random sample of all women. Whereas, when they are accustomed to making more money prior to coming to Lockheed than they made at Lockheed, they showed a lowering of attitude as indicated by a significant increase in the percentage of this group who had an unfavorable attitude toward the company.

Further, the amount of loss or gain in wages upon coming to Lockheed was related to sentiment toward the company.

The vertical axis at the left of the following chart shows the seven categories of sentiment; the horizontal

TABLE II

Relationship Between Level of Sentiment Toward the Company and Amount Gained or Lost



axis along the base shows the magnitude of changes in starting salary. The first column, -$10.00 or more, means that the employees' starting wage rates at Lockheed were $10 or more per week less than that rate which they received on their last job prior to coming to Lockheed. The mean level of sentiment for this group of employees is -2.1. For those employees whose starting wage rates were $10 or more per week greater than that which they received on their last jobs, the mean level of sentiment is +.73. This would indicate that the level of unfavorable sentiment among those receiving unfavorable starting rates is more than twice as intense as that favorable sentiment expressed by those receiving favorable starting rates. Further, that the amount of good will a company receives through relative "overpayment" does not offset the ill will created by relative "underpayment."

Studies at Lockheed and elsewhere suggest that adequate money (wages) may not produce better than usual attitudes or higher morale, but that inadequate money may contribute toward bringing about unfavorable attitudes and low morale.

What's our lesson from all this? We might speculate:

> Inadequate wages may cause a low level of sentiment toward a company.
>
> You cannot buy favorable attitudes with high wages.
>
> Adequate and equitable wages set the stage for non-financial incentives.

Among a large group of supervisors, a strong positive relationship was found between an increasingly favorable sentiment toward the company and (1) the frequency of merit increases and (2) the frequency of promotions.[2]

Authority. You may be surprised to see that both *authority* and *participation* are listed as tools for management's use. The debates between adherence of the democratic and autocratic approaches to management have created the opinion that we must accept either one or the other. Yet a realistic view of nearly any company's operations would show that if strictly autocratic methods were employed with

*Small raised numbers refer to references at the end of the article.

decision-making centered at high levels, the talents and enthusiasm of many throughout the organization would be lost. On the other hand, if wholly participative or democratic methods governed, with decision-making always at the lowest level possible, employees without the desire or ability for performing management activities would be forced into them. Inconsistencies in policies and practices, and chaos could be the consequences.

The use of authority, which is inherently a part of the autocratic philosophy of management, is a good tool to use because:

It accomplishes results fast.

It helps to indicate who is in charge—who has responsibility. It serves to "structure" the work situation, and reduces ambiguities about relationships of people in the work situation.

Employees generally need the presence of someone in authority.

When employee approval or recognition is given by someone who has clearly established his authority, it carries more significance.

Authority is most effective in establishing a course of action to accomplish a work objective. It is least effective in changing the attitudes of people. Attitudes cannot be legislated. Participation, our next tool, can have an effect on attitudes.

Participation. From numerous researches, especially those conducted by the Institute of Social Research, University of Michigan, and the Research Center for Group Dynamics, Massachusetts Institute of Technology, there is the suggestion that an employee may work more spontaneously and intensely if he is a part of the planning and decision-making involved. The results of these studies were not always clear, and suggested that participation may be in some instances a weak motivator and in others a strong one.

One study that is frequently described in the literature concerns a pajama factory that experienced difficulty whenever a change in pattern was placed into effect. These changes were quite disruptive, resulting in a loss of production rate and an increase in employee turnover and grievances.

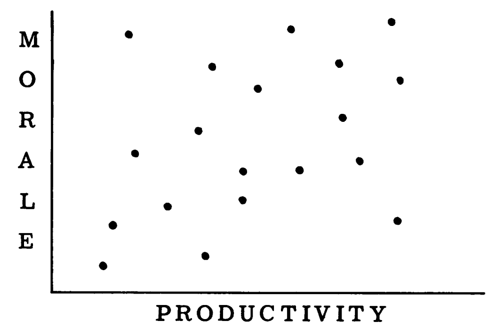
In an effort to spot underlying causes of the problem, employees who were to be involved in the next change were divided in two groups, a control and an experimental group. The control group got the usual treatment, were simply told of the change and how to bring it about. The other group was told of the necessity for the change, which in this instance was to meet competition. They were asked to work out a plan to put the change into effect.

Without going into detail, the control group's production dropped substantially and nearly 1/6 of its members quit. The group getting into the act of making the change increased its production over its usual rate without an increase in voluntary terminations. There have been many interpretations of these results: one that the participation of the experimental group did the trick; another that the feelings of the members of this group were changed so that they wanted to produce more.

Although we know some people don't want to get involved, work out problems, and make decisions, and further, that some situations do not lend themselves to this kind of approach, participation is an effective management tool if properly applied.

Use of Goals and Knowledge of Results. You have all read treatments of the relationship of morale to productivity. If we should take a sample of many such studies, we could probably represent them schematically in a diagram as follows:

TABLE III



Note from the roughly eliptical nature of the distribution a somewhat positive relationship between morale and productivity. From this we can gather that a high score in morale is more apt to be associated with high productivity and, conversely, low morale with low productivity. However, you can see there are enough exceptions, enough dots out of the eliptical pattern to imply that we are dealing with an involved relationship—one perhaps including some other elements.

It is quite possible that you have notices certain groups, happy as larks, having a fine time, but not producing as they should. Or perhaps you have witnessed a bunch of gripers turning out the work. Those who have looked into this subject speculate that the key to these exceptions lies in the extent of a group's presence or absence of the motivation to produce. They say that a bunch of gripers can have a real drive to get a job done, and that a happy-go-lucky, high-morale group can be quite unmotivated when it comes to "getting off the dime" and doing a day's work.

They explain that there are some added ingredients necessary for workers who have good morale to also be well motivated, hence, good producers. One is, they say, that workers must get some kind of personal kick out of their work. Another is, and this might sound conflicting, workers must have a certain dissatisfaction—a satisfaction with achievement—and this feeling has to be coupled with a possibility of self-improvement or it would be of little value. Thirdly, *an awareness of goals seems important.* Not only an awareness of goals, but the presence of indicators telling workers *how they are doing*—the extent to which they are reaching these goals. Knowledge of results apparently is a good motivator.

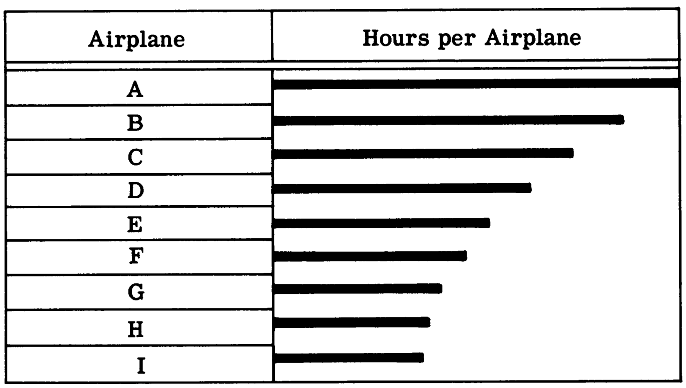
In the manufacture of one of Lockheed's airplanes, a problem existed because of the number of hours required to prepare airplanes for flight. In aircraft jargon this is called the shakedown operation. Influenced by a Training Department course,[3] the supervisors asked their subordinates to give them the number of hours taken for each assignment, then accumulated the information and merely posted it on a bulletin board. This is all that was done by the supervisors. No effort was made to motivate or criticize workers.

Prior to the posting of this information, production of this operation had been stabilized at 250 hours. By "stabilized" is meant that the influence of the learning curve had been reduced to insignificance. After the first posting, a drop of hours occurred, and within a month the average production time dropped from 250 to less than 150.

Subsequently, the number of hours dropped to 139, then to 92, and finally to 72. Further, inspection records indicated that the quality of workmanship had not been affected adversely.

Following is a chart showing the reduction of hours for the "shakedown" operation:

TABLE IV



There is an interesting side light to this story. Air Force inspectors (who had nothing to do with this study) saw the production charts posted, talked about them among themselves, and started to take note of the hours they were devoting to the inspection of these planes. The Air Force inspectors noticed that their own hours were reducing, so they charted them. They found that their improvement in hours was comparable to that of the Lockheed workers.

The Lockheed workers and Air Force inspectors had established their own goals—to beat yesterday's record. Employees expend more effort to reach goals they have set for themselves. Other suggestions for the establishment of goals are:

Have them represent an improvement (greater output, shorter hours, less cost, etc.) over past performance.

Have them attainable (not just once, but always, if employees "stretch" to get it).

Have them specific ("an increase of 10 units an hour" is better than "let's work a little harder").

Work Delegation. Investigations on the subject suggest that a majority of industrial employees are weakly motivated by their own jobs. This is attributable, in part at least, to technological advances in products and in the way products are manufactured. These advances have altered job content significantly. In the aircraft industry three decades ago, an aircraft worker would construct an entire section of an airplane, from the fashioning of the tooling to the finishing of the completed part. Now a comparable worker will devote his attention to the riveting of a wing panel assembly. Some jobs in aircraft have become delimited in scope, standardized, routinized, and made free of decision-making. This same trend, together with its soporific effects on the workers concerned, can be found throughout business and industry, to the extent that counteracting efforts have been made to enlarge jobs. Because of the more flexible circumstances surrounding management jobs, job revision and expansion has met here with some success. The success has been less spectacular in attempts to modify nonmanagement jobs; and one might suspect so, because an artificial restructuring of assignments within jobs can well run counter to the interests of efficiency.

A more logical approach to this problem lies in work delegation. The desires of a manager or supervisor to keep the choicest parts of his group's total work, to perform critical or exacting work, to stay close to and involved in the actual work of his group, and to be the decision-maker are all understandable. The human needs we have discussed explain with adequacy many desires a manager has of holding on to portions of a group's total job to the extent that it makes him a less ineffective leader than he otherwise would be.

To make the most of work delegation, the manager (or other person who delegates) might do well to:

Delegate to an extent greater than he does usually; for the chances are he delegates insufficiently.

Give others a piece of his own job occasionally, to:

Help train them

Motivate them

"Get a bead on them" evaluate their performance in a new job.

See that with the new assignments, commensurate *authority* and *responsibility* are given.

Include decision-making and problem-solving aspects if you are willing to accept the end-results.

Give assignments that require people to "stretch" their mentalities and efforts. The completion of such an assignment offers a strong feeling of accomplishment, near attainment provides a dissatisfaction that is highly motivating.

Selection and Placement. This is such an obvious management tool that it would not have been mentioned if management really made the fullest use of it. It is usual for the United States to have four to six per cent of its work force unemployed at any time. This means that roughly three or four million people are available to choose from in the filling of vacancies. True, not all of these people are accessible to any one company, which must depend on its local labor force for most of its recruits. But in most localities the number of unemployed normally greatly exceeds the number of openings to be filled within that locality.

Accepting this, the question becomes: what effort does a company, or the usual company, make in recruiting a larger number of candidates so that through the best evaluative means, including testing, those who have the best immediate ability and/or the greatest potential are hired?

The reader can best judge the effectiveness of his own company in this respect. However, there is no need to debate the importance of initial selection and subsequent placement. There are vast differences in the capacities, abilities and interests of people. Although humans are generally adaptable to situations for a period of time, in short order they become frustrated and unmotivated if misplaced. Conversely, the person who is properly placed and sees the possibility of advancement has an expanding motivational force of value to himself and his employer.

The assumption that intrinsic job satisfaction is a motivator has been generally accepted. Other well-founded assumptions are that:

> Job satisfaction is related to job content. Routine jobs requiring less skill are less satisfying.
>
> Employees with high intelligence and ability are more apt to be dissatisfied with routine jobs.
>
> Under-placement (placement of a worker on a job for which he is over-qualified) is as much a problem in industry as over-placement.

Recognition. The term recognition is sometimes used to apply only to the acknowledgment of a person's good or outstanding works. This is an acceptable use of the word, but a broader use fits more appropriately into our theory of motivation. In a broader application, recognition refers to the consideration of an individual as unique, different from anyone else in the world, and to that individual's work performance with all its variations, good and bad. To perceive of people being unique requires intimate knowledge of them: where and under what conditions they grew up, the extent and nature of their education, their family life, work history and career aspirations, their attitudes, interests, hobbies. Is it worth it? There is only one way to know, and that is to try it. To do this you should start with a few of your subordinates; get out their records, and interview them several times for the specific purpose of getting to know them. Does it help you to know why people have certain work habits, tendencies to go to certain work associates and not others for help, certain attitudes toward you, or particular work problems? Does this help you as a supervisor? It sure does. If you need convincing, read Zaleznik's little book Worker Satisfaction and Development,[4] and be impressed with the insight you get into the activities of a machine shop group and into the thwarting and facilitating influences of their total work setting.

Obviously a worker wants recognition when he does a commendable job. But when his workmanship is sloppy does he want this recognized? Perhaps not, but what is best for your group's production—and for the worker in the long run?

Perceiving a worker as a unique individual, paying attention to all significant variations in performance brings into play many needs, those of achievement, recognition, and also those of security, acceptance, and fear-avoidance.

The Shovel. A shovel is a good tool. It has lots of uses, and one is to shovel out debris cluttering up the place. There are impediments in work situations that should be cleaned out: imperfect tools, "almost-correct" job instructions, poor machine or equipment arrangements, drafty offices, unnecessarily long distances to restrooms, telephones, and time clocks.

In studies of group productivity, such frequent reference is made to the physical setting and its affect on working people that one wonders whether in our preoccupation with people we may not be overlooking one important aspect—their physical surroundings. This certainly was not the case several decades ago, because then much was done along these lines—and of course there was much room for improvement. Now, working conditions generally are good, and this fact may cause us to overlook factors that may be unimportant to us, but inhibiting and irritating to workers.

Zalesnick[4] refers to a rearrangement of machines that prevented normal social intercourse. Mackworth[5] found that high motivation didn't compensate for adverse atmospheric conditions. Women in one factory became disconcerted when a change in color of illumination made them look ghastly.

Although adverse working conditions are the exception, they can disrupt motivational forces, especially if only a portion of a work force are subjected to them. If such a condition exists, resulting feelings of inequity can have more serious consequences than the physical conditions themselves. So, the manager who wants his motivating efforts to work should get out the shovel and remove physical obstacles to production.

What has been presented has been a simplified version of our tendencies toward need satisfaction and an equally simple description of some management tools that will enhance the expression of these needs. In a real work situation an employee will have many needs operating at any one time. Some of these needs will be compatible and reinforcing. Someone may want to do a special job because it will give him a sense of achievement, and may also put him in line for a promotion and more money. Sometimes conflicting needs operate simultaneously. A worker may want more money and know he can secure this through night shift premium pay. Yet he may forsake the increased income because swing shift employment cramps his nighttime style. A worker might find himself forced to make a choice between two situations, both running contrary to his needs, for example, a choice between accepting a downgrade or taking a layoff.

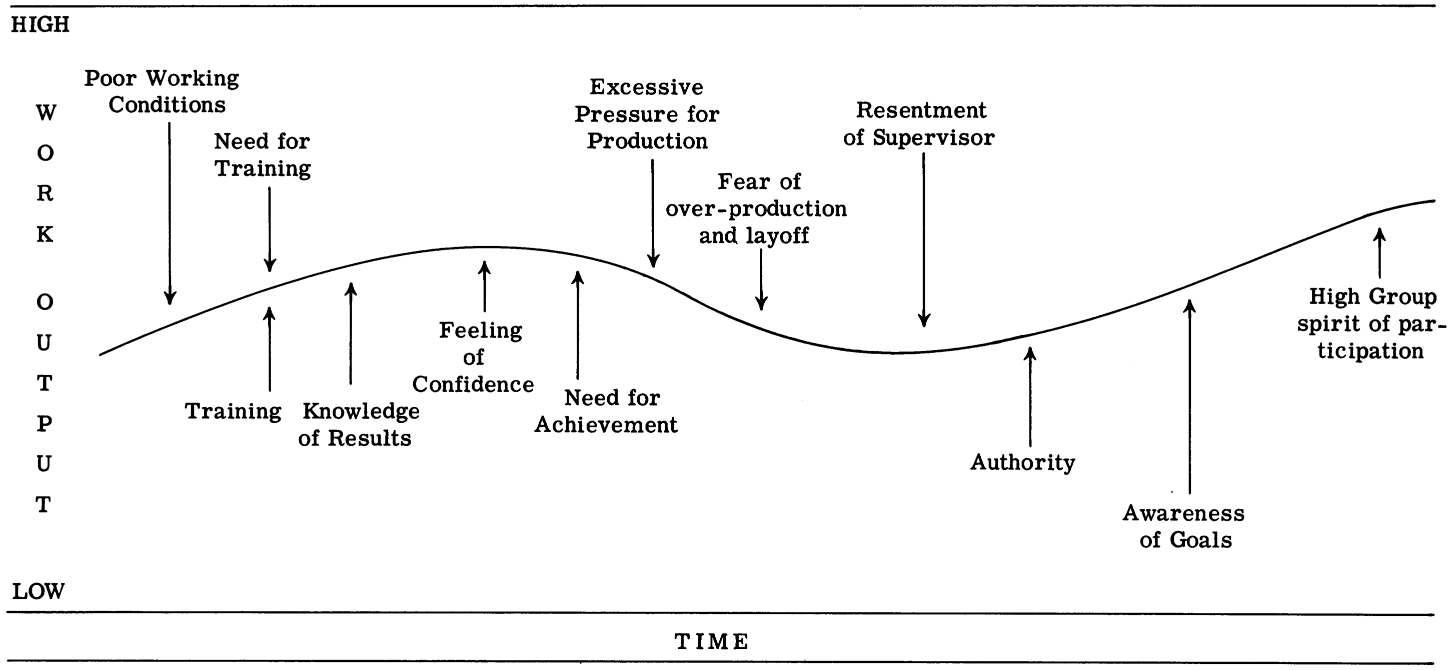
Further, a group's production may be influenced by a number of thwarting and facilitating influences at any one time, and in fact, over any period of time. The group's output can be conceived of as the point of balance between the two opposing forces. Lewin, a well-known psychologist, explains this aspect of the work situation in terms of negative and positive *valences* (or forces).

This idea of output representing the balance between opposing forces can be shown graphically as follows.

Management people in looking at a production chart are inclined to ask the question, "What can be done to push

TABLE V

Possible Influences to Group Productivity



up the line?" The thought may not occur to them that by reducing the intensity of negative forces the line might go up. In fact if this is not done, increased pressure from below may serve no purpose. What would happen if you attempted to accelerate an automobile and apply the brakes at the same time?

With the complex array of needs each person possesses, and the infinite number of forces impinging on the work group, how can you as a manager tell what to do for the best results? A knowledge of personal needs helps—including an insight into those that are most influential in governing your own actions. Skill in the use of management tools should also contribute. A willingness to try new approaches and a versatility in actions is another aid. Add to this a constant and critical appraisal of results, and thepprobability of your achieving effective managership should be on the increase.

REFERENCES

1. L. O. Stockford and K. R. Kunze, Psychology and the Pay Check, Personnel, Amer. Mgmt. Assoc., Sept., 1950.
2. From an unpublished company report, L. O. Stockford and K. R. Kunze, Preliminary Results from the Study of Supervisors' Attitudes, 1950.
3. A course titled Motivation Controls, Max Skousen, instructor.
4. A. Zaleznik, *Worker Satisfaction and Development,* A Case Study of Work and Social Behavior in a Factory Group, Harvard Business School, Boston, Mass., 1956.
5. N. H. Mackworth, High Incentives vs. Hot and Humid Atmospheres in a Physical Effort Task, Medical Res. Council, Gr't Britain, 1945.

METHODS ENGINEERING AND OPERATIONS RESEARCH

R. D. McLandress
Director
Work Standards & Methods Engineering Section
Process Development Staff
General Motors Corporation

The invitation to speak at this conference suggested that I cover something similar to the subject which was presented at the A. S. M. E. - S. A. M. April, 1958 Conference in New York City. My subject was "Utilizing Methods Engineering in Cost Reduction". I have talked on essentially the same subject a number of times before and I believe that a speaker as a result becomes typed and can easily lose the benefit to him of speaking on other subjects.

In an attempt to satisfy the invitation extended to me and at the same time to side-step to some extent most of the material which I have discussed before I have selected only one phase of the material and will enlarge upon it. It has to do with what we call the Methods Engineering Approach in General Motors and a demonstration of its effectiveness. Its close association with Operations Research and other newer techniques is interesting. In fact it has been described by our technical assistant to the Vice President as the "Shop Man's Operations Research".

Before we get into it, let's talk briefly about the Methods Engineer and his field today. Never has there been a more interesting period of only a few short years in which so many new developments have taken place. For example there is Operations Research with its many techniques, techniques which are not so new but only just now beginning to be understood. There is the development of computers which greatly simplify and cut down on the time element of obtaining the answers. Then there is Quality Control and on its heels Reliability born even before Quality Control had gotten a good start. There's mechanization with its many attendant problems of adequate controls and component standardization all affecting the economics of how far to go with mechanization. And in this same connection, the importance of simplification of product design to permit further mechanization is also important.

All these things are of extreme interest to the Methods Engineer because he must not only understand them but use many of the techniques himself. At the same time, the many techniques which have been considered basic in his responsibility in the past are still very essential and he must remain skilled in their use.

A sad but very true fact is that many of our methods engineers are not using their basic techniques, which, when used as they were designed, can contribute immeasurably to many of the problems where we are spending a great deal of money, much of which should not be spent. I refer to plans for tooling and equipment of many new jobs where alternate methods using the Methods Engineering techniques would have proven that there is an easier, better and less-costly way.

This is a great day and age for the Methods Engineer who is on the ball. There are so many new and fascinating developments that the good Methods man is kept stimulated to the limit of his capacity to absorb.

In the opening paragraphs of this paper it was mentioned that the subject which we will discuss is the "Methods Engineering Approach" as it is used in General Motors and a demonstration of its effectiveness. It was also mentioned that it has a somewhat close association with Operations Research. We hope to show that association. However, it should be made clear that we are not going to get into a long-haired discussion on the similarity of the Methods Engineering Approach and the higher mathematics associated with Operations Research because that kind of similarity does not exist. Rather we will present a technique currently practiced in General Motors that contains some of the elements of Operations Research and has proven extremely valuable in effecting important cost reductions.

Operations Research is a subject about which there is a great deal of conversation in today's industry. Many books have been written, many articles have been published; there are at least three or more major periodicals, and at least three societies are dedicated to its study and use.

In a talk before the American Society of Quality Control, Dr. Lawrence Hafstad, Vice President of General Motors in Charge of Research, made the following comments concerning operations research: "I think we are on what I like to call the second bounce. As with so many new things, there is an initial period of skepticism, followed by a period of enormous enthusiasm and an expectation of magical results. We've been through that stage with operations research. Then you go through a period of disillusionment and only after that do you come to what I call the second bounce, and you start developing something which is solid and serious. I think that we are approaching that stage in operations research at the present time."

There are many opinions on the subject and some of them widely divergent. These opinions range from great enthusiasm to extreme skepticism. There have been many successful operations research projects that justify this great enthusiasm. Excellent results have been obtained on studies such as optimum distribution of sales effort, lot sizes and inventory control, scheduling, sales forecast and service life estimation, to mention only a few. On the other hand, an article appeared a year or so ago in which the author suggested that with the exception of system engineers in a defense establishment, and certain universities, operations research today is being promulgated by a body of talented amateurs. This same author agreed that there have been ample cases to indicate operations research is fruitful but suggested that there are also limits of darkness into which it would be reckless and foolhardy for any general manager to plunge shielded only by the mass of data and methods used by operations research to guide him. We have mentioned a few of the problems that exemplify operations research. We know that some problems are so complex that advanced mathematics and costly computers are required to permit their solution in any reasonable time. Even with the aid of these tools, however, extended periods of time are sometimes required. This is not meant as criticism—the need for better solutions to such broad, basic problems is evident and operations research provides the means of solving them. But, the manufacturing man may well ask, "How can I apply operations research to my particular problems? Where can I get the trained mathematicians and computer help?" He might also think to himself it will be a rather slow process of getting across an adequate understanding to his key people.

Operations research, if you consider it as requiring a high order of statistical methods and other mathematics, is a very helpful tool; but there are many problems facing the manufacturing man which can be solved by using what he knows now and is available to him now. He needs an approach that will bridge the gap between what he is doing now and the complexities of true operations research.

Although the problems to which operations research has been applied are extremely varied and the theories that have evolved, the mathematical models that have been built and the computer programs that have been designed are equally as varied—there are certain steps in the method of attacking the problem that are basically the same. Objectives are established—existing conditions are studied—necessary data are collected and possible solutions determined and evaluated against the objectives. It is this portion of operations research that I would like to discuss today in connection with Methods Engineering as it is practiced in GM.

In the General Motors Process Development Staff, located at the General Motors Technical Center in Detroit, this method of attack or solution technique is referred to

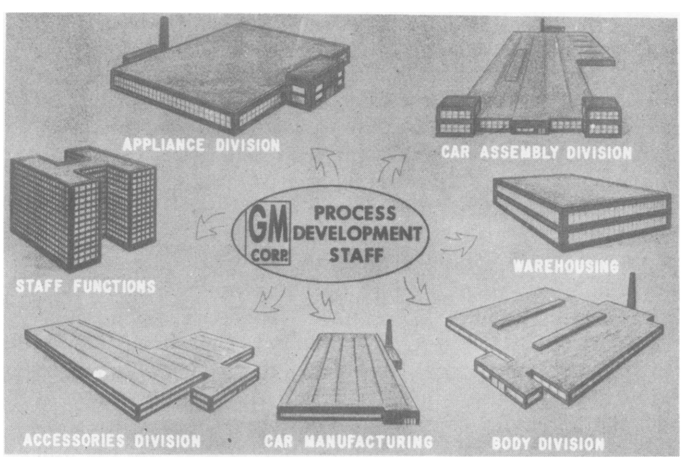


Figure 1

as: "The Planning Team Activity for Cost Reduction". Perhaps it is well at this point to explain briefly the functions of the Process Development Staff.

The Process Development Staff is a Central Office Staff organization responsible for the development of manufacturing processes which will reduce costs and improve quality. They are also responsible for the exchange of technical data among the divisions and the standardization of methods and work standards procedures throughout the Corporation. The Planning Team activity is only one of many at the Process Development Staff.

What is the Planning Team Activity?

*It is a cooperative, organized effort to solve a problem. Through this activity the Process Development Staff works with any manufacturing division or any other General Motors function including the Central Staff in the solution of particular problems in their organization. For example: it might involve an assembly line—the complete processing of a particular product—or simplification of warehouse procedures. The Planning Team activity derives its name from the fact that the studies are conducted by a team made up of Process Development Staff and Divisional personnel, usually two men from each organization. The team works to a formalized plan of attack which we call the "Methods Engineering Approach". Experience has shown that the best results are obtained when we follow this procedure step by step without deviation.

You might be interested in knowing why the Planning Team work was started. A number of years ago our Staff was asked by a divisional manager to examine his complete assembly line for possibilities of mechanical applications to bring down his labor costs. Several of us from our Staff visited the division to observe the conditions. We concluded that a thorough joint methods and mechanical analysis was necessary to get all the facts on which to base any equipment recommendations that we might make. We thought that we saw in this approach not only a procedure to give us enough facts to be sure we were making the right decisions but a new and much more satisfactory manner in which to provide our process development services in the design of special purpose equipment. We were amazed to find that this did not develop as we had planned. Very early in our team study work it became evident that major reductions in cost could be made without high investment for special purpose equipment. This was not the answer we expected and most of the team studies to date have indicated the same basic result. Whether in process development work, Methods Engineering, production engineering or any other function for that matter, frequently solutions are not what we anticipated prior to having the facts, and sometimes the facts are quite startling. A good example of this can be found in the book, "What Man May Be", written by Dean Harrison of M. I. T. Dean Harrison makes the point that of all the people who have ever been born, one out of twenty are alive today. I mention this only to point out how enlighting facts may be.

*Note: Embodied in this paper is a procedure taken from a talk entitled "The Shop Man's Operations Research" presented by my colleague Mr. Harry Hall, Director of our Process Development Section at the S. A. E. Aeronautical meeting in New York City in March, 1959.

What is this Methods Engineering Approach and How Does a Planning Team Work?

It is not new—it has no magical powers. It is simple and you will all recognize it. It merely states that there are seven steps to the solution of any problem and these are:

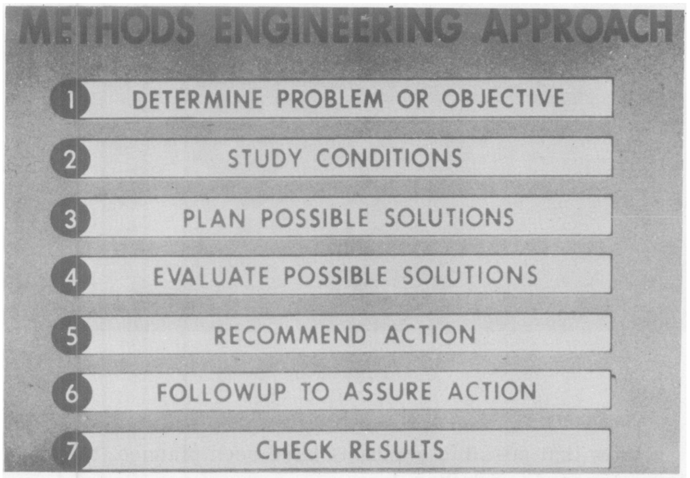


Figure 2

This is the foundation of our Planning Team activity. Let us see how we build on this in our work:

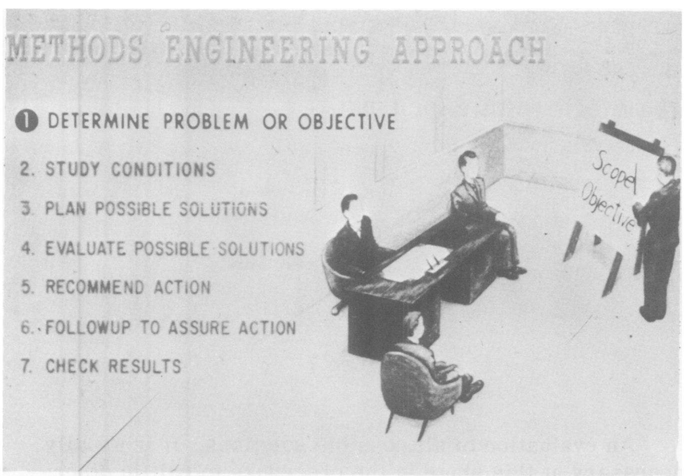


Figure.3

Management in the divisions, realizing that they have a problem and are in need of some outside assistance will contact our Staff. The supervisor of Methods Engineering and the supervisor of Process Engineering from the Process Development Staff then visit the divisional management for the purpose of setting preliminary objectives—establishing the scope of the project—and deciding upon the specific area or activity to be analyzed. This step in the procedure is extremely important and usually requires a full day of discussion with the plant manager and his staff.

Care is taken to see that the area to be studied is self-contained in order that changes made in the area chosen will not adversely affect other operations in other areas. What appear to be natural boundaries are established. We know, for example: that any system within an organization reacts in varying degrees to external factors. We recognize that in some cases these external controlling factors are not as good as they might be; at least, they do not lead to optimum operation of the system under study. Changes in these factors may well be desirable, but in most cases they are of such a complex nature that proper study and correction would be very time consuming, and in the meanwhile the system which they control *must continue to function at a minimum cost.*

At this meeting, the plant management decides what divisional engineers will act as team members and work with a methods engineer and a process engineer from the Process Development Staff. Usually one of the divisional men is a methods engineer and the other a process engineer. This is not a hard and fast rule, however, and in some projects one of the divisional team members has been from manufacturing supervision, or one of the staff functions directly involved with the area under consideration.

Once the original objectives have been established, it is important that we constantly police all activities in connection with this project to make certain that the team members do not deviate from the original objectives. This is accomplished by frequent visits to the division by the supervisor of Methods Engineering and the supervisor of Process Engineering from the Process Development Staff. Some typical objectives would be:

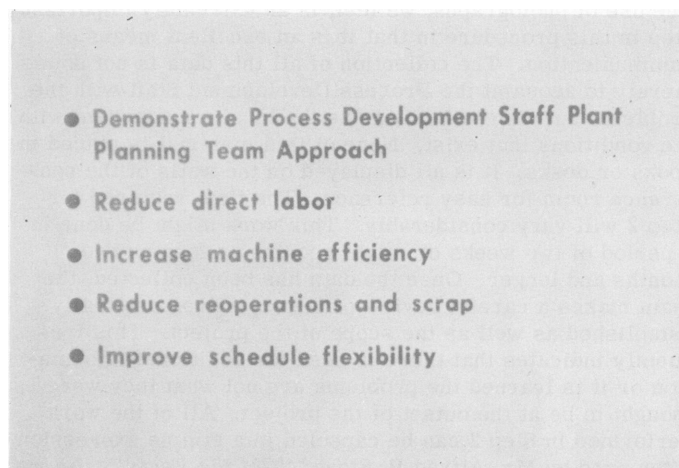


Figure 4

As the team study work progresses, it is sometimes necessary to re-establish objectives which will vary from the original basic objectives laid down in the initial conference. (See figure 5.)

The second step in the methods approach is to *study conditions*. The team is assigned a large conference room in the plant with ample wall space. With this room as a headquarters they start on the difficult task of studying existing conditions in the plant and recording them. Photographs are taken of all operations and a detailed methods

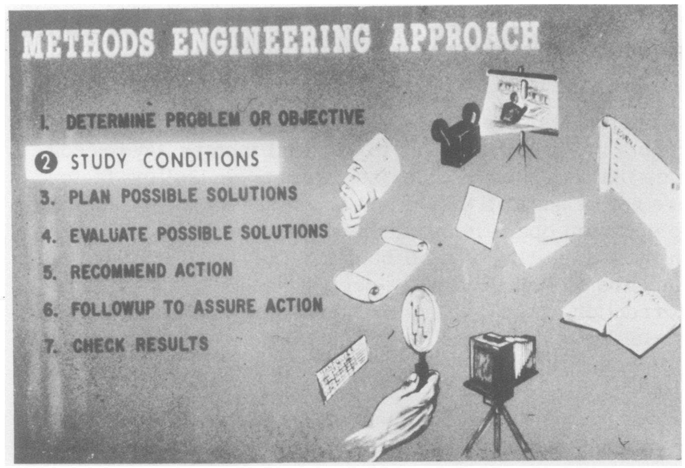


Figure 5

analysis is made for each. This usually will include a movement analysis. Movies are taken where required, flow charts are prepared, plant layouts are obtained or made and all other pertinent data, such as scrap reports, production schedules and performance reports are gathered. Operation sequence possibility charts are prepared where necessary to determine to what extent the sequence of operations could be changed if it is deemed advisable. It is important that the team study conditions as they actually exist. The team men maintain that there are three routings in each plant: The routing of record, the routing thought to exist by management, and the actual condition on the factory floor. The use of photographs, we feel, is an extremely important step in this procedure in that it is an excellent means of communication. The collection of all this data is not done merely to acquaint the Process Development Staff with the problems but also to familiarize the local management with the conditions that exist. None of this material is placed in books or desks. It is all displayed on the walls of the conference room for easy reference. The time required for Step 2 will vary considerably. This work might be done in a period of two weeks or might require as long as two months and longer. Once the data has been collected, the team makes a careful review of the objectives originally established as well as the scope of the project. This frequently indicates that there is need for additional information or it is learned the problems are not what they were thought to be at the outset of the project. All of the work performed in Step 2 can be capsuled in a simple expression often used by Mr. Alfred P. Sloan, *"Get the Facts"*. As we all know, it is not always easy to get true facts or conclusions.

Step 3 consists of planning possible solutions to existing problems. It is logical that in studying conditions many problems have been encountered. In Step 3, it is the team's objective to find solutions to these problems. In determining these solutions several alternates are considered ranging, for example, from minor improvement of operator methods to complete mechanization. Frequently proposed solutions consist of suggested changes in product design, changes in plant layout and revision to paper procedures within the plant. It is important that the team avoid a natural tendency which is to accept the first solution conceived. They must explore all possible solutions to determine which is best.

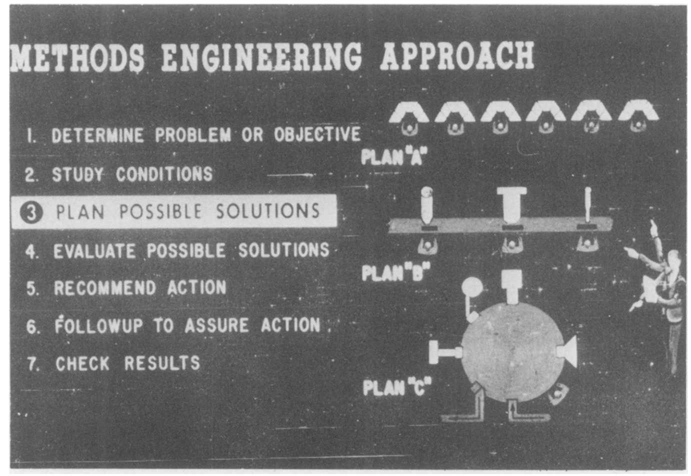


Figure 6

Now that possible solutions have been planned, the team proceeds with Step 4:

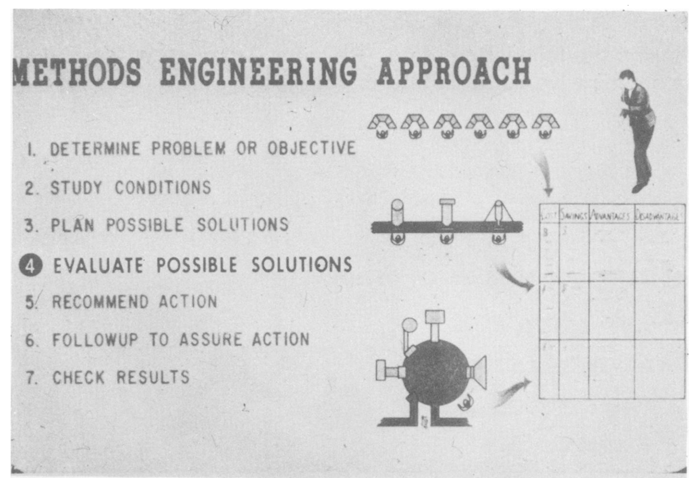


Figure 7

An evaluation of all possible solutions. It is usually necessary at this stage in the procedure to call in other specialists within the plant organization. For example, on proposed product engineering changes, the product engineer is invited to review the proposed changes with the team. In some instances this results in the actual making of sample parts and may be as far reaching as to require field tests on the proposed parts. Where changes in processing or tooling are considered, the tool engineer is consulted both from the standpoint of cost of the new tooling and obtaining his advice regarding the feasibility of the proposed change. This may also result in some physical work in that mock-ups may be built and tests conducted either in the plant or at the Process Development Staff. Where these changes become long range and considerable time is required for experimental work, they are divorced from the team study and a separate project is initiated which can extend beyond the conclusion of the project at the division. All of the proposed solutions to problems, of course, do not require physical changes and experimentation. For example: proposals that specific parts be manufactured rather than purchased are discussed with the Purchasing Department and the Master Mechanic's Section. This type of proposal can usually be resolved in short order. Proposed changes in paper work procedure, that is: the routing of reports and necessity for reports, and action taken as a result of reports, may require contact with accounting or production control as well as the Inspection Department. It is at this point in the team study work that the interest runs very high. The divisional personnel now have something to put their teeth into and we have found from experience that although the divisional people may have felt at the outset that the preliminary steps were superfluous, they are now convinced that the results justify this preliminary work. The team establishes means of measuring such things as: improved quality, reduced parts in process, etc., so that they can better evaluate some of the more intangible results of the study. In all cases, it is important that where reduced costs or savings are indicated in a particular proposed solution that we also obtain an estimate of the expenditures required to effect these savings. On each proposal sheet that is prepared, the savings and the investment are indicated. The effect of the team's efforts is very widespread within the plant organization when they are evaluating possible solutions, and the thinking of the entire organization is included. Naturally, there is not always agreement which is another reason for making trials or experiments.

It is important at this point that I do not give you the impression that all of the savings are in labor. Many of our savings are in material cost reduction, through more economical use of material, product design changes, or the use of substitute materials. Reduced inventory and floor space are also areas where savings are frequently possible.

When the evaluation of possible solutions has been completed we proceed to Step 5:

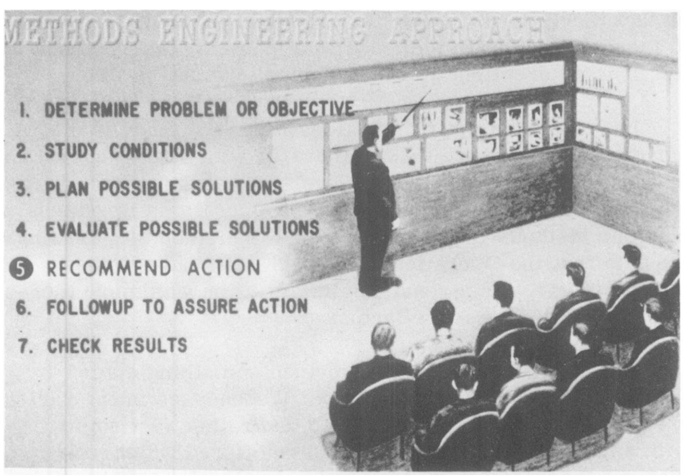


Figure 8

which is: *recommend action.* From the evaluation condc ducted in the previous step, a complete set of proposals is prepared. Each of these is individually recorded on large charts showing the old procedure, the proposed procedure, the savings to be gained, and a required investment. In some team study jobs these proposals have run as high as seventy-one in number. It is important in preparing these proposals that each stands on its own and that they are not grouped so that items which will not stand on their own ride along on the strength of others.

The results of the team study are reviewed by the Process Development Staff management and changes, or additional studies, are made if necessary. At this step, the team members have the opportunity to obtain additional ideas from the Process Development Staff management which takes advantage of the experience the management has had in shop problems.

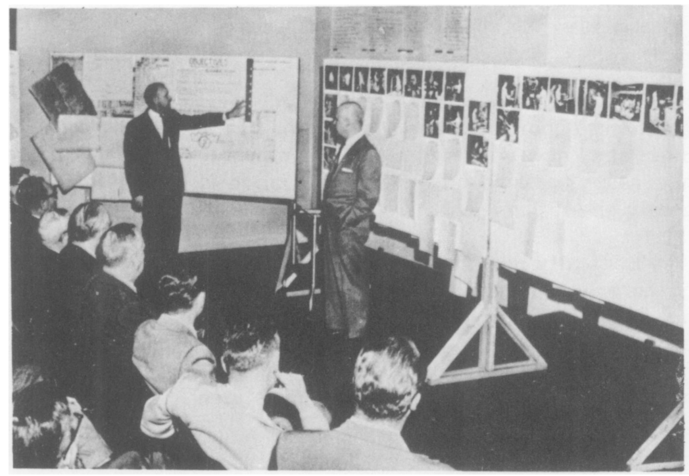


Figure 9

All of the material gathered is then presented to divisional management. Since this is usually a fairly large group, the manner of presentation is important. The photographs, schematics, special charts and diagrams developed during the study of conditions are displayed along the walls of the conference room as well as each of the proposals. All the material is explained and the proposals are presented. This job is usually split up so that each of the team members has a part of the presentation. By following this practice, the divisional men obtain valuable training in the presentation of material which will be helpful in future team studies carried on at the division without Process Development Staff assistance. The training the divisional members gain from participating in the team studies is one of the most valuable accomplishments of this work and it is expected that these men will go on to train others in the divisional organization.

The review requires an average of two to three hours. All of the material collected and developed at the division is left there for the use of the plant. (See figure 10.)

Step 6 is to *take action on the various proposals.* This, of course, is the responsibility of the operating division, but Process Development stands ready to assist in any way possible. Frequently, at the presentation session the management divides the proposals into categories and assignments are made to specific individuals at that time. The divisional members of the Planning Team are in an excellent

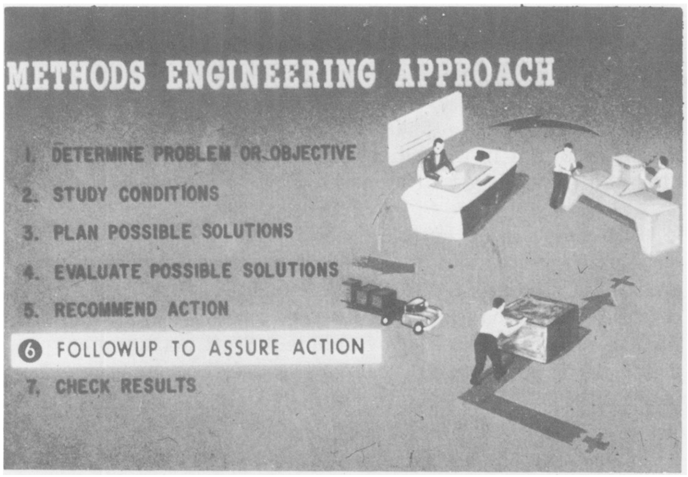


Figure 10

position to coordinate the installation of the proposals. Since they have worked on the entire problem, they have the necessary background and information to follow-up intelligently on all phases.

Logically much of this work becomes the responsibility of the process engineering and methods engineering personnel in the plant. Where other agencies are affected, they, of course, are given specific assignments. The plant management is naturally interested first in executing the proposals which show the highest return on investment.

To complete the picture we have the last step of *checking results*.

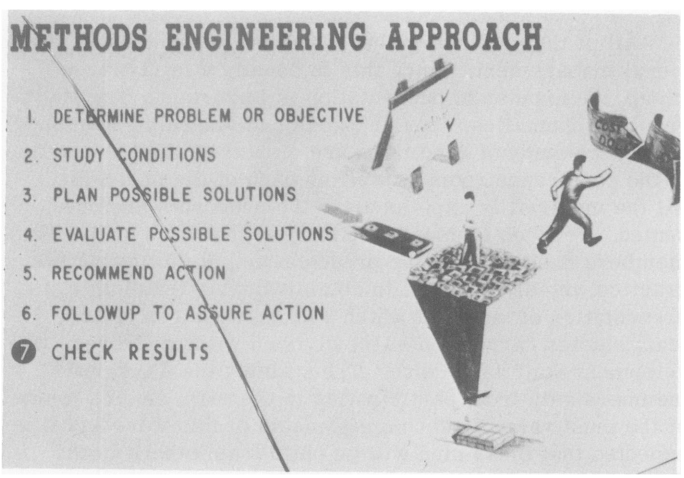


Figure 11

This is done by the divisions and also by the Process Development Staff. We request each of the divisions to report within a few months following the presentation on which proposals have been adopted, which presented difficulties, and what the over-all result has been. Within the plant, the summary report provided serves as a good document for

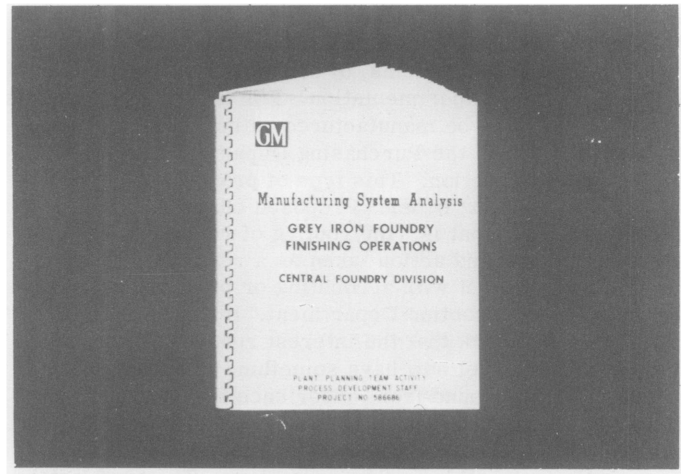


Figure 12

the management in following up on each of the proposals. A follow-up to date on team study jobs has proven very successful. Perhaps to more fully appreciate the results and effect of a study of this type it is necessary for one to see a typical presentation. The volume of data collected, the detail analysis and the number and quality of the proposed solutions are extremely impressive. If at this point after listening to this procedure you really are not impressed, then I can only suggest that you try it.

From my own viewpoint, with the responsibility for promoting the use of Methods Engineering in General Motors, it has been the most effective method that we have been able to put together up until now. Seeing is believing and an actual demonstration when done well can convince management of its potential value.

As you can see from this description of our Planning Team activity, there is nothing about it that is radically new. Presently, a team is working on our thirty-seventh project and the results of the previous thirty-six have proven that there is something very worthwhile in this approach to the problem of reducing costs in industry. For that matter, it is an excellent approach for solving any problem.

In a recent strictly operations research study in one of our divisions in which we collaborated with other General Motors Central Staff functions, we spent six months in helping to gather data. Working with the Operations Research men our Methods Engineers provided a method of gathering the data that the Operations Research men had not been trained to use. As a result the information was more thorough and therefore more factual.

Our Methods Engineers provided something else through the use of their approach. Weaknesses in the various areas studied were uncovered and rather fast solutions with small cost for the changes were offered which would then put the whole study on a better basis. It is truly said that no chain is any stronger than its weakest link. When an area is strengthened and the final procedure is placed on a more firm basis then its value as established by the Operations Research men becomes more factual and reliable in the way it may affect other phases of the business or be affected by them.

This kind of approach in furnishing analysis for use by the Operations Research men has another very great advantage. It provides the basis for the determination of any large areas of total plant operation that should be singled out for immediate improvement which can be accomplished rather simply and without much cost but with considerable immediate savings. Such savings can bring quicker returns without having to wait for many months which is one of the problems of intensive Operations Research programs.

We credit the success of the Planning Team activity to the organized manner in which studies are conducted. The objectives are well defined and all factors affecting the problem are considered in an orderly manner. The thinking and ideas of many people, both team members and others, are collected and evaluated and no improvement potential is considered too small.

The thirty-seven studies completed to date have been extremely varied, ranging from studies of jobs which are heavy in manual operations to jobs that are highly mechanized and studies of paper-work procedures to warehouse activity problems.

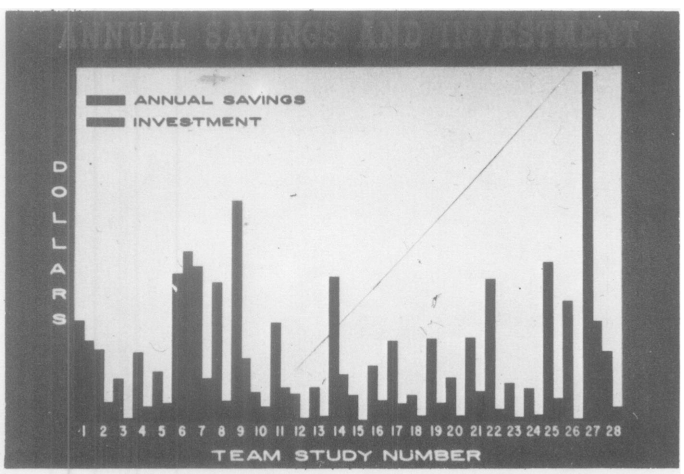


Figure 13

A tabulation has been made of the results that were directly measurable for each of the studies. This tabulation was made following the completion of our first twenty-eight studies. In all cases there were other improvements not so readily measured, such as improved housekeeping, safety, process simplification, less maintenance, floor space savings, etc. This chart shows the ratio of savings to investment required, and in all cases, the return on investment was good.

One of the more outstanding jobs, No. 22, shows that the savings were eleven times the investment required.

The average ratio of savings obtained to investment required is over 3:1 with a maximum ratio, as indicated previously, of 11:1.

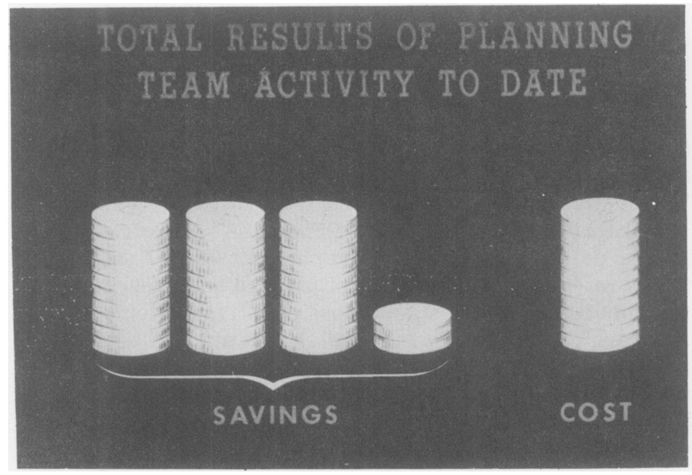


Figure 14

In conclusion I would like to anticipate your question of whether the cost of obtaining all of the detailed data and preparing these detailed analyses is justified. This can best be answered if we compare the results of our team studies with expenditures for capital equipment. Industry is constantly purchasing improved equipment for the purpose of reducing costs, and sizable cost reductions have been made by mechanization. The cost of team study work, however, can be extremely small when compared with the savings obtained. This has been demonstrated earlier by the fact that return on investment for the team study activity has run as high as 11:1. I am sure that you would all agree that it is very infrequent that capital equipment is purchased with this type of ratio for return on investment.

Perhaps a statement made by Mr. Seaton, our Vice President in charge of Personnel, when he appeared before the U. S. Senate's Special Committee on Unemployment Problems last November will serve as further evidence of the need for this approach. Mr. Seaton told the committee that the amount of capital required per job has risen from $5,822 in 1948 to $16,047 in 1959 with only a portion of the increase due to inflation. This seems like an astronomical figure when you multiply it by the number of jobs. It represents an enormous area in which to work to keep the figure from growing any faster than is necessary.

At the outset of this paper the statement was made that there is a somewhat close association of Methods Engineering with Operations Research. Certainly we would not want to be understood as believing that the approach which has just been explained is Operations Research but certainly it contains many of the steps which would be performed in an operations research analysis. The mathematics used to date have been very simple and it has been a matter of weighing one proposal against another. Conceivably this approach can be carried further with the addition of some mathematical techniques and models. This will take time. Meanwhile the Methods Engineer using his approach can make an outstanding contribution to the field of cost reduction. Manufacturing management in particular would do well to employ this approach for it will bring them substantial and fast cost reductions for a minimum of investment and that cannot be matched in any other way.

Recently I read a reprint of an article which appeared in the 1959 May-June issue of "The Journal of Industrial Engineering" written by Professor Gerald Nadler, Head of the Department of Industrial Engineering at Washington University. His article was entitled "Work Design: A Philosophy for Applying Work Principles". Professor Nadler defines his newly coined phrase "Work Design" as "the systematic investigation of planned and present work to formulate the easiest and most effective systems and methods". What Professor Nadler was after in his paper was to get across the idea that work should be planned before it is performed. And, of course, what he means is that while we do plan we do not plan with enough understanding of what eventually will take place when the job is installed.

Certainly we agree with Professor Nadler. The time to think about getting the most from the job is when the planners are conceiving all the ingredients and we all know that the things which affect the job begin with the design of the product and every step of the way in providing the facilities to make the product.

This is the most difficult to accomplish because there are so many more people involved and deadlines to meet, creating the additional problem of limited time in which to do the planning. We believe that properly trained planners working with experienced Methods Engineers can do a much better job in the same amount of time using the right approach, of course.

Our Methods Engineers have been working on this problem and in a number of our plants an excellent job is being done. To provide our Methods Engineers with an instrument through which they can gain the necessary understanding on the part of their management on just how the best planning can be done, we recently drafted material which they can shape to fit their individual needs. This material is entitled "Control of Operator Method" and is accompanied by a series of 76 color slides which makes a very effective local presentation.

It has been a distinct honor to have been asked to appear before you today and after traveling way out here to California, I hope that I have brought you something that you feel is worthwhile and that you will think enough of it to give it a trial.

STANDARDS FOR CLERICAL WORK

Maurice A. Murray
Assistant Superintendent
American Insurance Company
Newark, New Jersey

BACKGROUND AND HISTORY

Management today can no longer control their clerical operations through an intuitive process. Clerical operations are no longer simple and, in fact, are steadily increasing in complexity. For this reason direct access or even communications to all areas of clerical productivity is not always possible. Often the distinction between troublesome and trouble-free operation is not so obvious as one might think.

It has been said that to measure is to know, but unfortunately the traditional systems of work measurement do not always solve the problems found in the usual office situation.

It used to be that the expense of the office was labeled traditionally as overhead, and treated as a necessary evil with no real examination as to its intrinsic effectiveness.

However, today our country is somewhat unique in that our white collar labor force outnumbers the blue collar force.

Without a question, it is becoming more apparent that the long-held tenet that techniques such as work measurement and work sampling should be relegated only to factory type operations is, each day, losing the support of managers of clerical operations who cannot ignore today's spiralling costs and the increasing pressure of competition.

THE SCIENTIFIC APPROACH

Certainly no one will deny that the age in which we live today is truly one of miracles. No other period in history can boast of so many new developments in a single generation and the future is unlimited.

The scientific approach has been the hallmark of good management ever since most of us entered into the business world.

AND A QUESTION

But, Gentlemen, is the scientific approach the whole answer? So much concentration has been directed towards technique that management has been relegated to alchemy. Perhaps we are even like that class of people who having a technique are now seeking out an application. However, at the risk of being labeled an iconoclast, I ask you to forget the scientific approach for the moment and consider the lost art of management—the application of common sense.

THE COMMON SENSE APPROACH

The best part about common sense is that there's plenty of it available in your operations right now, and it is extremely unlikely that any future developments in clerical work measurement should eventuate in an extensive program of absolescence in the common sense approach.

I'd like to tell you that I have the panacea for all measurement problems, but such a distortion of the truth would soon be apparent for there is no substitute for the sound application of common sense.

Now just how does the common sense approach apply to clerical work measurement? Simply this, just ask yourself "What do I wish to accomplish through clerical work measurement?" Generally, your goals should be able to be summarized as cost reduction or improved service or some combination of these. If this is not the case, your solution may not be in the application of clerical work measurement, but in a re-evaluation of your management philosophy. I suspect a good many measurement programs have encountered resistance not because they are measurement programs, but because they are expected to accomplish goals beyond the scope of their ability. This is not unlike criticizing a duet because it only contains two people.

In summary, common sense rule number one is to define your objectives and limit the application of work measurement only to those areas in which it can provide a means to reach these objectives.

Unfortunately, there has been considerable of the "let's try anything" approach in the area of clerical work measurement. For this reason, clerical measurement techniques have followed the path of the swinging pendulum as far as complexity is concerned. Early attempts at measurement yielded the entirely unscientific work count as the sole basis for judging performance. As an out-growth the war, we saw ever-elaborate systems of time study proposed. None of these systems really answered the needs of the clerical application.

It seems only natural, then, that ultimately there should evolve a system of measurement that would capitalize on the advantages of these various proposals and minimize the disadvantages. Such a system will be the subject of my discussion today.

Any solution worth its salt must be tailored to fit the requirements of the problem at hand. This is just as true in the design of a life insurance program or a guided missle, as it is in the design of a clerical work measurement program.

The second common sense rule of clerical work measurement is to recognize the special needs of the clerical installations. Rightly or wrongly, clerical personnel feel that their work is different, and any form of measurement is an expression of dissatisfaction on the part of management and an out-and-out attempt to undermine their status. I am sure that there are few among us who have not heard these views expressed at some time in his career.

The rights of the clerical employee and the management prerogative of control are compatible. In fact recognition based on individual contribution is the basis of our successful and long-established economic system. Acceptance of a work measurement program by your clerical people will call for an extensive program of communication and education in the principles and mutual benefits of the program. The selling of this program will test your ingenuity and may even try your patience to the breaking point. But, Gentlemen, the rewards are well worth the effort.

Having spent some time under the "clerical atmosphere", I always get a chuckle out of an incident that happened within one company.

Being an insurance company it was predominately clerical in the nature of its jobs. It had, however, some subindustries that could be likened to the machine-production type job, such as Tabulating, Carpenter Shop, Duplicating, etc.

When proposing measurement in one of these areas, I was brought to an abrupt halt by the expression of an opinion on the part of the department manager. This manager agreed that measurement might work in a strictly clerical job as I had covered around other parts of the Company, but his work was quite different and hence unmeasurable as his was a factory-type installation.

I am sure my task of convincing him that factory work would be measured will probably be not much different than your problem of convincing your people that clerical work can be measured. At least we have one thing in our favor, both types of work have been measured before.

There is a tremendous potential for cost reduction through clerical work measurement. For here is one tool that the industrial engineer can use to analyze this area of overhead which is demanding an ever-increasing portion of total operating expense.

Keeping this in mind, such remarks as the work in offices cannot be measured, as the record keeping involved is too costly, just don't make sense.

Common sense rule number three—Record keeping must be accepted as a function of good management. The more reason Management should strive to find out more about it. Work measurement should not be regarded as extra expense, but rather as an area for over-all cost reductions. In my opinion, clerical work measurement is capable of accomplishing more in highlighting areas to reduce clerical costs than any other single tool yet devised. Surely, in most instances of clerical operation, our experience indicates that a combination of good management, good personal relationships, work measurement, and recognizable reward, will result in output in excess of anything previously experienced.

But so much for the philosophy of work measurement. Now let's explore the reasons why we feel that the clerical field offers such a tremendous potential for sound measurement approach.

In an insurance operation, the product, from the measurement viewpoint, is paper work, record keeping, clerical administration, and statistical analyses. We also encourage a continual process of simplification, mechanization, and streamlining in this phase of our operation, running from design to complex electronic data processing. Our problem is hardly unique, and I'm sure it is shared by each of you—how to keep our cost down, and yet maintain high quality and service standards. For this reason, work measurement has usually been practiced in various forms and to varying degrees for some years in most insurance offices. They most often start out with clerical unit counts, no standards, progressing to broad departmental counts, no standards, then to standards derived from historical averages, then ultimately to so-call "engineered standards" based first on accepted time study techniques. Presently I lean toward an approach that melds sampling, time study, and MTM in the establishment of these standards. It might be well to mention at this point that I do not suggest the use of any one of these tools to the exclusion of all others. Each has its place, and each its limitaion. I feel that a measurement program should be tailored to fit a particular need. Unless you're aware of this need, you cannot properly evaluate any application in terms of your operation. Common sense rule number 4: *The end use of the measurement should dictate the accuracy, the extent, and the technique of measurement.*

I am not suggesting that clerical work measurement will work all the time—no man-made invention ever does. However, this is no good excuse not to get the best possible use out of this tool, and this implies at the cheapest possible cost. This is an approach that can make or break your program.

The reason a good many measurement programs get off on the wrong foot is that the measurers do not know what to measure, and what not to measure. It is not desirable to measure everything. In fact, it would be downright foolhardy to try.

There is a basic law attributed to Pareto, I believe, that roughly states that in many situations you will find that a few items account for the majority of the time or cost. Common sense rule Number 5: *Determine the important areas to control before you start measurement.*

So much attention has been directed towards the accuracy of the techniques and the derived standards of measurement we are apt to miss the forest for the trees.

Let us concern ourselves first with a very simple measure. How much time in our clerical staff *not working at all!* Actually, the greatest savings made under measurement programs result from improved utilization of time not increases in speed.

I have found the easiest way to determine the utilization of time is through work sampling. A not untypical result of a work sampling analysis is shown below:

DISTRIBUTION OF OVERHEAD WORK SAMPLE CODE SHEET

TOTAL TIME %	NOT WORKING CODE	
.73	0000	Idle - not work to do
8.21	0001	Talking - personal (including pay phones if in or visible from department)
4.01	0003	Personal - cigarettes, eating, cleaning desk, at drinking fountain, etc.
	CONFERENCE	
8.70	0002	Conference - concerning business (not including training)
	ABSENT	
9.39	0100	Not in Today - vacation and sickness
7.60	0101	Not in Department - personal (bank, rest rooms, visitors in rotunda, etc.)
	OTHER WORK	
1.18	0200	Department Telephone - company business
1.42	0201	Training
1.74	0203	Miscellaneous (JJ'2s, job description, minor special assignments, etc.)
42.98		

Work sampling can be defined as the science of drawing conclusions about a large number of work items based on the actual study of a very few work items observed at random.

As our business increases in complexity, it becomes more difficult to get the facts necessary to the analysis of our operation. This is why I feel that concept of work sampling is so important, as now we can be assured of the opportunity to find out where the opportunities for cost cutting improvements lie.

Assume we want to find out how much time a file operator spends on the various activities that make up her day, and at the same time to determine how much time it takes to file each item.

Using the work sampling approach we visit the file operator a pre-determined number of times during the day. For purposes of simplicity, let us say we make one hundred observations, though in actual practice we make between 600 and 700 per day.

EXHIBIT 1

(File Girl Study)

At the end of the day the record might read:

Task	Observations	% of Total
Filing	25	25
Sorting	20	20
Telephone	5	5
Pulling	35	35
Personal	15	15
	100	100

Now as we know the number of minutes in the working day, 450 in this case, we can readily determine how much time is consumed on each task.

Task	% of total		Min. in day
Filing	25	x	450

= Time on each task: 112.5 min.

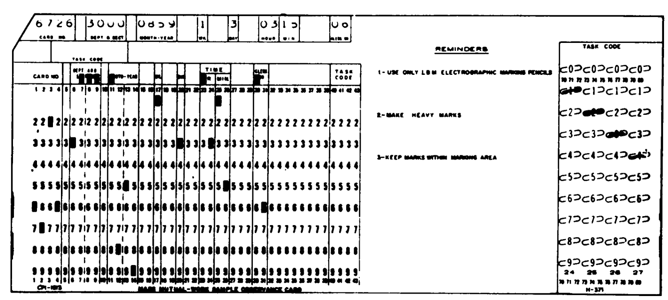
At the same time if we have kept a record of the production for the day on any task, we can determine the unit time:

Task	Time on each task		Production
Filing	112.5	÷	450 cards

= Time per unit: 0.25 min/card

The principle here is that the percentage distribution of the various elements, as they occurred during the work sample tends to equal the exact percentage distribution that would be found by continuous observation.

The key to the accuracy of sampling is in the number of observations made and how they are made. Generally, the larger the number of observations, the more accurate are the results. What we again seek is a practical balance of accuracy and expense. We use a punch card method of Sampling. That is, we have created a desk of 20,000 random time numbers as illustrated by this sample card:



WORK SAMPLE OBSERVATION CARD

The best part of this approach is that we can utilize junior college and even high school level girls to make the actual sample observations.

The unit times thus derived are then spot-checked on a time study or MTM basis to translate them to standard or levelled times. This operation is done by our higher skilled measurement analysts.

Some users of sampling advocate the practice of performance rating during the instant of observation, but we feel the use of MTM or our library of Standard Data is more accurate and, of course, permits the use of lower skills on the actual sampling phase.

As you can appreciate, the wealth of information obtained by Sampling has many other uses besides just work measurement. A few such uses are:

1. Sound basis of our Unit and Functional Cost Program
2. Means to distribute and determine the extent of our overhead
3. Means to evaluate improvements in methods or machines
4. Means to pinpoint areas for methods study

Summary of the Steps involved in establishing of a clerical Work Measurement Program.

1. Receive request for Measurement Study from Department Manager
2. Contact Department Manager to arrange preliminary orientation
3. Explain and discuss program with manager
4. Draw up a task list of operations within department jointly with manager
5. Define areas to be measured and respective staff assignments—arrange for necessary production counts
6. Schedule work sampling study
7. Orient department staff
8. Conduct sample (covers 4 week period)
9. Summarize sample and compute unit times
10. Discuss results of sample with Department Manager
11. Test sample unit times against Standard Data, MTM, etc.
12. Discuss changes with Department Manager
13. Time Study any necessary areas where agreement has not been reached
14. Obtain agreement on time values
15. Test time values and program for 6 months
16. After the test period submit this experience to Personnel to be used as a basis for preferential treatment under our company-wide merit-rating program
17. Maintain follow-up and service program

Selling Management

Work measurement, clerical or otherwise, is only a tool. It, like any other tool, will do nothing by itself. It has to be used to be effective. The actual techniques of measurement are relatively unimportant compared to the main problem of getting management to accept and use the results.

Top management support is necessary. So is a good educational program to inform all concerned, but even with all of this you need to reach your line supervision with the importance of measurement in this area.

Our approach has been to place in the supervisor's hands a distribution of salary costs among various areas of controllable overhead as found to be existing in his department during the period of the sample (shown earlier).

This perhaps is a little of the shock treatment, but our philosophy is not to criticize for past performance. We are seeing future improvement, and this report very dramatically convinces line supervision that future improvement is possible.

EVALUATION OF THE ENTIRE MEASUREMENT APPROACH

In the design of your clerical measurement program you will ultimately have to choose an approach that will embrace one of the following philosophies:

1. A program that will include the largest number of your clerical people.
2. A program that will furnish you with the maximum information about the individual.

This reduces itself to the old problem of group versus individual measurement. There are many areas in clerical installations that lend themselves to individual measurement: transcription pools, filing areas, typists, etc. However, the great majority of the clerical personnel are in the twilight zone. That is, they have some aspects of their work that can be covered, but the bulk defies easy establishment of standards; for example, jobs that require being at a location much as a secretary or receptionist, jobs that require mental determination, draftsmen, contract writers, etc. These jobs can be embraced under a group approach.

One operating philosophy has been to develop a program that will include as many of the clerical home office staff as possible under a common frame of reference. This choice has resulted in a group program tied into a merit rating program.

WAGE INCENTIVE VS. NON-INCENTIVE

Although the combination of work measurement and wage incentive has been highly successful, this does not imply work measurement by itself will not be effective. It is mostly a question of degree. Work measurement alone will not give you as startling attainments as can be realized by the addition of direct incentive payments.

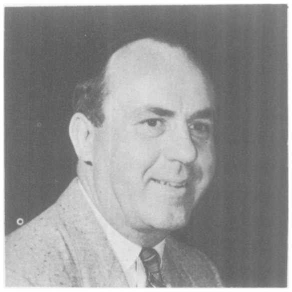
To be more specific here are a list of "gains" attributable to work measurement alone in our clerical cases.

1. More effective utilization of the working hours—oddly enough work measurement rarely increases speed. The main gain is the reduction of the non-productive time.
2. More effective staffing and distribution of workload.
3. Sounder method for the evaluation of new methods and equipment.
4. More tangible approach to the improvement of the supervisory skills of first line management.
5. Sound basis for costing.
6. Equitable method for judging group performance.
7. Aid in the training of new personnel.
8. More effectiveness in our operation.

Now let us evaluate what could be gained by the addition of wage incentive:

1. Easier acceptance and support of the people being measured.
2. Eliminates the pseudological reasons measurement won't work expressed by some measured personnel. Under incentive they want it to work.
3. In general, wage incentive will almost double any gain to be had from pure work measurement.

It is pretty difficult to summarize a philosophy (and to be successful, clerical work measurement must be an accepted philosophy) in this length of time. However, our experience indicates that a clerical operation can and should be measured and as an organization gets more complex, there is all the more reason why it should investigate clerical work measurement. We don't propose to have all the answers, but what we have seen of this tool as an aid to the management leads us to believe its application is only limited by your imagination.



CAN YOU MAKE YOUR STAFF PAY ITS WAY AND HOW CAN YOU TELL

W. W. Whitlinger
Manager of Professional Services
Kimberly-Clark Corporation
Neenah, Wisconsin

I am very happy to be invited to your Industrial Engineering Institute. For several years I have seen and been impressed by the Institute proceedings. This is my first opportunity to attend, and I must say that it has lived up to all of my anticipations. The level of interest, the attendance and the caliber of the individuals attending are certainly the best testimony to the stature and contribution of the Industrial Engineering Institute.

Your Committee has asked me to talk about "How Can You Make Your Staff Pay Its Way and How Can You Tell." Believe me, I feel somewhat inadequate as I face you with this subject this afternoon. However, several AMA seminars and a close association with the Industrial Management Society's seminar, Effective Techniques For Industrial Engineers, over the last three years and being over 50 miles from home may qualify me. Much that I will say this afternoon is not new. However, I have attempted to put it in a form that will be interesting and helpful to all of you.

But in a more serious vain, the topic also reminds me of a picture puzzle which I have used for years (Fig. I). How many of you have seen this? Will those of you that have seen it keep it to yourselves for a minute or two? How many of you (those who haven't seen it) can recognize a cow? (Time to assist the group in the identification and recognition of the cow in the figure.) Perhaps making your staff pay is a bit like the cow. Until you can identify the nature or form of the need, it is confusing or frustrating to say the least. Once you see or feel the need and approach, you wonder how you ever missed it.

Many of us are more aware than ever before of the research and the seminars being conducted and the articles and the books being written today on the subject of management and management improvement. Seminars like AMA, AIIE, IMS, your own Industrial Engineering Institute and others are being conducted all over the country. Books like "The Practice of Management" by Peter Drucker, "Developing Your Executive Skills" by Auren Uris, "Successful Executive Action" by Edward Schleh have been appearing almost monthly.

All of these are symptoms of the recognition and development of managing as a profession. The recognition and development of managing as a profession is, in my opinion, one of the real break-throughs of the Fifty's.

I feel that what we have seen is just the beginning. New and better management research, even more productive seminars and more practical and adequate books and articles are on the horizon.

We could spend the rest of the week talking about the many ways to make your staff pay its way, and each and every topic would be important and of value. However, with your permission this afternoon I would like to provide

How long will it take you to SEE
the COW in the above picture?

Figure 1

some ideas and inspiration about managing or the management of your staff which when mixed with real desire and perspiration can make you and your staff more effective. The ideas and inspiration will include the following:

1. A highlight summary of the elements of management.
2. Some ideas and sources of information which may aid you in appraising the progress and success of your staff.
3. An effort to encourage you to search out, get to understand and apply the modern principles and practices of managing.

What is management? Some people would define management as the use of resources and skills in an economic environment for the purpose of making a profit. Other people think of management as the upper echelon of an industrial hierarchy. Today I will be using the words management and managing as synonyms. In the broad sense, management is the judicious use of means to accomplish an end.

A few years ago, "Modern Industry" printed an excellent article written on "The Meaning of Control" written by Douglas Sherwin of the Phillips Chemical Company.

HOW CAN YOU MAKE YOUR STAFF PAY ITS WAY

Elements of Management Concept - Management is both art and science. Much has been written and said about management. Unfortunately, a great deal of this has concerned itself with why, when, how, where, and with whom management manages. There is also another body of knowledge that deals extensively with the experience, ability and skills required in management men. Still more confusion has been contributed by specialized management, emphasizing the management of various industrial functions. Here the emphasis has been on the technical skills required to manage that function, rather than management skills.

This afternoon we will deal exclusively with what management does. We will outline and describe the elements of management.

Figure 2, below, lists *Some Functions of Industry*. The functions might have been listed in much more detail, or they might have been condensed more generally.

Functions have been listed to emphasize the difference between them and management. This confusion of function with management is widespread. Some functions apply to all other functions. This overlap contributes to the function-management confusion. For instance, financial budgeting applies to all other functions, as does cost accounting. Purchase of materials and plant design apply to large groups of other functions.

All functions must be performed, each in its proper way and at its proper time. All functions must also be managed. Management is common to all functions. The kind and scope of management required change with the function. The basic art and science are unchanged.

Figure 3, on the following page, lists the *Elements of Industrial Management*. There are eleven of them:

1. Objectives
2. Policies
3. Programs
4. Organization
5. People
6. Economics
7. Facilities
8. Knowledge
9. Activities
10. Conformance
11. Corrections

Figure 3 also shows for each element a key question and a definition designed to communicate its concept.

The "Elements of Management" are unavoidably a mixture of things, actions, and thoughts. This list of Elements of Management is by no means original. They have been taken from the work of many authors and speakers. If there is any originality, it is because the list is orderly and logical.

Following is a brief description, definition, and discussion of each element of management.

FIGURE 2

Some Functions of Industry

Product Design	Plant Maintenance	End Use Survey	Employee Relations
Process Design	Warehousing	Shipping	Job Evaluation
Plant Design	Storage	Receiving	Setting Wages & Salaries
Plant Construction	Cost Estimating	Route Planning	Office Services
Purchase of Equipment	Pricing	Invoicing	Design of Forms
Production Scheduling	Direct Mail Advertising	Collecting	Social Benefits
Purchase of Materials	Convention & Exhibit Promotion	Banking	Process Control
Recruiting	Space Advertising	Disbursements	Material Inspection
Hiring	Credit Extension	Cost Accounting	Production Inspection
Placement	Provision of Capital	General Accounting	Financial Auditing
Training	Calling on Trade	Insurance Exposure	Financial Budgeting
Machine Tending	Quoting Price	Purchase of Land	Time Study
Processing	Getting Orders	Estimate Taxes	Motion Study
Finishing	Servicing Customers	Corporate Affairs	Woods Operations
Converting	Distribution Analysis	Community Relations	Pulpwood Scheduling
Packaging			

FIGURE 3

Elements of Industrial Management

Elements	Definitions	Key Questions
1. Objectives	PURPOSE of activity.	What must the work accomplish?
2. Policies	GENERAL RULES for guiding and restricting activity.	What decisions are needed to guide the work?
3. Programs	COMPREHENSIVE PLAN of activity.	How and when will the work be done?
4. Organization	IDENTIFICATION, definition, grouping and assignment of activities.	How will the work be divided?
5. People	REQUIREMENT, provision and renumeration of individuals needed for activity	Who will do the work?
6. Economics	REQUIREMENT, justification and provision of money needed for activity.	Is money available and the work profitable?
7. Facilities	REQUIREMENT AND PROVISION of physical things needed for activity.	What will the work be done with?
8. Knowledge	CONCEPTS, principles and methods needed for activity.	What "know-how" is needed to do the work?
9. Activities	ACTIONS necessary to accomplish.	What action is needed?
10. Conformance	ESTABLISH STANDARD, measure actual and report difference for activity.	What are the differences between what should be done and is being done?
11. Correction	EVALUATE DIFFERENCES, identify causes, develop alternatives, recommend or take action.	What changes are needed?

1. *Objectives - What must the work accomplish? - Purpose of Activity.*
Regardless of how big or small any task is, it is obvious that its purpose must be defined and understood. What must the work accomplish? A floor sweeper has the objective to clean a certain floor. The objectives a Corporation had in mind when purchasing another Company may be the acquisition of certain new products and technology, additional competent personnel, and certain physical facilities.

2. *Policies - What decisions are needed to guide the work? General Rules for guiding and inspecting activity.*
Whether policies are written or unwritten, they exist in all areas of corporate activity. Policy, in effect, is a decision made to do or not to do something. To the extent that the decision made influences similar decisions in the future. It constitutes policy. Policies provide broad guidance to top, middle, and supervisory management in the performance of their assigned responsibilities. Procedures are merely the best method of practicing policy. Systems are groups of procedures. Rules are very specific procedures. A "No Smoking" sign in a certain mill or office area is a specific prohibition based on policy. Within what framework will the work be done? Policy provides the framework. Centralized control, the unwillingness of general management to delegate authority to make final decision, requires comprehensive and definitive statements of policy. Policy permits all members of the organization to have common goals and common understandings of limitations on their authority.

3. *Programs - How and when will the work be done? - Comprehensive plan of activity.*
As we move down the management chain of command from general to division management, authorized objectives and policies take tangible form as programs, plans and schedules. Corporation programs to be operable must be decentralized; executing a given objective and policy may require programs and schedules in many areas. The work may have to be programmed in great detail for production employees. The integration of these many and varied programs into total corporate programs to accomplish overall objectives within authorized policies is one of the major activities of central management staff personnel. How and when will the work be done?

4. *Organization - How will the work be divided? Identification, definition, grouping and assignment of activities.*
Since more than one person is required for most projects and programs, the problem of how to divide the work is a prime management responsibility. What activities must be performed? Which must be delegated? Which reserved? How shall the responsibilities be grouped by division, by department, by position, for maximum effectiveness? What relationships shall be established, formally and informally? The structure of the organization defines the work delegated to people. Organization

always exists, whether it is formal or informal, defined or undefined, written or unwritten.

5. *People - Who will do the work? - Requirements, provision and remuneration of individuals needed for activity.*
   In theory, once objectives, policies, and programs are decided and an organization structure created, people must be found to fill the various positions. The interaction in the practical world in which we live between people and organization structure has been, is, and no doubt will continue to be a source of major concern and confusion to all kinds of management. It's been said many times that the art of handling people is the principle tool of management. In any event, the farther up the management hierarchy an individual goes, the more he finds himself working with people and ideas and the less with tangibles like materials, equipment, and product. Who will do the work? People make the program or the corporation. Management must select, train, place and direct them.

6. *Economics - Is money available and the work profitable? - Requirement, justification, and provision of money needed for activity.*
   Since one, if not the prime reason, for a corporation to be in business under a free enterprise system, is profit, it is obvious that one of the major elements of management is economics. Is money available? Is the work profitable? How are the costs and prices? Do income and expense balance favorably?

7. *Facilities - What will the work be done with? - Requirement and provision of physical things needed for activity.*
   The actual use of the Corporation's facilities is delegated to managers and employees down the chain of command. Providing these facilities is a management responsibility. Strictly speaking, people and economics are also facilities. This is one reason why Figure 3 is called the "Elements of Management." What will the work be done with? Which products shall be made for what markets, using which materials, equipment, etc.? Facilities are the tools of a project or a business. Management must supply them.

8. *Knowledge - What know-how is needed to do the work? - Concepts, principles and methods needed for activity.*
   It is obvious that knowledge is needed to manage as well as to perform any work or activity. Management knowledge as well as functional knowledge are required. We are talking here primarily about kinds of management knowledge. Functional knowledge is the concepts, principles and methods employed by various professional specialists, such as lawyers, accountants, engineers, scientists, physicists, etc., etc.

9. *Activities - What action is needed? - Actions necessary to accomplish.*
   A list of *activities* is included in Figure 4, following. Management must take action or make sure action is taken. Everybody in a Corporation, whether management or not, is actively doing something. Research, production and sales personnel at the end of the chain of command are actually operating or performing functions. The same is true of many people located at the Central Office. People in Engineering are actually performing certain plant design functions. People in Technical Research are performing product or process development, etc., etc. All of the activities in Figure 4 apply to the Functions of Industry listed in Figure 2. They also apply to the Elements of Management in Figure 3. General management delegates to specialists the activities of initiating, developing, and recommending objectives, policies and programs, with respect to organization, personnel, economics, facilities, etc. General management also delegates to other personnel the activities of establishing, supplying, directing, and performing authorized objectives, policies, and programs having to do with organization, personnel, economics, facilities, etc. Many more examples could be given to illustrate the activities of management that apply to all of the "elements" for a function. What action is needed? What management action is needed?

FIGURE 4

Some Activities of Industrial People

1. Initiate	8. Provide
2. Develop	9. Direct
3. Advise	10. Operate
4. Recommend	11. Audit
5. Approve	12. Analyze
6. Authorize	13. Correct
7. Establish	14. Represent

10. *Conformance - What are the differences between what should be done and is being done? - Establish standard, measure actual, and report difference for activity.*
    The word "control" is sometimes used as a synonym for "conformance." Unfortunately, "control" is badly abused in management semantics. It has been deleted from our Glossary of Terms except as a noun. "Conformance" is intended to describe the actions of (1) establishing standards of conformance required, (2) gathering performance information, and (3) reporting the difference between standard and actual. What are the differences between what should be done and is being done? It is obvious that management must know this to determine the adequacy of all other elements of management.

11. *Corrections - What changes are needed? - Evaluate differences, identify causes, develop alternatives, recommend or take action.*
    Correction has been separated from conformance, since in many organizations many corrections are organizationally separated from related conformance. It is insufficient to observe differences between actual and standard. Why did they occur?

What do they mean? What changes are needed? - Changes to objectives, policies, programs, organization, personnel, economics, facilities, activities and conformance. How should goals and performance be reconciled?

Application of Elements of Management Concept - Now let's apply the elements of management to a *Cost Reduction Program* - a program with which many of you may be or may have been involved. We must first establish *objectives,* or what the program must accomplish. First of all, we're trying to reduce corporate cost per unit of product.

We then need some *basic decisions* on how to go about this program. Will the program involve the entire payroll? Will it require money, and if so, what kind of money are we talking? Are we talking $100, are we talking a few thousand dollars involved in our contests, in our materials, in the time spent in crew meetings, etc.? Who will carry the lead role? Will it be the supervisor or will it be a staff agency? What will be the relationship of the staff agency? Some other basic decisions must be made. Are high cost operations to be investigated? If so, by whom? What would be the role of the union? These are basic decisions that we might frame up as *program policies.*

Specifically, what *projects,* or *sub-programs,* will be required for the cost reduction effort? Certainly we can name a few: monthly crew cost reduction meetings, staff and mill cost reduction reports, Methods Improvement Committees at the departmental and mill levels. Each of these sub-programs must be set up on a sustained basis and perpetuated.

How will the *work be divided?* Who will formulate the policies? Who will authorize policies? Who will develop the promotional materials? Who will actually carry on the program with the crews involved? Who will take the lead in the analysis of high cost operations? Who will summarize and report progress? Who will counsel and advise? Who will do all of these things? Of course, when we say "who," we mean "what groups or areas?"

Once we have gotten the groups, what specific individuals *will actually perform the work?*

The *economics* of the program become quite obvious when we start thinking of the amount of money required for the consulting, the straight time and premium time paid for meeting attendance, the promotional-material expenses, the professional time required, and the money required to make changes. Will the program pay off?

What *specialized know-how* is needed to do the work? Every foreman may be well skilled in the functions of his job, but is he a salesman for cost reduction? Can he put it across to his crew - the need for them to work effectively, not for the company only but for their own well-being and for the welfare of their families.

What *physical facilities* are needed to do this cost reduction job? Some units may be somewhat restricted in their promotional facilities. They have no auditoriums and very small conference rooms. They may have a minimum of promotional materials, literature or projection materials (equipment for films, film strips, etc.). The proper Industrial Engineering equipment - cameras, projector, manpower, etc. - may not be available. "What facilities are needed" may be a "make or break" consideration for a successful Cost Reduction Program.

Have we good *follow-up* and *reporting* cost reduction possibilities? What assurance do we have that when method improvements are reported and recommendations are made, that *corrective action* has been taken? What follow-up is there of that action?

As you can see these elements of management can be applied to any specific project or sustaining function.

We feel all individual and group effort should be "managed" - a project, a program, a function, a department, a division or corporation. As a matter of fact, I have used this philosophy and approach on church programs and Boy Scout projects with excellent success. The "elements" tick off factors to be developed and implemented no matter what the area of endeavor.

HOW WILL YOU KNOW

I am sure many of you have been looking forward to the second part of my topic with great interest - "How will you know?" I wish I could hand you a thermometer or a pat formula. It isn't that simple. A doctor uses the thermometer to provide data for diagnosis of a current situation and recognition of subsequent changes. But even the doctor must use many other sources of data in his examination - your throat, your lungs, your eyes, etc.

Many of us are searching for the magic number or ratio to determine, or prove, how our staff is doing. I feel that there is not just one number or one source. In the fields of safety, quality, profitability, etc., we find that a single index, number or ratio is generally inadequate. Likewise, in attempting to determine whether or not your staff is paying its way, some of us feel that this the single number hope is about as futile as the search for the fountain of youth.

Before I suggest some information that may "help you know," I want to ask a few pertinent questions:

1. Do you want to know or do you want your boss to know?
2. Do you have to know, really know, before you can tell your boss?
3. If you make your staff really pay, will you have to tell your boss? or will others do it for you?
4. Do you feel that "help you know" information is readily available?
5. Why don't more managers systematically collect and evaluate "help you know" data?
6. Is your organization and situation different?
7. Is it likely that you may require a particular type and amount of information?

With that preface I would like to mention a few sources of information.

First, the number and type of projects or requests for service. You may feel you know what you and your staff personnel are doing. The analysis of this kind of data has never failed to reveal some very soft spots. Figure 5 shows this kind of summary.

Figure 5.

1. From whom
2. For what
3. Nature of request - high effort, high payoff - low effort, high payoff, etc.
4. What competence and techniques are involved.

This analysis provides clues to your strong customers and your weak ones, your strong suit as far as type of problem and competence and your weak ones. Careful study of this base data and trends certainly provides basic managing information. And I might add that, if properly designed, a system to produce and maintain this information does not have to be costly.

Another excellent source of information is the use being made of the output from your staff. Is your work contributing to tangible savings. Are the results of your work quoted in meetings? Do the results of your work appear in reports and recommendations? If other people are really "using" your work, it is probably paying its way.

Another "sign of acceptance" which you shouldn't miss is the support of your associates. What is their attitude and working climate? Genuinely friendly - cooly cooperative or just sociable? What about their physical proximity to you? Do you see them often during work? Outside of work? If so, why? If not, why not? What about the mental proximity of you and your associates? Do you find yourself arguing with them "about the principle?" Or do they nod their heads when you talk? Why? The answers to these and other similar questions may tell you much about how you and your staff are doing and why.

Your boss is one of the best weather vanes. If you find yourself frequently arguing about the content and scope of your program, you probably aren't paying off - at least as well as he would like. Is your budget approved or slashed? What about the salary increases for your people? Are they readily granted or are they not? Do they give you clues? You bet your boots they do. But it requires you to diagnose the "case" and try some "cures."

The attitude and working climate of your people is also a pretty good indication of whether or not your staff is paying its way. Job security, a feeling of belonging and job satisfaction are pretty real and more often than not, outwardly obvious. Interest, enthusiasm and innovation certainly tell a story, and the lack of these may very well tell a different story.

Recognition of competence is an indicator. A demand for your deputies inside the companies or outside the companies is, I believe, a good sign. Invitations to speak, write articles, serve on industry or professional committees are a measure of acceptance and recognition.

Excellent information about staff acceptance and contribution can be obtained, I am told, by depth interviewing a random sample of in-plant people. I have not used this technique, but people using it recommend it highly.

There are, I am sure, many other excellent approaches and sources. Time and lack of my own personal experiences have prompted me to stop here.

I have not told you what you should use or how to derive it. Nor have I answered all of the questions I posed. I don't believe I could or should. This is where you take over. Like the football coach, the sales manager or the politician, the manager of staff activity must decide which information he needs and how he can best go about getting it. This may sound like an over simplification, but it has been my experience that once you are aware of a need and have the will, the way can be found.

This afternoon we have taken a quick look at the elements of effective management which, if used, can make your staff pay its way and some thoughts about how you can appraise your position and progress. The profession of management has great depth and breadth for exploration and application. Your particular management improvement plan must be fashioned to fit your situation, your people and your timing. If you are interested, and I hope you are, in further pursuit, the ways and means are available - the books and brochures, the professional societies and meetings, the institutes and seminars, the experience of others and consultants all provide a wealth of technical and practical know-how. However, management improvement is much like personal development; it must be self generated. Each of us must recognize the need and generate a genuine desire to manage more effectively.

As the motto of a famous religious group states, "Better to light one candle than to curse the darkness." I wish you conviction, courage and the best of luck.

RESEARCH SESSION

Three research papers were presented at the Institute by students of Industrial Engineering at Berkeley.

I. OBSOLESCENCE AND ECONOMIC LOT SIZE

by Alan J. Gradwohl

The role of obsolescence in determining economic lot size is investigated by introducing a probability function of lifespan. The conventional formula for economic lot size is modified in a simple way showing that under many circumstances the economic lot size may be approximately one half that used without considering obsolescence.

(See "Obsolescence and Economic Lot Size" by R. C. Grassi and A. J. Gradwohl in the Journ. of Ind. Engr. Sept-Oct 1959 Vol. x, No. 5)

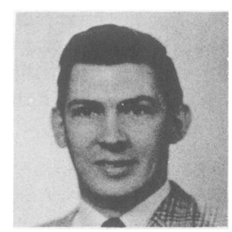
II. WORK MEASUREMENT PERFORMANCE RATING UNDER RHYTHMIC DISTURBANCE CONDITIONS

by Charles Schlegel

Groups of matched, experienced time study engineers were experimentally trained by conventional and special training and all groups were tested in performance rating under disturbance conditions.

III. AN ANALYTICAL STUDY OF FACTORS USEFUL IN EVALUATING JOB DESIGNS

by Richard Werling



Enlarged skilled and unskilled jobs were analyzed and a questionnaire study of the job content of workers was undertaken. Job factors which correlated with quantitative performance criteria were identified.

LOS ANGELES FILM SHOW

I. THE FOREMAN DISCOVERS MOTION STUDY

II. INTRODUCTION TO WORK SAMPLING

III. ESTABLISHING WORK STANDARDS BY SAMPLING

IV. ONE HOE FOR KALABO

V. THE INFORMATION MACHINE

ROSTER OF ATTENDANCE

BERKELEY

ABBOTT, G. R.
Fairchild Semi-Conductor
Burlingame

ABRAHAMSON, Warren D.
Mare Island Naval Shipyard
Vallejo

ACKER, Gale
Crown Zellerbach Corp.
San Leandro

ADAMS, J.
Continental Can Co., Inc.
Oakland

ANDERSON, John H.
Connor Spring Mfg. Co.
San Francisco

ARAGON, Errol F.
Supervisory Budget Specialist,
Overhaul and Repair Department
Naval Air Station
Alameda,

ARVIDSON, Dean B.
Norton Co.
Santa Clara

ASHLEY-WING, H. Henry
Friden, Inc.
San Leandro

ASKINS, Harold H.
Lockheed Time Standards Eng. Sr.
El Cerrito

BAIN, W. D.
Friden, Inc.
San Leandro

BALL, William H.
Asst. Plant Manager,
Tri Valley Packing Association
San Francisco

BARDEN, B. J.
IBM
San Jose

BARKER, G. H.
Southern Pacific Company
San Francisco

BARNES, Martin
Industrial Indemnity
San Francisco

BARNETT, William A.
McClellan Air Force Base
Sacramento

BARRETT, Jack K.
Armco Drainage & Metal Products, Inc.
Berkeley

BASTOW, Paul
Hewlett-Packard Co.
Palo Alto

BITTER, Jan
Schlage Locks
Burlingame

BOCK, William K.
Campbell Soup Co.
Sacramento

BOSSERT, Lt. Richard W.
Deputy Director, Management
HQ. WADF; USAF.
Hamilton AFB

BOYD, James S.

BRANAHAN, James
Fibreboard Paper Products Corp.
Antioch

BRANDT, Robert G.
NAS Alameda
Berkeley

BRAY, Charles M.
Connor Spring Mfg. Co.
San Francisco

BROWN, Arthur H.
Sacramento Signal Depot

BROYLES, C., Sr.
Columbia-Geneva Steel
Pittsburg

BRUMBAUGH, George U.
Peterbilt Motors Co.
Oakland

BRUNTON, Charles W.
Administrative Services Officer
Overhaul and Repair Department
Alameda

BUCHLI, E. A.
United Air Lines
San Francisco

BURKE, Maurice
Crown Zellerbach Corp.
Antioch

2 Representatives
California Spray-Chemical Co.
Richmond

CALLERORS, Charles
Sacramento Freezers, Inc.
Sacramento

CAMPBELL, Earl G.
Monadnock Mills
Oakland

CAROE, K.
Hexcel Products, Inc.
Berkeley

CARTER, Neil
Temescal Metallurgical Corp.
Richmond

CASADE, A. B.
Lockheed
San Mateo

CAVANAH, J.
Columbia-Geneva Steel
Pittsburg

CHEW, Roland
Cutter Laboratories
Berkeley

CHRISTMAN, R. H.
S. F. Naval Shipyard
San Francisco

CLARK, J.
Columbia-Geneva Steel
Pittsburg

CLEARY, Frank J.
Solid Rocket Plant,
Aerojet-Gen'l Corp.
Sacramento

CLEMONS, Harry
Military Sea Transportation
Service - Fort Mason
San Francisco

CLOW, Wallace F.
Tri Valley Packing Association
San Francisco

COLBURN, A.
Div. Staff Industrial Engineer
Libby, McNeil and Libby
San Francisco

COLLINS, Creigh W.
Sacramento Signal Depot
Ioni

CONTON, Lee
Nat'l Seal Div.
Redwood City

COX, H. A.
Mgr., Industrial Engineering
Libby, McNeill and Libby
San Francisco

CRIMMINS, John B. Jr.
Supervisory Methods & Standards
Spec., Overhaul & Repair Dept.
Naval Air Station,
Alameda

CROCKER, Angus M.
Lenkurt Electric Co., Inc.
San Carlos

DAILEY, Patrick D.
Lockheed
Woodside

DAHL, Osborne H.
Mare Island Naval Shipyard
Vallejo

DANIEL, Jim
Naval Supply Center
Oakland

DAVIS, W. E.
United Air Lines
San Francisco

DEROMEDI, Frank D.
Production Superintendent
Cutter Laboratories
Berkeley

DEWBERRY, D.
Columbia-Geneva Steel
Pittsburg

DI CROCE, N.
United Air Lines
San Francisco

DIEM, Fred
M. Greenberg Sons, Inc.
San Francisco

DODDS, J. W.
Lockheed
San Jose

DONNALSON, Clyde
Benicia Arsenal
Benicia

DOSTER, Kenneth H.
Fairchild Semiconductor Corp.
Mt. View

DOUD, David
Doud Lumber Co.
San Jose

DOWS, R. N.
Aerojet-General Nucleonics
San Ramon

DRYER, Pat A.
Mare Island Naval Shipyard
Vallejo

DUNMIRE, Paul G.
Craigh, Dunmire & Associates
Oakland

DWYER, Joseph S.
Continental Can Co.
Stockton

EGGLESTON, Douglas
Marchand
Oakland

EHLERS, Jack K.
Fairchild Semiconductor Corp.
Mt. View

ELSWOOD, R. G.
Lenkurt Elec. Co.
San Carlos

EMBRY, Gavin
Pacific Coast Engr. Co.
Alameda

EMERY, Ronald
Lockheed Aircraft Corp.
Sunnyvale

EPHRAIM, F. G.
United Air Lines
San Francisco

ERNEST, A. R.
Solid Rocket Plant
Aerojet-Gen't Corp.
Sacramento

EWING, Paul C.
Admin. & Planning Div. Officer
Supply Department
Naval Air Sta., Alameda

FEIFERT, Edward A.
F.A.B. Mfg. Co., Inc.
Oakland

FEITEN, W. P.
United Air Lines
San Francisco

FERRIS, G. B.
East Bay Municipal Utility District
Oakland

FERRITER, W. S.
Hexcell Products, Inc.
Berkeley

FICALORA, P. J.
IBM
San Jose

FISHER, B. B.
Fibreboard Paper Products Corp.
Stockton

FORREST, Norman P.
S.F. Naval Shipyard
San Francisco

FRANKLIN, D. W.
Colgate Polmolive
Berkeley

FRASER, Arthur G.
Supervisory Electronics Engineer
Overhaul & Repair Department
Alameda

FRATUS, R. A.
Kaiser Aluminum & Chemical Corp.
Oakland

FROST, J. R.
C. & H. Sugar Refining Corp., Ltd.
Crockett

FULLER, G. W.
W. P. Fuller Co.
San Francisco

GILES, Edmund N.
Simpson Redwood Co.
Aracata

GILICKA, S.
Caterpillar Tractor Co.
San Leandro

GLUCK, Jerome
Lockheed
Sunnyvale

GREEN, Jack H.
American Smelting & Refining Co.
Selby

GREENBERG, John M.
M. Greenberg Sons, Inc.
San Francisco

GREENBERT, Stuart L.
M. Greenberg Sons, Inc.
San Francisco

GRIESCHE, Robert B.
Henningsen & Associates
Berkeley

GRIFFITH, Jack E.
Supervisory Management Analyst
Overhaul and Repair Department
Alameda

GYARMATHY, Joseph
Office Services Mgr., Admin. Dept.
Naval Air Station
Alameda

HAILEY, S. H.
Kaiser Aluminum & Chemical Corp.
Oakland

HALL, W. B.
IBM
San Jose

HAMMOND, Gordon
Ampex Professional Products Co
Redwood City

HANNAH, John
Fenestra, Inc
Oakland

HANSEN, Jim B.
Industrial Engineer, Overhaul
and Repair Department
Alameda

HARE, Vern
Falstaff Brewing Corp.
St. Louis 10, Mo.

HARMER, Geoffrey L.
USAF
Sacramento

HAWE, William B.
Metropolitan Furniture Mfg. Co.
San Francisco

HECHINGER, B. L.
United Air Lines
San Francisco

HEINLE, Lawrence W.
Kaiser Aluminum & Chemical Corp.
Oakland

HELM, Jack E.
Production Sup't., Fulham Bros.
of California
Santa Rosa

HENICH, J. Dry
Columbia-Geneva Steel
Pittsburg

HENNINGER; Larry E.
Philco Corp.
Palo Alto

HEPPE, C. James
Johns-Manville Prod. Corp. of
California
Stockton

HERBERT, R. W.
E. I. duPont de Nemours & Co.
Antioch

HIBBARD, Frank E.
Harron, Rickard & McCone Co.
San Francisco

HINSINGER, Harold W.
Avionics Div. Superintendent,
Overhaul & Repair Dept.
Alameda

HODSON, Robert W.
Industrial Engineer, Tri Valley
Packing Corp.
San Francisco

HORST, James A.
Moore Business Forms, Inc.
Emeryville

HORTON, Murray D.
Hewlett-Packard Co.
Palo Alto

HOSKINS, Donald L.
Lafayette

HOWELL, Robert P.
Standard Oil Co. of California
San Francisco

HUBERMAN, S. Arnold
Industrial Engineer, Overhaul
and Repair Department
Alameda

HUEBNER, H. R.
Pacific Vegetable Oil Corp.
San Francisco

HUSSEY, J. E.
Production Engineering Dept.
San Leandro

HYDE; D. M.
Aerojet-General Corp.
Sacramento

IRWIN, R. D.
Rheem Manufacturing Co.
Richmond

JACOBI, Gerald
Coast Mfg. & Supply
Livermore

JENSEN, John L.
Asst. Shops Group Superintendent
Overhaul and Repair Dept.
Alameda

JESSE, William A.
Westvaco Mineral Products Div. - FMC
Newark

JETER, Donald
Maxwell House
San Leandro

JOHNSON, A. W.
Ralston Purina Co.
Stockton

JOHNSON, Robert L.
Lockheed
Santa Clara

JONES, E. O.
The Standard Register Co.
Oakland

JONES, Wilbur W.
AIIC
Pittsburg

JOSSELYN, P. Dudley
Food Machinery & Chemical Corp.
San Jose

JURCZENIA, Edward
Circus Foods
San Francisco

KAHN, Roy
Yale & Towne Mfg. Co.
San Leandro

KEMP, Robert M.
Philco Corp.
Palo Alto

KEYES, W. R.
Underwriters Lab
Palo Alto

KINNEY, Charles
Line Material Industries
Visalia

KOENINGER, W. M.
The Clorox Co.
Oakland

KOBRIN, Donald
Fairchild Semiconductor Corp.
Mt. View

KRAXBERGER, Douglas
Ralston Purina Co.
Stockton

LASHBROOK, Thomas S.
Owens Illinois Glass Co.
San Francisco

LAUGHLIN, Alvin
Electro Engineering Works
San Leandro

LAURSEN, Milton
Marchand Corp.
Oakland

LEE, H. J.
Lockheed Aircraft Corp.
Sunnyvale

LEHTIN, Laurie L.
Tri-Valley Packing Association
Secretary & Prod. Mg.
San Francisco

LEITNER, R. T.
American Pipe & Const. Co.
Hayward

LePAGE, Don S.
Work Analyst, East Bay Municipal
Utility District
Oakland

LESCHYN, E. C.
Maintenance Base, United Air Lines
San Francisco

LOUGHLIN, John
Ampex Data Products Co.
Redwood City

MACKAY, Hugh (Capt)
USN
San Francisco

MACKEY, G. L.
Maintenance Base, United Air Lines
San Francisco

MANGELS, Warren H.
Digital Computer Systems Mgmt.
Analyst, Overhaul & Repair Dept.
Alameda

MANUS, Edwin R.
Norton Co.
Santa Clara

MARINGER, Larry
S.F. Naval Shipyard
San Francisco

MARMONT, C. Joseph
Ampex Corp.
Redwood City

MARTIN, Edgar
Customer Services Research
Bank of America
San Francisco

MARX, John B.
Ampex Corp.
Redwood City

MASCARIN, A. E.
Colgate Polmolive Co.
Berkeley

MATHEWS, Howard H., Jr.
Ampex Data Products Co.
Redwood City

MATLOCK, Kern T.
Fibreboard Paper Products Corp.
Antioch

MC CORMICK, G. H.
U.S. Navy
Alameda

MEYER, Jack
Procter & Gamble Mfg. Co.
Sacramento

MEYERS, Dan
The Standard Register Co.
Oakland

MICHAEL, Gene D.
Connor Spring Mfg. Co.
San Francisco

MICHELSON, L. D.
Western Pacific RR Co.
Sacramento

MILLARD, Robert I.
Lockheed MSD
Sunnyvale

MILLER; Howard A.
Lenkurt Elec. Co.
San Carlos

MIRKO, Bryce M.
Supervisory Prod. Control Specialist,
Overhaul & Repair Department
Alameda

MONCRIEFF, Robert E.
McClellon AFB
Citrus Hgts.

MOORE, William J.
Assist. Control Division Officer
Supply Department
Alameda

MORAN, David H.
Industrial Engineer,
Aerojet-General Nucleonics
San Ramon

MORRISON, W. R.
United Air Lines
San Francisco

NAPOLI, Robert L.
Moore Business Forms, Inc.
Emeryville

NODEN, Roger
Calif. State Dept. of Education
San Francisco

NORDAHL, James D.
Coast Mfg. & Supply Co.
Livermore

O'FARRELL, Sean
Fibreboard Paper Products Corp.
Stockton

OLDHAM, J. R.
Mgr. Industrial Dynamics
Hughes Aircraft
El Segundo

OLDHAM, M. E.
Caterpillar Tractor Co.
San Leandro

O'NEIL, E.
Columbia-Geneva Steel
Pittsburg

ORR, W. F.
Basic Vegetable Products, Inc.
Vacaville

OWENS, Ernest M.
Management Analyst, Supply Dept.
Alameda

PARKER, Wendell R.
Cutter Laboratories
Berkeley

PARVIN, Robert
Bechtel Corp.
San Francisco

PAVACK, T.
Caterpillar Tractor Co.
San Leandro

PEAL, Marshall
Benicia Arsenal
Benicia

PETERS, Frank W.
Bemis Brothers Bag Co.
San Francisco

PETRIS, Gus C.
Moore Business Forms, Inc.
Emeryville

PFEFFERLE, J. T.
Production Engineering
San Leandro

PHILLIPS, Albert P.
Malsbary Manufacturing Co.
Oakland

PIZZI, Joseph, Jr.
Johns-Manville Prod. Corp. of
Stockton

PROSSER, Stanley
The Pacific Coast Co.
Sonoma

PURCELL, Charles W.
Bank of America NT & SA
San Francisco

PYTEL, Leonard P.
San Francisco Naval Shipyard
San Francisco

QUICK, Don
The Standard Register Co.
Oakland

RAGGIO, R. A.
San Francisco Naval Shipyard
San Francisco

RAMSEY, Lesle J.
Electro Engineering Works
San Leandro

RAY, Charles H.
Supervisory Electronic Engineer
Overhaul & Repair Department
Alameda

RAYMER, Robert L.
San Francisco Naval Shipyard
San Francisco

REARWIN, W. Heath
Friden, Inc.
San Leandro

REED, E. W.
National Seal Co., Inc.
Redwood City

REGUL, Tom
Fairchild Semiconductor Corp.
Mt. View

REYES, E.
San Francisco Naval Shipyard
San Francisco

RHOADES, Russell H.
Sylvania Elec.
Mt. View

RICHARDS, Lionel W.
Bercut-Richards Pack. Co.
Sacramento

RIORDAN, J. A.
Columbia-Geneva Steel
San Francisco

RITTER, James R.
District Public Works Office
San Bruno

ROBINSON, Chad
The Procter & Gamble Mfg. Co.
Sacramento

ROBINSON, W. E.
Friden, Inc.
San Leandro

ROCK, William A.
Gerber Products Co.
Oakland 3

RODGERS, J. F.
Colgate Palmolive Co.
Berkeley 10

ROGERS, Cecil S.
Supervisory Production Control
Special., Overhaul & Repair Dept.
Alameda

ROSKI, John C.
Supervisory Admin. Services Officer
Overhaul & Repair Dept.
Alameda

ROSS, Donald G.
Renon-Parisian-Fontana
Bakeries, Inc.
San Francisco

ROWDEN, Gene L.
U.S.A. Ordnance
Oakland

RUSSELL, Howard
Hewlett-Packard Co.
Palo Alto

RUTH, Robert W.
Lenkurt Electric Co., Inc.
San Carlos

SAHAROFF, A.
Columbia-Geneva Steel
Pittsburg

SCARICH, C. V.
Procter & Gamble Co.
Sacramento

SCHAEFFER, Robert
Hewlett-Packard Co.
Palo Alto

SCHEUERMANN, Milton T.
Industrial Relations Department
Employee Development Officer

SCHIFFERLE, Joseph
U.S. Navy
Treasure Island

SCHIRM, Phil
Fairchild Semiconductor Corp.
Mt. View

SCHOTLAND, Roy C.
Ampex Corp.
Redwood City

SCHUESSLER, Robert G.
The Nestle Co., Inc.
Ripon

SCHULTZ, Capt. Floyd B.
San Francisco Naval Shipyard
San Francisco

SCHUMACHER, Charles H.
Rheem Semiconductor Corp.
Mt. View

SCHWING, D.
Columbia-Geneva Steel
Pittsburg

SCOTT, W. G.
IBM Data Processing Division
San Jose

SEGAL, Mayer H.
American Radiator & Standard
Sanitary
Berkeley

SEHLMEYER, E. G.
Maintenance Base, United Air Lines
San Francisco

SHALVARJIAN, Harry
Indl. Engr., Varian Associates
Palo Alto

SHERBOURNE, J. N.
Southern Pacific Co.
San Francisco

SHORT, William
The Standard Register Co.
Oakland

SIECK, Herb
Owens Illinois
Berkeley

SMITH, K.
Columbia-Geneva Steel
Pittsburg

SMITH, Ronald E.
Solid Rocket Plant, Aerojet-Gen'l Corp.
Sacramento

SMITH, Ross
Safeway Stores
Oakland

SMURTHWAITE, R. C.
Colgate Palmolive Co.
Berkeley

SPALDING, Stan
Aerojet-General Corp.
Sacramento

STANFORD, John
State Dept. of Public Work
Sacramento

STANTON, E. C.
Friden, Inc.
San Leandro

STEWARD, S. G.
C & H Sugar Refining Corp., Ltd.
Crockett

SUGARMAN, Barnett
Aerojet-General Nucleonics
San Ramon

TATE, Frank
Asst. Plant Manager, Tri Valley Packing Association
San Francisco

TAYLOR, Frank
Marchand
Oakland

TEDFORD, C. W.
Friden, Inc.
San Leandro

TEEGARDEN, B. H.
Cal Farm Insurance Co.
Berkeley 4

TEMPLE, D. M.
Customer Services Research, Bank of America
San Francisco

THAYER, Sanford
Stanford Res. Inst.
Menlo Park

TILSON, David Jr.
Ampex Data Products Co.
Redwood City

TRAVER, Harmon
Hewlett-Packard Co.
Palo Alto

TRITT, Edgar H.
Supervisory Indus. Engineer, Overhaul & Repair Department
Alameda

TROUGHTON, T. D.
Rheem Manufacturing Co.
Richmond

TRYON, W.
Columbia-Geneva Steel
Pittsburg

WALDE, Leonard O., Jr.
American Standard
Richmond

WALKER, Don
The Standard Register Co.
Oakland

WALKER, Nelson
Fairchild Seminconductor Corp.
Mt. View

WANERSTRAND, Per O.
Schlage Locks
Burlingame

WARNER, Hugh F.
Proj. Mfg. Controller, Link Div., Gen'l Precision Inc.
Palo Alto

WENDEL, D. N.
Southern Pacific Company
San Francisco

WIESE, Charles
Johns-Manville Prod. Corp. of California
Stockton

WHEELER, Kenneth
Benicia Arsenal
Benicia

WIHTOL, Arnold
Mgr. Manufacturing - Tube Div., Varian Associates
Palo Alto

WILCOX, W. W.
United Airlines, Maintenance Base
San Francisco

WILDENSTEN, Charles K.
Marchand
Berkeley

WILLARD, Charles L.
Connor Spring Mfg. Co.
Berkeley

WILLIAMS, L. T.
Colgate-Palmolive
Berkeley

WILSON, Earl
Cutter Laboratories
Berkeley

WINKLER, Allen
National Container Corp.
Oakland

WINSLOW, Dwight R.
American Pipe & Const. Co.
Hayward

WORTMAN, Calvin B.
Mare Island Naval Shipyard
Vallejo

WRIGHT, E. V.
Lighthouse for the Blind
San Francisco

ROSTER OF ATTENDANCE

LOS ANGELES

ALLEN, William
U.S. Air Force
Santa Monica

ANDERSON, Ralph N.
U.S. Air Force
Redlands

ANDERSON, W. G.
U.S. Chemical & Borax Corp.
Boron

ANDREWS, Robert B.
University of California
Los Angeles

APPLETON, W.
Wayne Mfg. Co.
Pomona

ARNOLD, Wallace D.
PaperMate Mfg. Co.
Santa Monica

BARBEAU, Wm. A.
Burroughs Corp.
Pasadena

BARCLAY, Robert J.
North American Aviation, Inc.,
Downey

BARNES, Ralph M.
University of California
Los Angeles

BAROCH, George F.
Motorola
Phoenix, Arizona

BARRANCIK, Bill
System Development Corp.
Santa Monica

BARTH, William
Autonetics, Div. of NAA
Altadena

BARTON, Dean
Beckman Instruments, Inc.
Anaheim

BAUER, Richard
Western Gear Corp.
San Pedro

BEARDMORE, Robert L.
Calif. State Polytechnic College
Pomona

BECKER, Robert A.
Aerojet-General-Avionics
Pasadena

BERG, Robert
Western Gear Corp.
Compton

BERRY, W.
Robertshaw-Fulton Controls
Los Angeles

BERTOLA, H. Peter
General Conveyor, Inc.
Los Angeles

BIDDLE, C. J.
Hughes Aircraft
Culver City

BILLINGS, Page A.
California Bank
Los Angeles

BISBEY, E. J.
Firestone Tire & Rubber Co.
Los Angeles

BLEKKING, Earl
Florida University
Florida

BOBROSKY, Samuel
Autonetics, Div. of NAA
Altadena

BONSACK, Robert A.
Link Belt Company
Montebello

BOTTORFF, O. E.
Douglas Aircraft Co.
Encino

BOYLES, John S.
S. Calif. Edison Co.
Los Angeles

BRECKAN, Erling A.
Calif. State Polytechnic College
Pomona

BRIN, Burton
U.S. Air Force
Colton

BROOKS, Ron
Western Gear Corp.
Whittier

BROWN, Helen Ray
System Development Corp.
Santa Monica

BROWN, Robert W.
Eastman Kodak
Hollywood

BRYANT, D. L.
DelMar Engr. Labs. Inc.
Los Angeles

BUFFA, Elwood S.
University of California
Los Angeles

BUNCH, James
Thermador Elec. Co.
Los Angeles

BURSTALL, William M.
Byron Jackson Div. of Borg.
Warner Corp.
Los Angeles

BUSETCH, Harlan
Librascope
Glendale

CAMPBELL, Joseph C.
USAF Ballistic Missile Center
Los Angeles

CARRABINO, Joseph D.
University of California
Los Angeles

CHAPLE, Charles
Hospital Service of So. Calif.
Los Angeles

CHAPMAN, D. W.
Hughes Aircraft
Culver City

CHEESEMAN, James T.
PaperMate Mfg. Co.
Santa Monica

CHIPPS, James
Mattel Toys
Gardena

CHMUROWICZ, Roman
Bourns, Inc.
Riverside

CLARK, T. Hollis
Pacific Telephone
Los Angeles

CLARKE, George B.
Librascope
Glendale

CLEVELAND, Jack
Robershaw-Fulton Controls
Anaheim

COFFIELD, Michael
U.S. Air Force
San Bernardino

COLLAR, Grant
U.S. Air Force
San Bernardino

COOK, W. B.
Paçific Tel. & Tel.
Los Angeles

COPPLE, F. T.
Librascope
Glendale

CORSER, Edwin H.
Grant & Grant
Los Angeles

COSTANZA, R. R.
DelMar Engr. Labs. Inc.
Los Angeles

COVER, Millard W.
Ernst & Ernst
Los Angeles

CREASON, John E.
North American Aviation In.
Downey

CURTIS, Ray H.
California Bank
Los Angeles

DAHLBERT, Oscar A.
So. Calif. Gas Co.
Los Angeles

DAVIS, Keith
Arizona State Univ.
Tempe, Arizona

DELAND, E. Leon, Sr.
Utility Appliance Corp.
Los Angeles

DEMAIN, Norman
Hughes Aircraft
Los Angeles

DENT, Charles
System Development Corp.
Santa Monica

DENTLER, Eugene C.
Rome Cable Corp.
Torrance

DIFFLEY, W. J.
U.S. Borax & Chemical Co.
Boron

DILLON, Dr. Charles R.
Douglas Aircraft Co.
Los Angeles

DIMARE, Vincent L.
U.S. Air Force
San Bernardino

DISMUKE, Ben F.
Autonetics, Div. of NAA
West Covina

DOMBROW, R. J.
Air Force Ballistic Missile Center
Los Angeles

DOUCETTE, L. E.
Nortronics
Hawthorne

DOYLE, Eugene
Permanent Filter Corp.
Los Angeles

DYER, Allen C.
Baker Oil Tools
Los Angeles

EDMOND, Jackson C.
Autonetics, Div. of NAA
Whittier

EGGERT, B. F.
National Cash Register Co.
Hawthorne

ELLINGTON, Earl
U.S. Naval Ordnance Test Station
China Lake

ELLIOTT, W. E.
Long Beach Naval Shipyard
Long Beach

EMERICK, Paul N.
Transicold Corp.
Montebello

EPPERLEY, Charles L.
Autonetics
Pomona

ESHELSON, Mel
Bendix Aviation Co.
North Hollywood

ESKANGS, Robert
U.S. Borax & Chemical Corp.
Boron

FELBERG, Robert A.
Slip Ring Co. of America
Los Angeles

FELDMAN, John
Air Defense Command USAF
Santa Monica

FELDMANN, Howard U.
American Airlines
Tulsa, Oklahoma

FENNESSEY, Joseph T.
Johns-Manville
Long Beach

FERGUSON, W. H.
Quality Control Co.
Los Angeles

FILER, J. C.
Ryan Aeronautical
Torrance

FISHER, Jerry
The Feldman Co
Los Angeles

FRANKLIN, W. W.
So. Calif. Water Co.
Los Angeles

GAINES, Carl B.
Byron Jackson
Los Angeles

GALBRAITH, Oliver
San Diego State College
San Diego

GEBHARDT, Robert E.
U.S. Naval Ammunition Depot
Seal Beach

GEIGER, Ralph P.
Long Beach Naval Shipyard
Long Beach

GERNER, G. E.
North American Aviation, Inc.
Downey

GEYER, Elwood W.
North American Aviation, Inc.
Downey

GLASER, Frank
Collins Radio Co.
Burbank

GOFFMAN, Jack
Telecomuting Corp.
Los Angeles

GOFFS, A. L.
Hoffman Electronics
Los Angeles

GOLDFARB, Jack
Packard Bell Electronics
Los Angeles

GORDON, Robert
System Development Corp.
Santa Monica

GREEN, James R.
Johns-Manville Corp.
Long Beach

GRIFFITH, James B.
Security 1st Nat'l Bank
Los Angeles

GROPP, G.
Wayne Mfg. Co.
Pomona

GRUBER, F. M.
Rocketdyne
Canoga Park

GUDGELL, Frank W.
Fibreboard Paper Products Corp.
West Covina

HAKOLA, Allan
Air Firce Ballistic Missile Center
Rolling Hills

HALL, H. Lawrence
Univ. of Southern California
Los Angeles

HALLER, F. M.
Nortronics
Hawthorne

HARDING, Clyde I.
Thermador Elec. Mfg. Co.
Los Angeles

HARRIS, Frank
U.S. Air Force
Redlands

HATFIELD, G. A.
National Supply Co.
Torrance

HAUSRATH, Don A.
Slip Ring Co. of America
Los Angeles

HAWKINS, Robert C.
California State Poly
Pomona

HAZZARD, Harry
McCulloch Corp.
Los Angeles

HENNESSY, Robert L.
So. Calif. Gas Co.
Los Angeles

HERBST, Walter R.
Consolidated Western Steel
Los Angeles

HESS, Willard C.
RCA
Van Nuys

HIRTLE, Allen
So. Calif. Gas. Co.
Los Angeles

HODGE, Glenn L.
San Diego State College
San Diego

HOLMES, Dale R.
U.S. Borax & Chemical Corp.
Boron

HOLTHAUS, G. W.
Hughes Aircraft Co.
Fullerton

HOPKINS, G. P.
Pacific Tel. & Tel.
Los Angeles

HURLBUT, Stewart W.
Anaconda Co.
Butte, Montana

IRWIN, R. W.
Proctor & Gamble Mfg. Co.
Long Beach

JACOBS, Raymond
Bendix, Pacific Division
Burbank

JAY, Les
Smith Tool Co.
Compton

JENSEN, Clarence E.
Forest Lawn Memorial Park Assoc.
Glendale

JERCHA, Richard
Elgin Instrument Co.
Burbank

JEROME, W. R.
Autonetics
Downey

JUBINA, William
Ducommun Metal Supply
Los Angeles

JUNE, Robert
Mattel Inc.
Torrance

KADAU, R. L.
Johns-Manville Corp.
Long Beach

KARP, Chester
Central D Manufacturing Co.
Culver City

KAUFMAN, Seymour E.
Veterans' Administration
San Francisco

KEEFFE, Donald J.
Air Force Ballistic Missile Center
Los Angeles

KELLER, John R.
Fibreboard Paper Products Corp.
Downey

KIEFER, Carl J.
North American Aviation, Inc.
Downey

KITTREDGE, P. H.
American Potash & Chemical Corp.
Trona

KLOPPENBURG, John
Gladding McBean & Co.
Los Angeles

KNAPP, Don J.
Hughes Aircraft
Culver City

KUSTER, William E.
Hughes Aircraft
Culver City

LANE, Benjamin
General Conveyor, Inc.
Los Angles

LARSEN, M. L.
Pacific States Cast Iron Pipe Co.
Provo, Utah

LAUFER, Art
Long Beach State College
Long Beach

LEHMAN, David A.
Shell Chemical Corp.
Wilmington

LOCKE, Robert
Pacific Tel. & Tel. Co.
Glendale

LOGUE, Murl F.
Telautograph Corp.
Los Angeles

LONGLEY, S. W.
Hughes Aircraft
Los Angeles

LUMMERS, Clinton
Gladding McBean & Co.
Los Angeles

LYONS, F. M.
Hoffman Electronics
Los Angeles

MACCOON, Grant K.
Grant & Grant
Los Angeles

MARGOLIN, Jack
Central D Manufacturing Co.
Culver City

MARSON, Arnaldo
So. Calif. Gas Co.
Hollywood

MARTIN, Arthur S.
Fibreform Electronics
Los Angeles

MARTIN, Maurice
Autonetics
Downey

MATTASOFF; Henry
ASQC
Los Angeles

MAYER, R. L.
Consolidated Western Steel
Los Angeles

McCOWN, W. L.
DelMar Engr. Labs.
Los Angeles

McDONALD, Floyd
U.S. Air Force
San Bernardino

McDOUGALL, H. L.
Meridian Metal Craft, Inc.
Whittier

McFADDEN, R. George
University of California
Los Angeles

MERCURIO, C. A.
Hughes Aircraft
El Segundo

MERRILL, F. L.
Hughes Aircraft Co.
Culver City

METGER, Vernon A.
Long Beach State College
Long Beach

MICHAELSON, James P.
U.S. Air Force
San Bernardino

MILES, Jack
North American Aviation, Inc.
Downey

MILLER, S. A.
Rocketdyne
Canoga Park

MOESCH, Robert
San Diego State College
San Diego

MOFFETT, James W.
Hughes Aircraft Co.
Culver City

MONTES, Nicholas R.
Hughes Aircraft
Los Angeles

MOORE, F. Donald
White Sands Missile Range
Las Cruces, New Mexico

MORTIMER, Joseph T.
Kennecott Copper Corp.
Hayden, Arizona

MOTT, Clinton P.
Kennecott Copper Corp.
Salt Lake City, Utah

MURROW, James R.
Johns-Manville Corp.
Long Beach

MYERS, C. H.
National Supply Co.
Torrance

NAGLE, R. L.
Hoffman Electronics
Los Angeles

NASH, Wesley L.
California Bank
Los Angeles

NELSON, Arthur
City of Vernon
Vernon

NELSON, Frank R.
Aerojet General
Sacramento

NEWTON, Don L.
Telecomputing
Los Angeles

NICHOLS, Arthur S.
Fibreform Electronics
Los Angeles

NORMAN, Kenneth J.
Hoffman Electronics Corp.
Los Angeles

NORTHROP, Joseph F.
Borg-Warner Corp.
Los Angeles

NOVACK, Paul
Packard Bell Electronics
Los Angeles

NUTT, Merle C.
Arizona State University
Tempe, Arizona

O'BRIEN, John T.
Pacific Tel. & Tel. Co.
Los Angeles

OCELLO, Ben
Beckman Instruments, Inc.
La Habra

OLDHAM, J. R.
Hughes Aircraft
El Segundo

OLSEN, Pete E.
Fibreboard Paper Products Corp.
Vernon

OLSON, G. Howard
Los Angeles

OLSON, Lawrence M.
Aerojet-General Corp.
Downey

OSTRANDER, Hall
Aeroquip Corp.
Burbank

PAGE, Paul
Gladding McBean & Co.
Los Angeles

PALLO, Louis
Packard Bell Electronics Corp.
Los Angeles

PAMER, Karl
General Conveyor, Inc.
Los Angeles

PARKER, R. W.
Hughes Aircraft
El Segundo

PAYNE, Edward J.
North American Aviation, Inc.
Downey

PETERS, I. J.
Baker Oil Tools, Inc.
Los Angeles

PETERSON, A. W.
Meridian Metalcraft
Whittier

PHILLIPS, D. G.
Long Beach Naval Shipyard
Long Beach

POEHLER, Kenneth M.
Minnesota Mining & Mfg. Co.
St. Paul, Minnesota

POEPOE, Andrew K.
Castle & Cooke Terminals, Ltd.
Honolulu, Hawaii

POMEROY, Robert D.
So. Calif. Gas Co.
Los Angeles

POSTON, Homer G.
Long Beach Naval Shipyard
Long Beach

PRINCE, W.
Robertshaw-Fulton Controls
Long Beach

PRUCE, Peter
Hughes Aircraft Co.
Los Angeles

QUANEY, Robert A.
California State Poly
Pomona

RAINIER, Maury W.
L. A. Period Furniture Mfg. Co.
Los Angeles

RAMRAKHIANI, Bheru J.
Ministry of Labor
Govt. of India

RANDOLPH, J. H.
Firestone Tire & Rubber Co.
Los Angeles

RAPHAEL, Lawrence
U.S. Air Force
Los Angeles

ROBINSON, J. R.
Hughes Aircraft
Los Angeles

ROBISON, Stuart W.
American Potash & Chemical Co.
Trona

RODNEY, Earl
Smith Tool Co.
Compton

ROSEN, Daniel
Ryan Aeronautical
Torrance

ROSS, S. J.
Packard Bell Electronics Corp.
Los Angeles

ROSSCUP, D. F.
Robertshaw-Fulton Controls
Long Beach

ROUSE, Harold W.
Ryan Aeronautical Co.
San Diego

ROUSH, J. W.
Ryan Aeronautical Co.
San Diego

RUBEN, Ted
Central D Manufacturing Co.
Culver City

RUDVIN, Knut
American Standard
Torrance

RULE, Wm. J.
Robertshaw-Fulton Controls Co.
Anaheim

RUSSELL, H. L.
DelMar Engr. Labs.
Los Angeles

SATTEN, Mortimer
Rohr Aircraft Corp.
San Diego

SCHAD, Robert
Thermador Elec. Co.
Los Angeles

SCHEIBEL, E. L.
Elgin Instruments
Burbank

SCHULENBURG, Burton G.
U.S. Air Force
San Bernardino

SCHMIEDER, Fremont R.
Shell Oil Co.
Los Angeles

SCHNEIDER, K. O.
Hughes Aircraft Co.
Fullerton

SCHROEDER, C. R.
San Diego Zoological Garden
San Diego

SCHUYLER, Dan
Bendix Aviation
North Hollywood

SCHWARTZ, William C.
North American Aviation, Inc.
Los Angeles

SCHWEMLER, Paul R.
Autonetics
Downey

SCOTT, Joseph
Thermador Elec. Co.
Los Angeles

SHAW, C. G.
Pacific States Cast Iron Pipe Co.
Provo, Utah

SHEPPARD, Paul
Thermador Elec. Co.
Los Angeles

SILVER, Robert H. I.
Hoffman Electronics Corp.
Los Angeles

SIMON, Frank
Aeroquip Corp.
Burbank

SINHA, B.S.P.
Productivity Council
Govt. of India

SIPOS, Joseph S.
Eldon Plastics Corp.
Los Angeles

SIVAGNANALINGAM, Vyramuthu
Ceylon Institute of Scientific & Industrial Research
Columbo 7, Ceylon

SLOTTEN, Herb T.
North American Aviation, Inc.
Downey

SMITH, Irwin F.
Stauffer Chemical
Los Angeles

SOBLIN, Donald
Air Defense Command USAF
Santa Monica

SPALTER, S.
Convair
San Diego

SPENCER, Herbert C.
University of California
Los Angeles

SPERBECK, Fred H.
Fibreform Electronics
Los Angeles

SPIELBERG, Frank E.
Borg-Warner Corp.
Los Angeles

SRBICH, Alexander
San Diego State College
San Diego

STAFFORD, Martine
Autonetics
Long Beach

STARK, John
U.S. Air Force
Santa Monica

STEIN, Arthur L.
Gladding McBean & Co.
Los Angeles

STEVENS, G. W.
Society of Applied Ind. Engr.
Playa Del Rey

STIFFLRE, U. L.
Rocketdyne
Canoga Park

STONBERG, Charles H.
Hospital Serv. of So. Calif.
Los Angeles

STOUGHTON, Marshall F.
Convair Astronautics
San Diego

SUGAR, Carl
1st Western Bank & Trust Co.
Los Angeles

SUGIMOTO, Paul
Bendix Aviation
North Hollywood

SUMPTER, James L.
Eastman Kodak
Hollywood

SWANTON, D. M.
Autonetics
Downey

SWINGER, Henry
Norton AFB
Redlands

TAYLOR, Kemper
Firestone Tire & Rubber Co.
Los Angeles

TEACHENOR, Lewis G.
North American Aviation, Inc.
Downey

THOMPSON, D.
Robertshaw-Fulton Controls Co.
Long Beach

THORNTON, D. J.
Rohr Aircraft Co.
Chula Vista

TIESO, Joseph
Gladding McBean & Co.
Los Angeles

TRAEGER, K. B.
Pacific Scientific Co.
Anaheim

TRIGG, John
Naval Ordnance Test Station
China Lake

VORIS, William
Los Angeles State College
Los Angeles

WADHWANI, Kushi
Radio Lamp Works Ltd.
Bombay, India

WALLIS, Daun
Bourns, Inc.
Riverside

WAYMAN, Wm. E.
Sunstrand Turbo
Pacoima

WELCH, Paul W., Jr.
White Sands Missile Range
El Paso, Texas

WESTBERG, F. T.
Autonetics
Whittier

WHEELER, Don
Robertshaw-Fulton Controls Co.
Long Beach

WHIPPLE, Donald G.
Los Angeles

WHITE, Thomas H.
Stillman Rubber
Culver City

WHITE, Truman R.
Tyler Pipe & Foundry Co.
Tyler, Texas

WHITESEL, Phil
Permanent Filter Corp.
Los Angeles

WHITING, Richard J.
Los Angeles State College
Los Angeles

WILLIAMS, James I.
University of California
Los Angeles

WILSON, Robert
So. Calif. Gas Co.
Whittier

WILSON, Wayne W.
Aeroquip Corp.
Burbank

WOLTKAMP, Clarence G.
Rome Cable Corp.
Torrance

WOOLWINE, W. R.
Thermador Elec. Mfg. Co.
Los Angeles

YOUNG, Duane
North American Aviation, Inc.
Downey

YOWELL, J. Neal
Kimberly-Clark Corp.
Fullerton

ZIELLO, Alfred
Marquardt Corp.
Van Nuys

ZIRGES, Glen G.
Firestone Tire & Rubber
Los Angeles

CHRONOLOGY – ALL INSTITUTES

No.	Date	General Chairman and Editor	Welcoming Speaker
1	1949 May 21	D. G. Malcolm	Richard G. Folsom, Chairman, Mechanical Engineering, Berkeley
2	1950 Jan. 27 - 28	D. G. Malcolm	M. P. O'Brien, Dean, College of Engineering, Berkeley
3	1951 Feb. 2 - 3	D. G. Malcolm	George A. Pettitt, Assistant to President, Berkeley
4	1952 Feb. 1 - 2 Feb. 4 - 5	D. G. Malcolm	H. A. Schade, Director, Institute of Engineering Research, Berkeley Wesley L. Orr, Assistant Dean, College of Engineering, Los Angeles
5	1953 Jan. 30 - 31 Feb. 2 - 3	D. G. Malcolm	E. Paul DeGarmo, Assistant Dean, College of Engineering, Berkeley L. M. K. Boelter, Dean, College of Engineering, Los Angeles
6	1954 Jan. 29 - 30 Feb. 1 - 2	Bruce G. McCauley	M. P. O'Brien, Dean, College of Engineering, Berkeley Raymond B. Allen, Chancellor, Los Angeles
7	1955 Jan. 28 - 29 Jan. 31, Feb. 1	Joseph D. Carrabino (Gen.Ch.) Bruce G. McCauley (Ed.)	Paul H. Sheats, Associate Director, University Extension, Los Angeles Arthur M. Ross, Director, Institute of Industrial Relations, Berkeley
8	1956 Feb. 3 - 4	John R. Huffman	M. P. O'Brien, Dean, College of Engineering, Berkeley David F. Jackey, Dean, College of Applied Arts, Los Angeles
9	1957 Feb. 1 - 2	Louis E. Davis	E. Paul DeGarmo, Chairman, Industrial Engineering, Berkeley L. M. K. Boelter, Dean, College of Engineering, Los Angeles
10	1958 Feb. 7 - 8	Robert B. Andrews	Robert Gordon Sproul, President, University of California, Berkeley William G. Young, Chancellor, Los Angeles
11	1959 Feb. 6 - 7	E. C. Keachie	Glenn T. Seaborg, Chancellor, Berkeley Vern O. Knudsen, Acting Chancellor, Los Angeles
12	1960 Feb. 5 - 6	John G. Carlson	L. M. K. Boelter, Dean, College of Engineering, Los Angeles John R. Whinnery, Dean, College of Engineering, Berkeley

INDEX
FIRST THROUGH TWELFTH INSTITUTES

AUTHORS

SUBJECTS

AUTOMATION

COST REDUCTION AND CONTROL

COMPUTERS, DATA AND INFORMATION PROCESSING SYSTEMS

Planning for Electronic Data Processing — IX - 1957
Wesley S. Bagby

Seminar on Automatic Data Processing — IX - 1957
Richard G. Canning

Use of Digital Techniques in Industrial Control Systems — X - 1958
George Kozmetsky

Management Information Systems — XII - 1960
M. O. Kappler

ELEMENTAL AND MOTION TIME AND DATA

The Practical Applications of Methods-Time Measurement — III - 1951
W. K. Hodson

The Practical Aspects of Work Factor — III - 1951
J. H. Quick

Developing Standard Data for Predictive Purposes — IV - 1952
Adam Abruzzi

A Study of the Additive Properties of Motion Element Times — V - 1953
Donald E. Stiling

ENGINEERING ECONOMY

The Engineering Economy of Plant Investment: The Interest Rate — VI - 1954
Robert J. Brown, Feliciano M Gonzales, and Edward C. Keachie

The Effect of Economic Policies on Plant and Equipment Expenditures — VII - 1955
Neil H. Jacoby

An Investigation of the Reasons used to Justify the Leasing of Automobiles and Trucks by Corporations — XI - 1959
Joseph F. Rodgers

HUMAN ENGINEERING

The Human Factor in the Design of Indexing Machines — III - 1951
G. L. Marshall

Studies in Multiple Grasping and Positioning of Small Parts — III - 1951
A. Shapero

A Method for Kinematic Analysis of Motions of the Shoulder, Arm, and Hand Complex — IV - 1952
Alfred C. Blaschke and Craig L. Taylor

A Motion and Time Method for the Evaluation of Prosthetic Devices — IV - 1952
M. S. Gottlieb

The Evaluation of an Electrical Articifical Arm using Motion and Time Study Techniques — V - 1953
M. S. Gottlieb

Accuracy in Reading Instrument Dials — V - 1953
Bruce G. McCauley

Human Factors in Engineering Design — VI - 1954
Alphonse Chapanis

A Study of Intra-and Inter-Individual Differences in the Performance Times of Three Everyday Living Tasks — VI - 1954
John R. Huffman

Some Physical Variables in the Design of Protective Handcoverings — VIII - 1956
John H. Lyman

Some Contributions of Psychology to Man-Machine Performance — XI - 1959
S. D. S. Spragg

INCENTIVES

Presentation and Installation of Performance Standards and Incentive — IV - 1952
T. L. Carroll

Statistical Description of Wage Incentive Systems — IV - 1952
Jack Drandell

Dynamic Incentives — IV - 1952
Col. Alexander Heron

Incentives for Indirect Labor — V - 1953
George H. Gustat

A Statistical Evaluation of Worker Productivity — VI - 1954
Donald C. Demangate

Installation and Maintenance of Wage Incentives for Manufacturing and Non-Manufacturing Personnel — VII - 1955
John J. Barry

Multi-Factor Wage Incentives - A Case Study — XI - 1959
John J. Rench

INDUSTRIAL ENGINEERING

The Place of Industrial Engineering on the Management Team — III - 1951
R. Conrad Cooper

Industrial Engineering in a Manufacturing Plant - A Case Study IV - 1952
Charles A. Bogenrief

The Tremendous Potential of Industrial Engineering IV - 1952
George Lawrence Hall

The Future of Industrial Engineering V - 1953
Lillian M. Gilbreth

The Industrial Engineering Function in Medium Sized Business V - 1953
Stewart M. Lowry

The Application of Industrial Engineering Techniques in Purchasing VI - 1954
N. A. Lamberti

Evaluation of the Industrial Engineering Program in Small Plant Management VI - 1954
Martin S. Meyers

Industrial Engineering - Food Processing Industry VII - 1955
L. V. Burton

Administrative Controls for the Industrial Engineering Department VIII - 1956
O. J. Feorene

The Challenge Ahead for Industrial Engineering VIII - 1956
A. F. Vinson

How Industrial Engineers can be of Most Use to Management X - 1958
J. E. Angle

Industrial Engineering in the Small Company X - 1958
Donald C. Demangate

Tailoring Industrial Engineering to the Company's Needs X - 1958
Lee S. Whitson

The Industrial Engineer's Crucial Role in Today's Business Climate XI - 1959
Robert Erickson

Administration of the Industrial Engineering Activity XII - 1960
R. A. Forberg

Methods Engineering and Operations Research XII - 1960
R. D. McLandress

INDUSTRIAL PSYCHOLOGY, HUMAN RELATIONS

The Human Factor in Industrial Engineering II - 1950
Mason Haire

How Industrial Engineers and Management Alienate Workers III - 1951
E. P. DeGarmo

Psychological Factors Influencing Productivity III - 1951
Mason Haire

The Role of Psychology in Industrial Engineering IV - 1952
R. Hollis Hamstra

An Analysis of a Fatigue in a Manual Operation IV - 1952
Dudley Josselyn

Overcoming Barriers to the Acceptance of New Ideas and Methods IV - 1952
Robert Tannenbaum

Helping People to Accept New Ideas VII - 1954
Gilbert Brighouse

Group Participation: The Gap between Principle and Practice VII - 1955
Thomas Gordon

Attitudes, Motivations and Industrial Productivity VIII - 1956
Stanley E. Seashore

Motivating Scientific Personnel IX - 1957
Dwight Palmer

Human Relations on the Assembly Line IX - 1957
Charles R. Walker

Practical Implications of Human Relations Research X - 1958
Aaron Levenstein

The Creative Worker in Engineering XI - 1959
Donald W. MacKinnon

Some Contributions of Psychology to Man-Machine Performance XI - 1959
S. D. S. Spragg

Gaining Acceptance to New Ideas in the Power Structure of an Organization XII - 1960
Robert R. Blake

Motivational Tools for Management XII - 1960
Karl R. Kunze

LABOR RELATIONS

Union Problems in Setting Production Standards III - 1951
William Gomberg

MATHEMATICAL AND STATISTICAL TECHNIQUES

METHODS STUDY, WORK SIMPLIFICATION

PRODUCT DESIGN

PRODUCTION ENGINEERING

PRODUCTION PLANNING AND CONTROL

QUALITY CONTROL

WORK MEASUREMENT

UNIQUE TOPICS

PANEL DISCUSSIONS