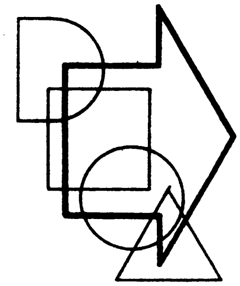
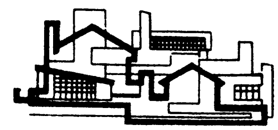
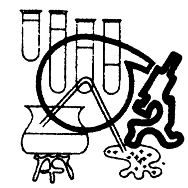
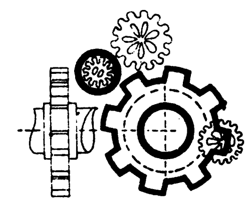
PROCEEDINGS

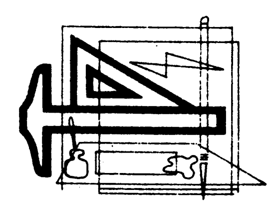
NINTH ANNUAL INDUSTRIAL ENGINEERING INSTITUTE

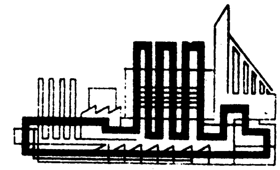












Institute of Industrial relations (Berkeley + Los Angeles)

UNIVERSITY OF CALIFORNIA

BERKELEY **February 1 and 2, 1957** **LOS ANGELES**

PROCEEDINGS

NINTH ANNUAL

INDUSTRIAL ENGINEERING INSTITUTE

Presented by

UNIVERSITY OF CALIFORNIA

THE COLLEGES OF ENGINEERING

THE SCHOOLS OF BUSINESS ADMINISTRATION

THE INSTITUTES OF INDUSTRIAL RELATIONS (Berkeley and Los Angeles)

UNIVERSITY EXTENSION

at Berkeley and Los Angeles
February 1 and 2, 1957

In Cooperation with:

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

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

SOCIETY FOR ADVANCEMENT OF MANAGEMENT
Los Angeles 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
Los Angeles Chapter

Editor: Louis E. Davis, Associate Professor of Industrial Engineering
University of California, Berkeley

PREFACE

LOUIS E. DAVIS

Editor and General Chairman
9th Industrial Engineering Institute

The Ninth Industrial Engineering Institute is brought to you in fulfillment of our objectives concerning a continuing engineering education. These objectives focus upon the further development of the engineer for maximum utility to society, to his profession, and to himself. These general objectives become operational necessities for industrial engineering. This is emphasized in the definitions of industrial engineering where the core concept is the design, development and installation of "integrated systems." The need to deal with "integrated systems" poses the impasse confronting the future development of the industrial engineering profession.

Industrial engineering stands at a crossroad at present in maintaining its professional status. The proper turn will lead to continuing evolution as a technological profession. The wrong turn will lead down to the semi-professional status of technician. The forces that determine which turn will be made are generated through the leadership provided by technical societies, universities and institutes such as this one. Too many practitioners have already found it relatively easy to slide down to the status of technician, carrying on routine duties learned in some bygone day.

The path to professionalism is strewn with requirements to be satisfied in (1) developing ethics of means, i.e., value systems; (2) truly incorporating all of the scientific disciplines, not merely the physical sciences, into training and practice so that "integrated systems" can be truly designed, rather than being said to be designed; (3) understanding the fundamental variables and mastering the methods of human relationships so that the systems which are designed make possible the "human use of human beings" providing thereby our needed "integrated systems." Perhaps our preoccupation with "selling" blinds us to the fact that no amount of selling can correct for poorly conceived systems that are fundamentally faulty.

Two needs confront industrial engineering education and practice if we are to maintain our professional status. These are:

1. The introduction of more powerful quantitative, mathematical, statistical methods to provide more precise tools for planning and evaluation;

2. The introduction of and thorough grounding in the behavioral and social sciences to prepare industrial engineers for the job of designing integrated systems.

Examination of curricula of various engineering schools and the practices of companies indicates that by and large the two needs stated above have not been recognized nor implemented. In most instances there is hasty movement in the direction of introducing the latest quantitative methods in the form of operations research programs of various shades and complexions. Although heartily supporting these belated actions, we must express some very serious misgivings concerning the quantification fad currently sweeping schools and industry alike. These reservations are stated because of our desire to see that the contribution of the new quantitative methods are maximized.

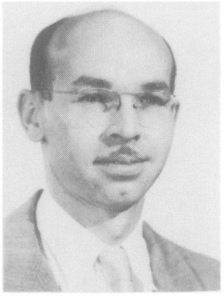
Concern should be expressed over the strong prospect that the bandwagon movement toward operations research is no more nor less than a search for the panacea of mechanical answers to the problems of complex operations, all of which involve human relationships. To be avoided, because we can predict its failure, is treating these problems with a more sophisticated version of old fashioned Taylorism with statistics added.

Most educational institutions, professional societies, and employers of engineers have not yet recognized the need for a grounding in the behavioral and social sciences and have only some fuzzy understanding of the means for satisfying it. To design integrated systems, the industrial engineer must be as technically expert in this area as in the physical sciences area. In effect we are asking for a new edition of the industrial engineer in practice and a new version of the educational programs designed to prepare the industrial engineer for practice.

The program in which you are about to participate is faithful to this new version and reflects the needed balance between new quantitative methods, established and well-tried analytical design methods, and behavioral and social science methods.

Needless to say, institutes such as these are made possible only as a result of countless hours of planning and preparation freely given by the chairmen of our planning and activities committees and the local institute chairmen on the Berkeley and Los Ángeles campuses. Obviously these institutes would not be possible without the cooperation and support of University Extension and the local chapters of our national professional societies. Lastly, we are indebted to our speakers who are enthusiastically giving of their time to share with us their abundant knowledge and experience.

TABLE OF CONTENTS

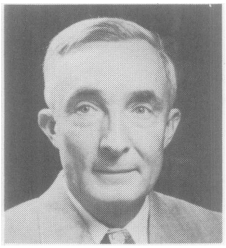


James T. Lapsley, Jr.

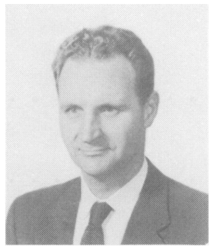
INSTITUTE AND SESSION CHAIRMEN

BERKELEY SESSIONS

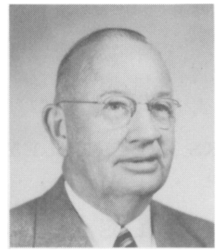
SESSION CHAIRMEN



Ewald T. Grether

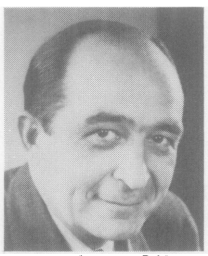


Allan M. Hull



Arthur K. Ingraham

Robert L. Knighton



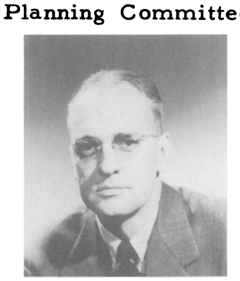
Morrough P. O'Brien

Alf E. Werolin

Harry G. Wood

ACTIVITIES CHAIRMEN

Berkeley
Planning Committee

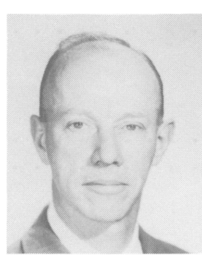


E. Paul DeGarmo

Speaker Reception
and Visual Aids

Edward C. Keachie

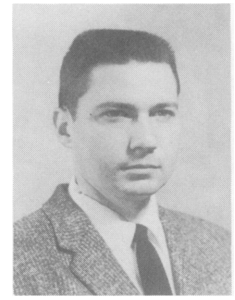
Student-Faculty Relations
and Photography



James S. Campbell

INSTITUTE AND SESSION CHAIRMEN

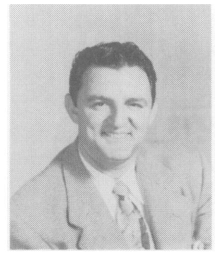
LOS ANGELES SESSIONS



Robert B. Andrews

SESSION CHAIRMEN

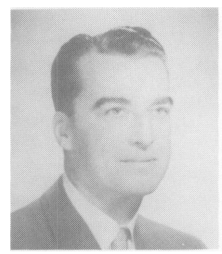
L. M. K. Boelter



Arnold A. Cowan

George W. Robbins

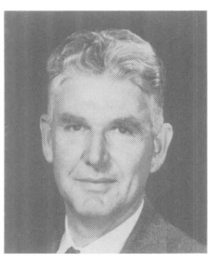
George A. Steiner



Raymond Thomas

ACTIVITIES CHAIRMEN

Los Angeles
Planning Committee



Ralph M. Barnes

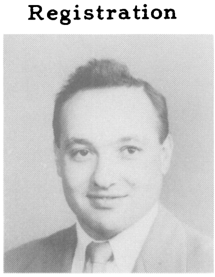
Luncheons

Erling A. Breckan

Recording and
Photography

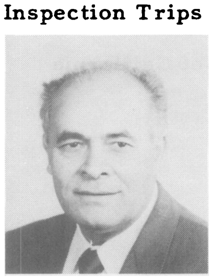
Elwood S. Buffa

Publicity and
Registration



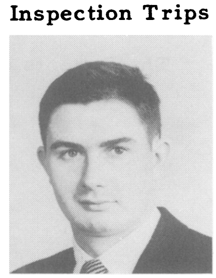
Milton A. Franks

Inspection Trips



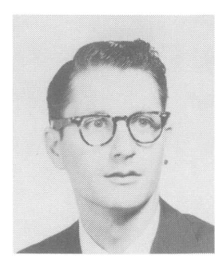
Louis L. Grandi

Inspection Trips



Fred McFadden

Student-Faculty
Relations



John C. Scheib

Additional copies can 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 by
PACIFIC ROTAPRINTING CO.
Oakland, California

WELCOMING REMARKS
BERKELEY

E. Paul DeGarmo
Professor of Industrial Engineering
and
Chairman of Division of Industrial Engineering
University of California
Berkeley, California

It is a very real pleasure for me, on behalf of the University of California, to welcome you to this Ninth Annual Industrial Engineering Institute. It is an even greater personal pleasure to have once again the opportunity to greet so many former students and old acquaintances.

This university believes that one of its functions is to be on the frontiers of all areas of intellectual activity, and through leadership to give substantial aid to the discovery and dissemination of new knowledge. Faithful to this role, this university has contributed a number of significant "firsts" in the field of industrial engineering on the Pacific Coast. For example, so far as I can determine, the first formal course in motion and time study given in any college or university on the Pacific Coast was offered on this campus. The first curriculum in Industrial Engineering on this coast approved by E.C.P.D. was on this campus. And not the least of the endeavors in industrial engineering of which we are proud is the establishment of the annual Industrial Engineering Institutes, of which this is the ninth.

Those of you who have attended these institutes from their beginning will recall that each has had on its program at least one session devoted to controversial "out-in-the-future" subjects. Many of you will also recall that some of those topics which seven or eight years ago did not seem to have any great immediate significance are commonplace today. We hope that we shall be able to continue to provide in these institutes a place where topics of the future, as well as those of immediate importance, may be presented.

Today this country is engaged in two cold wars. The importance of industrial engineering in waging the cold war against those who espouse the discredited doctrines of communism has been amply demonstrated in both government defense establishments and in private industry. However, in the second cold war—that against creeping inflation, the role of the industrial engineer will be even more important. The past few years have seen unions asking for wage increases proportionately greater than the increase in productivity of the workers. Management has acceded to these demands and then raised the prices of products so that the increase in wages was meaningless; more and more products have been priced out of foreign markets, and creeping inflation has diminished the value of all savings and insurance and threatened the security of those on fixed incomes.

Several possible solutions exist for this situation. The first, requiring unions to be more farsighted and moderate in their demands, and management to use some backbone in countering union demands and to impose some limitation on profits, does not appear too promising.

The second, which would be better for all concerned, would involve negotiating price decreases with wages remaining fixed. Regrettably, I do not expect to see either unions or management become farsighted enough to adopt this approach.

A third solution would be to depend solely upon governmental fiscal and financial controls, and these alone are probably not adequate.

The fourth, and probably the most practicable solution, is in greatly increased productivity. Automation, in various degrees, offers great promise in this connection, but only if used properly and economically. Automation is going to mean a marked increase in the amount of invested capital per worker. As this ratio goes up, it becomes more and more important that expenditures be made wisely and that available plant and equipment be fully utilized. Production systems will have to be designed and operated for maximum efficiency. It is here that the industrial engineer of the future will have key responsibilities. Industrial engineers must be ready to accept the responsibilities which will be open to them.

We hope that you will find much in this Ninth Annual Industrial Engineering Institute that will help you in preparing for the problems of the future. We trust you will enjoy your two days on our campus and will return each year for future institutes.

WELCOMING REMARKS

LOS ANGELES

L. M. K. Boelter
Dean of the College of Engineering
University of California
Los Angeles, California

Gentlemen of the Ninth Annual Industrial Engineering Institute and Ladies:

All of you have gambled on what would happen to you after you came here or you would not have come, and I am sure that you feel welcome.

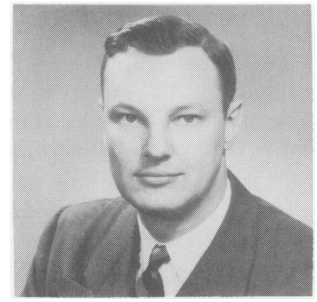
I studied the program for this Institute and noticed one heartening phenomenon; we have worked for a long time to establish that industrial engineering, indeed all of engineering, is based not only on the physical sciences but also upon the life sciences and in particular upon our knowledge of physiology and psychology. Many data are available in the areas of physiology, anatomy and psychology for use by engineers. Particularly in the aircraft industry have man's characteristics begun to influence design and operation; it is my hope that it will be strongly recognized very soon in another great industry, the automotive industry.

A second item I believe that you will be interested in has to do with some of the plans of the University of California. The State of California has performed a miracle in the last generation. The State has been changed from a primarily agricultural community to an industrial state within about one generation; and during this period, agriculture has not been displaced.

The State has further demonstrated resilience in absorbing a great population increase since the war. The University of California will heed the challenge of these two great forces and will continue to lead the way. Each campus will be expanded, the faculties will be strengthened and new campuses will be established. The University will seek solutions for the problems of the expanding economy of the Pacific Basin and in particular, those of the State of California.

You may now wish to proceed with the Conference. We wish you a rich and bountiful experience.

TESTING GROUND FOR MANAGEMENT IDEAS - THE BUSINESS MODEL



Warren E. Alberts
Director of Industrial Engineering
United Air Lines, Inc.
Chicago, Illinois

THE NEED

Scientific management will never be very scientific until a means is found to better predict and evaluate the over-all effects of changes in our modern business systems. The manager of today, unlike people working in other sciences, has little chance to test his ideas before making major decisions regarding the over-all systems by which his services or goods are produced and distributed. The very complexity of these systems and the costs associated with their operation have greatly increased the risks involved in each decision.

The term "optimizing" is a best seller these days and staffs are busy applying techniques to optimize many objectives, the most popular one being profits. However, in most cases these techniques involve a static analysis of what usually is a very dynamic system. What both management and the industrial engineer are after is a means whereby the operation of an entire system can be simulated.

Maybe what we are talking about should be called a business model or a system simulator. Now the word "model" is not new to the various branches of engineering, but the concept of a model which will simulate the interaction of men, machines, and materials in a complete system is relatively new.

Models of business operations which do exist at present are extremely limited. The organization chart is a static model which in reality means very little. Process or flow charts nearly always represent a static situation. Similarly, the accounting model, one of the oldest, is mostly historical; it attempts to keep score and price out some of the costs involved according to current concepts.

If industrial engineers are going to be the system designers of the future, it behooves them to devise a method of testing their designs somewhere other than on the production floor. The trial and error method of testing system changes is usually too costly or impractical. The complexity of the scheduling process alone in most industries today demands the development of a means to simulate the over-all operation. Management, therefore, has a right to expect a tool which will enable it to test its ideas and measure alternatives so that it may have a better basis for making decisions and calculating the risks involved.

THE CONCEPT

Underlying every repetitive process or system is a pattern or flow. This pattern may be planned and readily apparent or it may require considerable study to uncover and understand. If the key variables of the system involving workers, materials, and machines are measured in terms of their probability of occurrence, the possibility of reproducing or simulating the system becomes apparent.

The measurement of the variable factors in an operation must be approached in a practical manner. First of all we must face up to the fact that we must measure life as it is and not try to second-guess or idealize it. We can not wait for the social scientists to figure out completely all the patterns of human behavior in various business situations. Although we may be far from measuring in detail the reasons why people do certain things, we certainly can at this time measure what they do and face up to those facts in any given situation.

Many of our headaches are caused by idealizing each situation and not recognizing the facts that are staring us in the face and the interaction of the variables involved. There will be those who say that you can not measure certain intangibles or judgment areas. But here, too, we can take a practical approach and get together with management at least to assign values which will be acceptable to it and consistent with its objectives.

THE METHOD

In some cases an operation can be completely represented by a mathematical model; however, we have found that in a complex business operation a straightforward operational or logical model must often be used.

Once the pattern in an operation is determined, the key variables along it measured, their probability and relationships determined, and the logical or decision rules developed, all the means are present to simulate the system, utilizing what has been called the Monte Carlo method. Those things which happen in life in a random fashion can be simulated by coding their probability of occurrence and then drawing random numbers from a table or computer to breathe life back into them. Where definite relationships exist, they can be stated. Due to the complexity of many problems, an electronic computer is the only practical device that will follow the necessary logic, handle the large volume of repetitive steps, and combine the various probabilities so that the resultant interaction can be determined. Speed is also a big factor because with a computer the results of a month's operation can be obtained in a matter of minutes.

Once a model has shown that it simulates life, it can be used to test various ideas or plans by varying one item of the input to determine the effect on various outputs which the model has been asked to produce. There are, of course, limitations, and great judgment must be exercised in the development and use of the model.

Probably the best way to illustrate this concept of system simulation or business models is to tell you briefly about a project we have been working on.

THE PROJECT

In July of 1954 we decided to undertake a full-blown operations research approach to our system aircraft routing and maintenance problem. We had been told to start off on a small problem; however, we decided to tackle one of the most complex ones in the whole company. Our management, with a great deal of vision, agreed to underwrite this project with very little promise of what might be their return. As members of the research team we picked Mr. S. Nowlan, our Superintendent of Flight Operations Engineering, who is a topnotch aerodynamist with an excellent background in higher mathematics. He was from our San Francisco Engineering Department. Next we chose a 25-year veteran in the Flight Operations field, Mr. T. Plunkett, from the system Flight Dispatch Manager's group at our Denver Operating Base. Recognizing the importance of statistical techniques, we assigned our Staff Superintendent, Quality Control, Mr. W. Dalleck, and in addition, an Industrial Engineer, Mr. J. Porter, who had a good deal of experience working on system problems.

The project involved a basic study of the whole process of providing serviceable aircraft to meet schedules over our 14,000 mile system. Our first objective was to determine and analyze the true nature of that operation and measure the variables which existed. The second was to develop a means or a model which could be used to test the effects of changes in policy, maintenance concept, schedules, facilities, and manpower. It is important to note here that we started out to do research and to first understand, not to formulate or study, a particular problem. We didn't want to sub-optimize, as it is generally termed, or to force any part of the operation into a particular form through use of a certain technique.

APPROACH

As is our practice, a detailed approach was prepared and the project started with the team interviewing more than 100 persons who were directly concerned with the aircraft routing and line maintenance functions. With this background the team proceeded to evaluate all existing data. In applying basic questions to the operation and following them through to the point where data needs were defined, it was found that practically none of the data needed was available or in the desired form. This experience will, we feel, be duplicated in many industries and points up how little data is being gathered today which really measures an operation and enables management to manage, versus that required to satisfy legal, accounting, government agency, and staff needs.

To obtain the necessary data, three special forms were designed and field people briefed in their preparation. Over four months' data were then collected from our major service stations and checked for bias.

As the study progressed, it soon became apparent that the key to our system lay within each major service station. It also was obvious that a definite flow or work process existed at each station and we made sure that the variability, nature and probability of key factors at each significant point along that flow was measured.

For example, our Flight Schedule represents the schedule input and output to a station but we knew that the actual arrival times varied. Therefore we prepared a variability table which showed the full range of deviation from schedule; in other words, the probability of an aircraft arriving 20 minutes late, 30 minutes early, etc. This chart, although a simple one, was in reality a realistic measure of our entire operation as our customers see it.

We went on to determine the probability of the different types of maintenance work that would have to be done on an arrival, and the variation in the different types of work that would be required, both what we call routine and non-routine work. We even measured the variation in the number of men actually available to work from those on the payroll.

It soon became apparent that, as a result of the station flow and our measurement of it, we had all we needed to construct a model that would simulate an entire station operation. We finished Phase I in June of 1955 and presented the findings in a two-hour illustrated presentation to 200 of our management and field people.

Phase II, or detailing the logic of the station model, was completed in January of 1956 and turned over to IBM's service bureau for programming on their new 704 computer in New York. Just to give you an idea of the size of the model, it took nine months just to translate the logical program into machine language and some 9,000 machine instructions are involved. In fact, we had to break the model up into parts so as to stay within the capacity of the computer.

The station model as it is now set up on the 704 computer enables us to simulate three months of actual operation at a station like Newark in less than 15 minutes. By varying the input of such items as manpower, facilities, schedule or maintenance policies, we can compare outputs and get an indication as to the best course of action. As output the model gives us such things as idle manpower, utilization of maintenance docks, schedule delays, maintenance working and waiting time, etc. It must be remembered that these outputs are in the form of distributions which represent the full range of operating results for the test run. Levels of service and costs can all be obtained from them. Management has numerous questions to ask this model which, with the substitution of the proper data, can be used for any one of our major stations.

A CHALLENGE

If a science of managing is ever to emerge, a way must be found to better predict the consequences of changes in our industrial systems. Managers are finding the trial and error method too expensive and are looking for a means to test their ideas, calculate risks and predict results. Models which dynamically simulate integrated systems of men, machines and materials can help satisfy these needs. The concept, the method, and the means are available. It is up to men of imagination and perseverence to apply and shape this tool. System simulation may well represent the next significant step forward in scientific management.

PLANNING FOR ELECTRONIC DATA PROCESSING

Wesley S. Bagby
Comptroller
Pacific Mutual Life Insurance Company
Los Angeles, California

Planning for electronic data processing is a long-range and complex process. We at Pacific Mutual Life Insurance Company are certainly not experts on the subject. As a matter of fact, there are very few companies who have had an electronic system for business type data processing in operation long enough to be certain that their plans were successful. However, as one of the growing group of companies who have studied this subject, installed a system and are even now converting our operations to the new system, I believe our experiences over the past four and one-half years may be of interest to you. The considerations which led to our decision that an electronic system was economically feasible, the problems we studied before selecting an appropriate system and the methods we used in building a staff for our Electronic Records Department should all be fairly typical.

A few facts about Pacific Mutual Life Insurance Company will help you put our experiences into proper perspective. We are a medium sized life insurance company which also issues Accident and Health and Group insurance on a national basis. We have about two and a quarter billions of dollars of life insurance in force, over half of which is in three hundred fifty thousand individual policies in our Ordinary Department. The total office force in our home office in Los Angeles is about nine hundred people. Last September we purchased an electronic data processing system, primarily to do all the record keeping on our Ordinary policies. We are now at the stage of running parallel operations on our old and our proposed new basis and expect to be entirely dependent on electronic handling of our ordinary insurance operations later this year.

We first became interested in the possibility of adopting electronic methods late in 1952. The first electronic data processing system offered for commercial application was designed with specific requirements of insurance operations in mind. It was natural for the manufacturers to make great efforts to interest members of the insurance industry in the virtues of their particular systems. Two of the largest computer manufacturers believed we had a potential application. We selected two of our key men, one the executive in charge of our Methods Department and the other an actuarial technician, relieved them of their normal duties and assigned them to study the electronic data processing field. These men were given basic training in programming for computers, after which they visited several manufacturers and spent time getting acquainted with existing installations.

By July, 1953, these men had enough knowledge of electronic systems to report that they agreed with the two manufacturers—they also thought we had a potential application. Our management believed we could not afford not to explore the possibility fully—not solely for the distinction of being a pioneer but as a matter of retaining a proper competitive position. We had some historical precedent, for in 1873 Pacific Mutual made good use of an Arithmometer, the first calculating machine in the West.

We knew that a long and detailed study and analysis of our present methods would be needed before we could evaluate possible savings from electronic methods. Both manufacturers offered to make this study for us but we were pretty sure that the results of their study would not be unbiased. At that time there were few, if any, qualified outside consultants with very much experience in business applications of electronic computers. We decided that our own people were the only ones with sufficient intimate knowledge of our business to make the study. Incidentally, our experiences since then have confirmed this opinion. Any potential user of electronic business methods will have to plan on doing most of the analytical work with his own people, even if he decides to use the manufacturers or outside consultants to confirm their judgment before reaching a final decision.

THE COMPUTER SYSTEMS COMMITTEE

Therefore management appointed a five-man Computer Systems Committee, made up of men responsible for the systems in the areas where the electronic system would probably apply if acquired. Each of the men had long years of experience and was high enough in the management picture to assure executive reliance on his judgment. The committee was given an initial working staff of four young men who were members of the company's Management Training Program.

This Computer Systems Committee was given the responsibilities of:

1. Keeping abreast of developments in the field of electronic data processing machines through
   a. Training each member of the committee in techniques for their use;
   b. Familiarizing each member with equipment now available and improvements being made thereon and with equipment planned for the future;
   c. Learning of the activities of potential users both within and without the insurance field.

2. Determining whether such machines were practical for use by our company and if so

   a. Ascertaining what equipment would do our work adequately, reliably and more efficiently than present equipment and methods;
   b. Encouraging the adoption of new systems more adaptable to conversion to the systems which would be required if electronic equipment were obtained.

3. Being prepared to make recommendations about acquiring such machines and being ready to guide necessary organizational and systems changes if such recommendations were approved.

Committee members were sent in pairs, for best training results, to programming and familiarization courses conducted by several manufacturers of equipment. Some members received their schooling from Remington Rand, others from International Business Machines and others from Computer Research Corporation, now a division of National Cash Register. We believed that a variety of exposures such as this would give the Committee knowledge of the different approaches of the different manufacturers in both the giant type machines and the medium size lower cost machines, such as Computer Research Corporation and Electro-Data offered.

The Committee members in turn trained their four-man staff in computer techniques. During this same period the members made several visits to equipment manufacturers and to users and potential users in order to keep abreast of current developments. By late fall in 1953, the Committee members believed they had sufficient knowledge of data processing to embark on a feasibility study.

THE FEASIBILITY STUDY

There are three main conditions under which a large business may find the installation of electronic data processing of the officework type to be economically feasible. First, the volume of punched card accounting and statistical work may be so great and the tabulation machine installation of such size that a large scale data processor can be applied by using it simply as a larger and more complex machine to do the work already being done by punched card devices. The same source punched cards, prepared in the same way as previously, will be used as input data and the end product will be reports and summaries in the routine form. It becomes, then, a matter of converting present machine procedures virtually intact to electronic procedures with their much greater speed and capacity. The extra costs would be offset by the savings from eliminating many sorters, tabulators, collators and calculating punches, as well as by the reduction in number of operator personnel. Pan American Airways and Farmers Insurance Company have both installed IBM 705 systems on the basis of this approach.

A second type of use for an electronic system can be found in a large company which uses much punched card equipment but for a number of different applications. These applications may be relatively unrelated or individually large enough to warrant their treatment as separate processing problems. An example is General Electric in Louisville, who found it profitable to install a large scale Univac to handle their payroll accounting. Separate applications are developed later for such areas as production control, material control and general accounting. John Hancock Mutual also put in a Univac to do its premium billing, expecting later to develop completely separate programs for premium accounting, commission accounting and policy loan accounting, with each application being treated as a separate problem. In these examples there may or may not be a change in the form of the source data used as input.

The third kind of situation in which it might be profitable for a large company to install electronic data processing is to use such a system to bring an entirely new concept of record keeping to clerical work. This means consolidating existing functions or combining existing operations and replacing them with new procedures, with new types and forms of records and with different operational and clerical organizations. This approach brings with it some improvements in the quantity and quality of management information. Mr. A. B. Toan, Jr., of Price, Waterhouse & Company, has called this the "new concept" approach.

In addition to systems which have been justified on one or more of these three general bases, there have been a few installations of electronic data processing equipment that were made without regard for their effect on clerical and other operating costs, but simply because the company was willing to make a large investment in order to provide new or improved methods for controlling and operating the business more effectively. At Pacific Mutual, the Computer Systems Committee was instructed that it could not take this "operational" approach but should study only those possible uses where the cost of the new system could be offset by reductions in existing costs.

By the time the Committee was ready to embark on its feasibility study, it had long since decided that our Company was not large enough to be able to justify even a medium scale system on either of the first two approaches—and the equipment manufacturers, themselves, agreed with that decision. The Committee had developed the viewpoint, however, that if we consolidated all of the work connected with record keeping on our ordinary insurance operations, we might be able to eliminate enough of the more than three hundred jobs involved to consider installing the new system.

Representatives of both Remington Rand and IBM had already demonstrated to their (but not to our) satisfaction that their particular equipment could pay its way on this basis.

During the time the Committee members were receiving their training, before they were ready to start the feasibility study, we had conducted a detailed time study covering one full month's work of every employee in each of the seven departments in our Company which were doing some of the accounting and record keeping on our ordinary policies. This gave us a pretty complete record of activity that occurred daily, or on a weekly or monthly cycle. We realized that it did not include those jobs which occurred only quarter-annually, semi-annually or annually, but we did not believe that this was a major item in determining whether an electronic computer was economically applicable to our work. The staff of four, which was previously mentioned, recapped these individual time records into a divisional time inventory. Each department head was given a copy of this divisional time inventory for review and action in connection with current routines—in many instances, as was expected, the time study pointed the way to real improvements that could be made in our present systems without resorting to electronic methods.

The Committee used these divisional time inventories as a basis for procedure-charting on a functional basis all present routines of the ordinary insurance activity processing area. To these procedure flow charts, in turn, were matched the man hours developed in the divisional time inventories, adjusted downward in those cases where it had been determined from the time study that the present system could be improved. Analysis of all of the man-hours in the seven departments showed that 57% of the hours expended could definitely be handled by electronic methods. 37% definitely could not be handled by electronic methods and 6% were in a doubtful area which might or might not be able to be included in an electronic processing system.

Factors based on our known costs for clerical operations were applied to the percentages of total man hours thus determined. We used a standard based on routine clerical man hours, recognizing that the man hours which would be released by computer operations were far less costly man hours than our average overall man hours costs. The hourly cost assigned included overhead in the form of fringe benefits but did not include such matters as space occupied nor equipment used by the individuals.

I should point out that the definition of work to be performed by the computer was based on studies made with the assistance of IBM and Remington Rand. These two studies were independently conceived and when compared showed that while the methods differed the overall area of work embraced was just about the same under either method. This gave us a fairly well defined area of operations to be performed by the computer even though at this point we had no knowledge as to whether or not any computer would be found to be desirable for our operations.

In April 1954, after almost ten thousand man hours of study, the Committee presented management with a comparison of costs which showed that investment of $2,000,000 for a large scale system would pay its way fully in five or six years on our ordinary insurance operations application alone. The savings resulted primarily from reduced clerical costs and from some slight reduction in costs of punched card equipment. In the comparison, we included the loss of interest we would receive if the money were otherwise invested. We gave no weight to the fact that we would have enough available machine time for other applications such as mortgage loan accounting, Group insurance billing, Group experience rating calculations, etc. We also gave no weight to the greater amount of information we will have although we are sure it will enable us both to improve service to our policyowners and to make better management policy decisions.

Management studied the Committee's recommendations carefully for two months and in June 1954 decided that Pacific Mutual would "go electronic". They instructed the Computer Systems Committee to go ahead with its study of available equipment, as well as developments that appeared to be "just around the corner", and to recommend to management what specific machines should be acquired.

SELECTING THE EQUIPMENT

The Computer Systems Committee was reduced to three members chosen from the original Committee and it proceeded with its assigned task of directing the work of selecting and converting to an electronic data processing system. In this task we believed it was important for us to have full benefit of the knowledge, experience, and skills of key personnel in the affected departments. Accordingly, the Committee created eight working subcommittees to assist in such specialized areas as personnel, methods, statistics, accounts, space, programming, costs and allocation of conversion expenses. Key personnel from the appropriate departments were placed on these subcommittees.

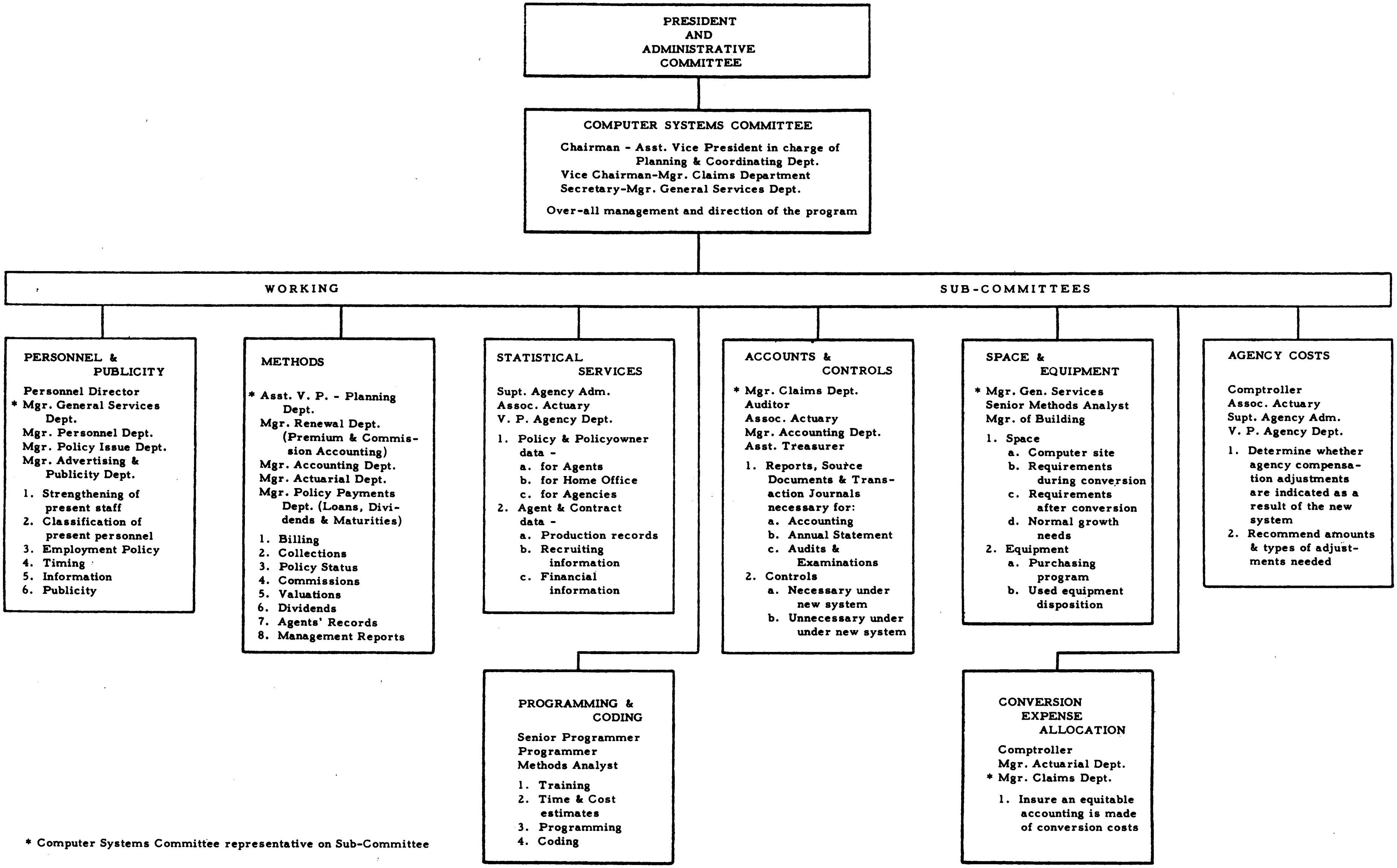
Figure 1 shows the membership and functions of the working subcommittees. This approach allowed us to study detailed areas on a decentralized basis using the talents of the best qualified people, while still retaining central control of their separate efforts through the parent committee. Our experiences during the past 2-1/2 years have confirmed our initial belief that this use of committees would be a good medium to bring a larger number of our qualified people actively into our electronic program on a controlled basis.

Now, back to the problems of selecting an appropriate system. The Committee had to consider whether it should be general purpose or special purpose, large-scale or medium-sized, and which specific manufacturer should be recommended to top management.

For us, it was easy to decide that a general purpose system was the best. The nature of our basic application fits in excellently with general purpose systems, which give great flexibility and generally lower cost.

Whether our general purpose system should be large scale or medium in size required detailed study of several systems. Insofar as IBM was concerned, we left it up to their representatives who were working with us to recommend a system between the large scale 702 and an approach involving the IBM 650 (The IBM 705 was not known then). We felt their decision would be their sincere opinion as to which was better suited to Pacific Mutual. After comprehensive study, their representatives told us that they saw no reason for us to consider "two steps", inferring that since we could utilize the 702 we would be using the 650 only as an intermediate step, and advised the use of their 702.

Electro-Data Corporation's Datatron was another medium sized computer which we studied extensively. Their equipment costs were materially less than those



* Computer Systems Committee representative on Sub-Committee

ORGANIZATION FOR CONVERTING TO AND INSTALLATION OF AN ELECTRONIC DATA PROCESSING SYSTEM -

PACIFIC MUTUAL LIFE INSURANCE COMPANY

Figure 1

of IBM's 702 or Remington Rand's UNIVAC, even if we required two or three of their complete systems to do our job. The multiplicity of systems had some advantages, too, as a complete breakdown of one does not put you entirely at the mercy of the manufacturer insofar as getting your work out is concerned. It appeared to us, however, that the methods approach using Electro-Data included much more manual processing. We ultimately decided to stay with our desires for a method offering as high a degree of automation as possible.

The further our study went, the more it became apparent to us that we should think in terms of a large scale system. We narrowed our final choice to IBM and Remington Rand. The UNIVAC Model I of the latter company had been in successful operation since 1950. We had previously determined that the economics of the two were very similar with regard to area of work, cost of equipment, and operating costs. Both suppliers have excellent reputations. Both appeared to offer (and this is important) adequate help in training, in programming, and in maintenance activities. Business machine equipment, including electronic models, of both suppliers is recognized to be dependable, accurate, and flexible.

There were three items of difference, however, which influenced our final decision. The UNIVAC could be leased or purchased outright; the IBM 702 could then only be rented. Second, UNIVAC had been thoroughly field-tested; the 702 had not yet been used by any customer. Third, it appeared to us that UNIVAC had some technological advantages.

Remington Rand's UNIVAC was getting more and more of our attention. Because our basic operations would <u>have</u> to be handled by the system chosen, we placed a great deal of emphasis on the importance of proven performance and known operating costs. UNIVAC alone satisfied us here. Just about this time IBM announced their proposed model 705, and indicated that the costs for the 702 would be higher than original estimates. The Committee decided that we should not wait for the development of an IBM 705, which from a machine specifications viewpoint appeared to be superior to UNIVAC, and which would be appreciably more expensive, nor for any other yet-to-be developed system, and recommended acquisition of a UNIVAC as the best system for our purposes.

In September 1954, after reviewing all of the Committee's work leading up to their recommendations, Pacific Mutual decided to acquire a UNIVAC Model I system.

LEASE OR PURCHASE?

Each individual company must make its own survey before knowing whether any electronic data processing system is economically wise for it. If this survey shows feasibility, each company must also decide for itself on the basis of its own needs and internal organization just what kind of equipment will be best for it. Similarly, when it comes to the question, "Shall we lease or purchase?", there are no universal principles which can be applied—each company must make its own decision in the light of its own circumstances.

Pacific Mutual elected to purchase rather than to lease. As a matter of fact, the opportunity of having this option was one of the advantages we saw in Remington Rand's UNIVAC, as that was before IBM's 1957 policy of allowing the customer to buy if he wished. We believed that ownership would give us greater control over the equipment, not only in our day-to-day use of it, but also over possible future changes in the manufacturer's leasing policy or requests to divert it to other uses in event of a national emergency.

Our decision to purchase was not reached until late in 1956, after the equipment had been in successful operation for almost a year and had demonstrated its ability to handle our ordinary insurance work and thereby pay its way. We had carefully considered those arguments advanced in favor of leasing: that rental gives the user greater assurance of good maintenance by the manufacturer, and protects the user against obsolescence. The manufacturers will gladly enter into contracts under which they will provide maintenance. Although we have chosen to do that work ourselves we are sure that Remington Rand will continue to give us just as much help as we may need to keep our installation in top shape. In other words, whether we or Remington Rand own the actual equipment, we believe they have just as much at stake in seeing that it continues to be a successful installation.

Proponents of leasing argue that it gives the user assurance of always having the latest equipment, without having to take a loss because of obsolescence. Here, too, the manufacturers will often include in their original purchase contract the right to exchange the equipment for future improved models. We realize fully that our UNIVAC Model I is technically obsolete even before we have it in full operation. This is not important, however, as long as this proven model can effectively and economically perform the job for which it was purchased, and still have available machine time for other applications, perhaps enabling it to pay for itself in less than the five or six years we expect. There is a vast difference between technical and economic obsolescence. A good example is in the Constellation airplanes built ten years ago. They were technically obsolete before they first flew, yet a used plane today sells for more than it cost the original purchaser because it can still pay its way.

Each company acquiring an electronic data processing system must study its own situation—its cash position, alternative uses for the money, tax consequences of rental and ownership, as well as the items discussed above—before deciding whether to lease or purchase. For Pacific Mutual, outright purchase with the option of exchanging for new, improved models in the future was the better course.

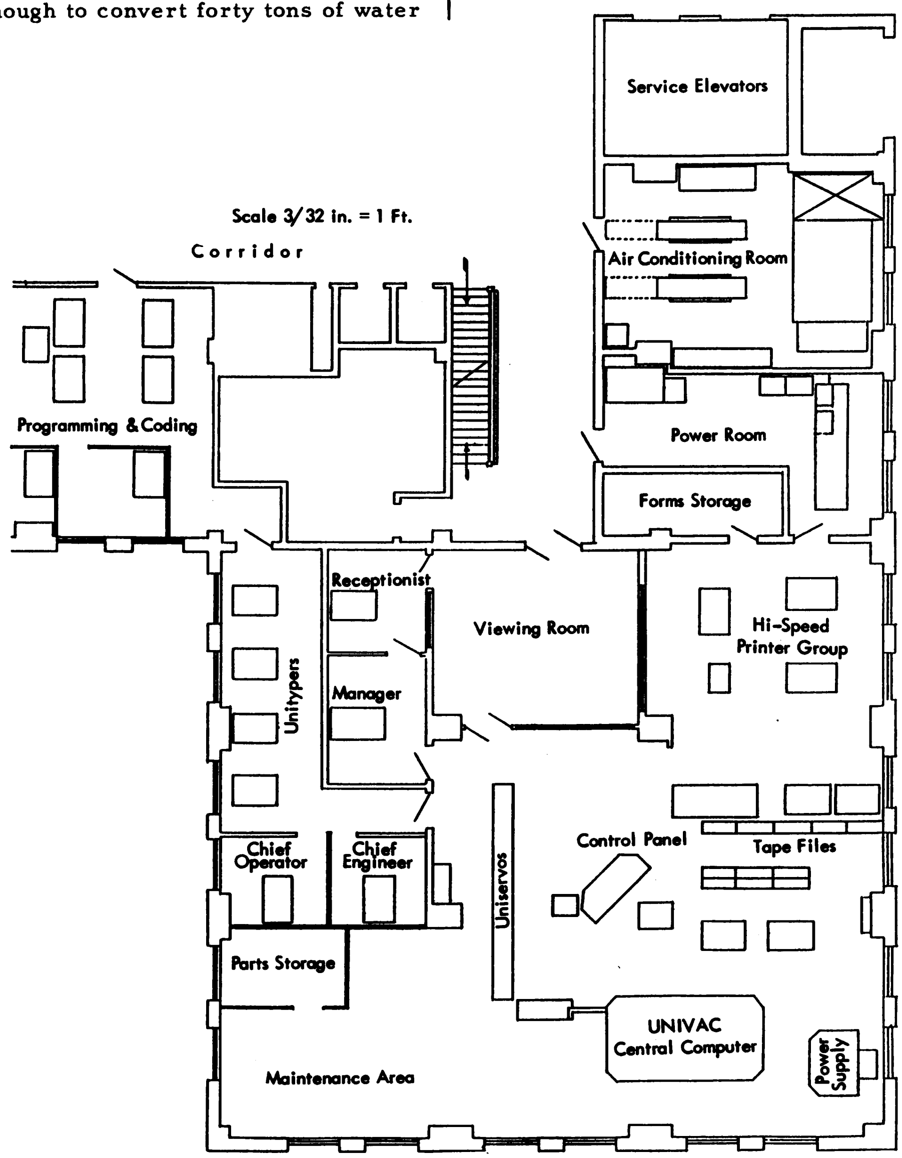
PREPARING THE SITE

At the same time that the Computer Systems Committee started work on selecting specific equipment, our Methods Department began to study the problems of space. Any company going into an electronic system is in a paradoxical situation concerning space—it must expand in order to contract! We needed about 7,000 additional square feet to house our installations, our programming group, and the thirty people we anticipated would be needed for data conversion work during the year before cut-over to the new system. And after cut-over we expect to have available in a very short time over 10,000 square feet from replaced job stations! Unfortunately, it can't be the same space.

The location finally chosen was on our fourth floor, centrally located in relation to our Ordinary insurance operating departments. Preparation of the site for the system included many problems. Structural engineers helped check out the floor-loads—the whole system weighs about 20 tons. The central computer alone weighs almost 17,000 pounds, and its 6,000 pound power supply unit comes to 295 pounds per square foot. The installation demands heavy refrigeration and power requirements—we found the services of an air-conditioning consultant helpful. Our two refrigeration units weighing six tons are each large enough to convert forty tons of water to ice every day.

It will interest you to know that actual costs of our site preparation ran nearer to $150,000 than the $85,000 we had thought was conservative. This is an area where each situation differs and the equipment manufacturer can't give you much help beyond the details of what costs have amounted to at other installations.

Figure 2 shows the layout of the actual UNIVAC installation in our Electronic Records Department. Only a small portion of the adjacent area occupied by the Programming and Coding Division is shown. You will notice that we provided a viewing room with public access to the main corridor of our building. This was done because of the tremendous public interest which has been shown in this subject. We wanted to provide an attractive place from which all working components of the system could be seen by visitors without having them actually in the working area where they might interfere with normal operations. We hope you will come in and see it for yourselves when you are in downtown Los Angeles.



LAYOUT - ELECTRONIC RECORDS DEPARTMENT

Figure 2

PREPARING THE EMPLOYEES

Everyone agrees on the importance of maintaining good communications with his employees. I believe this is especially true in the field of office automation. At the same time that we decided to make a full-scale feasibility survey in 1953, we set up a comprehensive program to orient our staff on the subject of electronic data processing. All employees were told by a member of top management why the study was being made, what it might lead to, and how they would be affected. It was emphasized to them that any jobs eliminated would be the repetitive, monotonous tasks. They were told that they would have a chance to qualify for the upgraded jobs which would be created by the machine if the study justified acquiring it. Perhaps most important, each employee was assured that even if his or her job was eliminated, the employee would be retained and relocated in suitable work at no reduction in salary.

We kept our staff informed of the progress of our study, and when a decision was reached, of the reasons for our decision to install a system. We told them of every major step in our long-range plans for converting our ordinary insurance record keeping activities from manual and punch card to tape processing methods. Educational material on electronics was a regular feature in our internal magazine. A series of lecture courses was made available for those interested. Gratifyingly, over half the staff voluntarily attended some ten hours of lectures, mostly on their own time.

When our equipment was delivered, all of our staff were invited to be "sidewalk superintendents" at the unloading operations. They watched the progress of the installing, assembling and testing operations. After the system was operable, they were all taken on conducted tours of the entire electronic records operation. Their families and friends have been invited to "open houses" featuring the installation. They have been kept informed as we have made each major step in our conversion operation.

We believe that the careful attention we paid to drawing up a thorough program of communications early in the game, to following through to be sure that it was carried out, and to amplifying it to meet changing conditions, have all paid dividends. Almost all of our people, including those who are being transferred to other work because their jobs will be eliminated, are enthusiastic about our electronics progress.

SELECTING AND TRAINING THE STAFF

When we are dependent on electronic methods for our ordinary insurance operations later this year, we expect to eliminate some 150 job stations. Before there can be any reduction in personnel, however, it is necessary to expand the total working force in order to handle the new jobs created by electronic systems. The work which is being mechanized must be fully proven on the new basis before you can discontinue the same work under old methods. This means an appreciable build-up of personnel. During parallel operations you must have the same people that have been needed under the old methods, additional people to perform the new work, and still more people to compare in detail the results of the two methods.

Pacific Mutual's electronic records work now requires a staff of 60 people and has used almost this many constantly for the past two years. Their work has been preparing for the new system—organizing and writing the series of instructions (programs) needed for the machine to perform its multitude of complex duties, converting data from manual and punch card to tape-machinable form, and learning how to operate and maintain the machine. The new jobs created by the electronic system are of four basic kinds:

Programming and methods
Clerical
Operations
Maintenance

It is axiomatic that you must select your best talent for every phase of your electronic work. When the Computer Systems Committee's recommendations to "go electronic" had been accepted and its members started their study to select the most appropriate system, we began to prepare additional personnel for the coding and programming work we knew was ahead. We believe that a person who knows the principles of programming any one of the large machines can rapidly learn to program any other machine. We explained our plans to all our employees, cautioning our managerial and supervisory staff that we were going to tap them for some of their best talent for this new work—the kind of people that "they just couldn't possibly get along without". We asked each manager to recommend some of his qualified "indispensables" for the program, and he did! Perhaps this cooperation was enhanced by the fact that individual employees, even though not included in their managers' nominations, were allowed to apply.

The first and key group of ten programmers was given two six-week courses in programming conducted by our manufacturer. For our next group of programmers we prepared a simple power test in elementary mathematics and logic as an aid to selection, then trained the successful candidates in programming, using one of our own men with programming experience as our instructor. We have found that an individual's record in his programming class is not a good indicator of what we can expect of him. Some of our better programmers today were at the borderline of acceptability as they finished their first study course.

A programmer analyzes the details of the job that is to be performed by the machine and prepares a series of coded instructions which will enable the machine to do the job in minimum time. A good programmer needs special skills. He must have an inquiring, logical mind. A background of systems analysis and a knowledge of statistical principles are desirable. College level work in mathematics, engineering or business administration is helpful—some may say essential.

Two-thirds of the thirty programmers and coders we trained were from within our own company. The others, mostly coders, were hired for the job. Eight of the total group were women. Our experience has been that it is easier to teach experienced life insurance people how to program than it is to teach experienced programmers about life insurance operations. After their formal schooling in programming techniques, our programmers required an additional six to twelve months of actual working experience before they became proficient. As you probably know, experienced programmers are very scarce and in heavy demand.

The clerical work of converting data from old records to tape form takes a staff of about 25 people in our job. This type of work requires a superior employee who is paid about 15% more than a regular typist. Typing accuracy is of even greater importance than speed. Input data for our electronic system is prepared on a special Unitypewriter which can be learned by any experienced typist with essentially no special training. About eight weeks of training time was needed to teach these typists how to read and interpret our old insurance records from which they were to type on tape.

Our operations staff is made up of six men now and will have one more later this year when we will be running the machine on a three-shift basis. Operators are mainly concerned with getting the work done and are more interested in the system's production than in its philosophy. It is difficult to put your finger on the special skills needed by a good operator. The chief operator is normally an engineering or mathematics graduate with prior experience on the appropriate kind of machine system. The rest of the staff will usually be production minded men with mechanical aptitudes. They need about two months of formal training, plus three or four months of on-the-job training. Although it has been reported that there is no correlation between good punch card machine operators and electronic system operators, three of our operators were formerly top grade tabulating men.

Maintenance work on the system requires a staff, in our instance, of six or seven men. Our chief engineer is a graduate engineer with prior experience on our kind of system. The rest of his staff are senior technicians and trainees. Much as we would like to have some graduate engineers, they are in such intense demand that they are inclined to regard this work as merely good practical experience prior to going elsewhere as chiefs, or entering design and development work. Turnover of engineers doing maintenance work on electronic systems has been very high and we believe it will be best to concentrate on on getting topflight technicians with some engineering training.

		1953			1954				1955				1956				1957
		2nd Quarter	3rd Quarter	4th Quarter	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	1st Quarter
Programming and Methods	PM	2	6	6	5	5	14	26	26	30	26	26	26	26	24	24	24
	SR							1	1	2	2	3	4	3	1½		
Operations	PM										1	3	4	4	5	5	6
	SR																
Maintenance	PM										1	1	1	1	1	6	7
	SR									1	9	7	7	7	6		
Clerical	PM						1	1	19	27	32	31	24	21	27	16	25
	SR																
TOTALS	PM	2	6	6	5	5	15	27	45	57	60	61	55	52	57	51	62
	SR							1	1	3	11	10	11	10	7½		
		2	6	6	5	5	15	28	46	60	71	71	66	62	64½	51	62

P M } Pacific Mutual

S R } Sperry Rand

ELECTRONIC RECORDS DEPARTMENT
Staff By Quarters

Figure 3

Figure 3 details the extent of the personnel build-up in Pacific Mutual's Electronic Records Department by quarters for the past four years. Shown separately are Pacific Mutual Personnel and employees of Remington Rand, the manufacturer, who were assigned full time to this installation during the testing period before we accepted the equipment. Separate figures are shown for programming and methods work, operations, maintenance, and clerical activities which are mainly concerned with the conversion of data to machinable form.

You will notice that our electronics staff and the manufacturer's personnel assigned to us both reached their peak in the third quarter of 1955 when the equipment was actually installed. The total number has since then remained fairly constant up to the present time except for a reduction in the clerical staff late last year when our data conversion work got a little ahead of our programming.

The figures in Figure 3 relate to personnel required for our basic application—our ordinary insurance operations. This application, with its consolidated functions approach, requires many times as many programming steps as would be needed by a larger company with a single application, such as payroll accounting or insurance billing. The number we will need for programming and clerical work on our basic application is expected to drop appreciably in the latter half of this year. It is then our intention as programming staff becomes available to assign them to the study of other applications, such as group premium billing, group experience rating calculations, mortgage loan accounting and general accounting.

THE FUTURE OF ELECTRONIC DATA PROCESSING

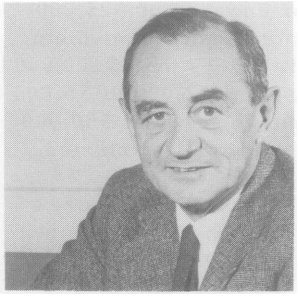
This has been the story of the planning behind one of the more than seventy large size electronic data processing systems installed and in use today. Each costs more than a million dollars or rents for upwards of $25,000 monthly. In addition, there are more than 500 medium size computers, costing from a little less than $100,000 to as much as $400,000, or renting for $2,000 to $6,000 monthly. Small size computers costing around $50,000 or renting for $1,000 monthly are just getting started, with some fifty installations already in operation. There are perhaps a thousand additional systems of all sizes on order. Thousands of other firms are studying to see whether they should adopt these new methods.

All of these business installations have been made in a brief period of five years, and more than 90% of them in the past two years. I believe there will be even greater growth in the use of these new office methods in the next five years for three main reasons. First, they are a means of reducing costs. Second, they replace clerical jobs, and there is today a serious shortage of clerical workers. Third, and perhaps most important, they provide more and better management information.

Many of you undoubtedly are active in this field already. The chances are that if you are not, you will be in one way or another in the near future. I hope some of our experiences may be useful to you. I would like to emphasize a few major points:

- Each company should study its own methods and needs;
- Long range planning of every step is essential;
- Keep your people informed;
- Anticipate conversion problems, particularly errors in present records;
- Be willing to spend more time, and money, than the plans indicate;
- Use your very best people at every stage.

For those of you who are or will be engaged in this new field, you have interesting experiences ahead—experiences that I'm sure will frustrate you occasionally, stimulate you often and challenge you always.



PHYSIOLOGICAL APPROACH TO PROBLEMS OF WORK MEASUREMENT

Lucien A. Brouha, M.D.
Haskell Laboratory for Toxicology and Industrial Medicine
E. I. du Pont de Nemours and Company
Wilmington, Delaware

At present, work measurement is based on time study, predetermined "motion-times" and standard data. There is no doubt that these methods have been and still are very useful. In most instances the energy expenditure necessary to accomplish a task is not measured, which leaves the assessment of human effort up to the judgment of an observer. Consequently inconsistencies and errors can occur; and even though progress has been achieved, one should not take for granted that a satisfactory solution to the problem of human utilization in industry has been found.

Work and rest standards as they are now established are more or less arbitrary. They do not take into account the efficiency and the power of the worker's muscles, heart and lungs; they do not necessarily represent the time needed to perform an operation with a minimum physiological cost and a maximum efficiency of production; they represent even less the time needed to insure an adequate recovery between successive operations. The "physiological cost" of jobs should be measured because it is the only accurate means of determining human effort and it should be kept within safe limits. This is an essential factor in job organization, in job evaluation, in the selection of workers and, as a consequence, in labor-management relations.

Numerous experiments have been performed to study the physiological effects of muscular work of varying degrees of intensity. It is known that, when shifting from a resting condition to one of physical activity, many physiological functions change from their "resting level" to a "working level." Heart rate, blood pressure, cardiac output, pulmonary ventilation, oxygen consumption, chemical composition of the blood and urine, body temperature, and rate of sweating are all modified by muscular activity.

By measuring one or more of these variables during activity it is possible to determine by how much the "working level" differs from the "resting level." This gives an estimate of the degree of physiological stress experienced in performing a given task. After activity ceases it is possible to follow the return of these variables to the "resting level" and to determine the duration of the "recovery period", at the end of which the individual is back to the preactivity physiological equilibrium. In order to evaluate the physiological expenditures involved in a given job one has to take into account not only the physiological reactions during work but also those during the recovery period. In other words, from the human point of view, a complete "work cycle" includes the physiological cost of work plus the physiological cost of recovery since, when mechanical work stops, physiological work continues above the resting level until recovery is completed.

The question now arises: what physiological reactions should be used in work measurement? The determination of oxygen consumption and/or heart rate changes are the most reliable and the most practical methods. All muscular activity requires the consumption of oxygen above the resting level. This additional oxygen requirement is proportional to the intensity of work per unit of time and to the duration of work. Energy expenditure for any specific activity over a definite period of time can thus be calculated and is expressed as oxygen consumed or as kilo-calories per minute. This technique has been used extensively and the average energy expenditure has been measured for a great number of industrial operations. Tables have been computed which permit one to estimate daily energy expenditure. With the help of a few metabolic measurements, these estimates can be accurate within 10 per cent.(1) In spite of its usefulness this method has several drawbacks in practical industrial applications. The equipment is rather clumsy and uncomfortable to wear; the number of workers who can be studied in a given situation is limited because the apparatus is expensive and the procedure is time consuming; it requires qualified technicians to collect and analyze the samples of expired air from which the oxygen consumption is calculated. Furthermore, additional factors of physiological stress, such as heat and clothing, cannot be evaluated by oxygen consumption alone. The result is that, in many industrial operations, measuring oxygen consumption gives only a partial picture of the total physiological cost.

On the other hand, heart rate values during work and during recovery from work are now recognized as being an accurate means of evaluating physiological cost. The heavier the load, the greater the energy expenditure and the faster the heart rate.(2)(3)(4) During exercise "the pulse curve alone quite accurately depicts the physical state".(3) It has also been shown that the behavior of the pulse rate after muscular exertion depends on the work load and the duration of effort.(5) For a constant duration of activity, the greater the work load per unit of time the longer will be the recovery to the resting heart rate. For a constant work load per unit of time, the longer the duration of muscular activity the longer will be the recovery of the heart rate to its resting level.

In addition the heart rate is influenced by the heat dissipating mechanisms of the body, and it varies during work and during recovery according to the environment in which the work is done and to the clothing worn by the worker. Consequently the working level of the heart rate is determined by the work load, the environment in which the work is done and the physical capacity of the individual. The heart rate recovery to the resting level also depends upon these various factors and is proportional to the stress experienced during work. By measuring the time it takes to recover from work, a situation leading to physical fatigue can be evaluated.

A man who cannot recover to a satisfactory level between work cycles will present increasingly higher physiological reactions as more work cycles are performed and fatigue will develop as the shift progresses. If fatigue is not too severe, it will completely disappear during the interval between two shifts and the man will report to work with a normal resting level of physiological reactions. If the work load is greater, the interval between shifts may not be long enough to insure complete recovery and accumulated fatigue over days, weeks or months may occur. It is, therefore, essential to evaluate with reasonable accuracy the recovery time or "physiological rest allowance" for industrial operations. The work time can be accurately assessed by a stop watch, but without physiological measurements the recovery time cannot be determined.

If the physiological cost of a given job in a given environment is to be estimated, the reactions of the workers doing the job must be studied. Not only the average reactions but also the range of reactions must be determined in order to obtain precise information.

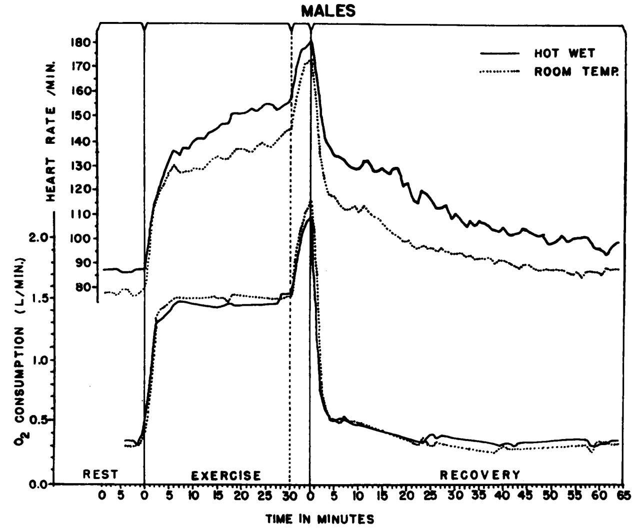
The variability of human adjustment to a standard stress situation is seldom appreciated and can be illustrated by the following example. Students at Harvard College were given a physical fitness test known as the "Harvard Step Test".(6) Over two thousand healthy students participated in the experiment. This group included men of low physical efficiency as well as varsity athletes in excellent condition. It was found that the capacity to withstand the stress of hard muscular work was ten times as great in the fit as in the unfit.(7)

Even in a more restricted and highly selected group of varsity and junior varsity trained athletes, the best men were able to perform hard physical work twice as efficiently as their less fit colleagues. These results emphasize, quantitatively, the well-known fact that men vary markedly as far as their physical capacity is concerned; and that, even in trained and selected groups, wide variations are found in the physiological price that individuals have to pay to accomplish a given task.

The physical capacity of the individual is the result of numerous factors such as the innate potential of physiological mechanisms, age, health and nutritional status, sex, specific fitness for a given job and for given environmental conditions. These factors exist in any industrial population, and similar differences have been found among workers.(8)

Considering the range of individual differences that may occur in the same industrial situation, it is obvious that the usual techniques of work measurement are unable to evaluate, even grossly, the physiological cost of a given job. It is also obvious that no observer, regardless of how competent he is, will be able to formulate a sound and quantitative estimate of human effort by using judgment alone. The lack of precise knowledge about the workers' physiological reactions to the job is probably the most fundamental criticism that can be applied to the classic methods of work measurement.

1. Subjects were pedalling a bicycle ergometer against a known load in a room where the temperature and humidity were strictly controlled. Among other variables heart rate and oxygen consumption were recorded continuously before, during and after exercise. During the first thirty minutes of exercise the work load was 540 kilogram-meters per minute. Then the load was increased to 900 kilogram-meters per minute for four minutes. After the end of exercise the recovery processes were followed for sixty-five minutes. These experiments were performed under two different environmental conditions; namely, 72° F and 50 per cent relative humidity and 90° F and 82 per cent relative humidity.



Heart rate and oxygen consumption variations during exercise at two work loads and during recovery. These experiments are performed in two different environments.

Figure 1

Figure 1 presents the average curves calculated for six different male subjects. It shows the immediate increase in heart rate and oxygen consumption which takes place as exercise begins. As the moderate work at low temperature progresses there is a slight increase of the heart rate, but the oxygen consumption remains at a steady level. As soon as the work load becomes heavier, heart rate and oxygen consumption increase immediately and keep increasing until the end of exercise. During the recovery period the oxygen consumption returns to the resting pre-exercise level after twenty-five minutes; the heart rate diminishes less rapidly and is still well above the resting level after sixty-five minutes of recovery.

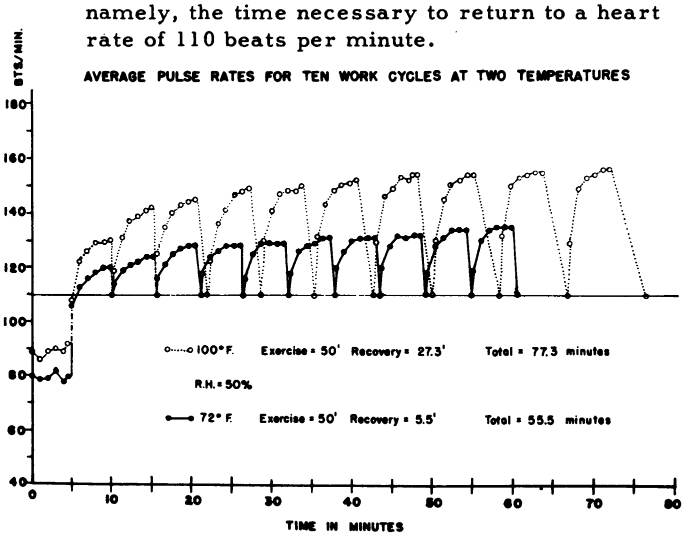
When the experiments are repeated at higher temperature and humidity, the heart rate increases definitely more than at lower temperature both during moderate and heavy exercise. It also remains at a higher level throughout the recovery period. On the other hand, the changes in oxygen consumption are similar to those observed at the lower temperature and the slight difference between the two curves is not significant either during exercise or during the recovery period.

In addition to the well-known fact that heart rate and oxygen consumption vary with the work load, these experiments show that oxygen consumption was not affected by the environmental conditions in which the exercise was performed. On the other hand, heart rate was definitely higher when the stress produced by a warmer and more humid environment was greater, and therefore it appears to be a more faithful index of physiological cost.

In such experiments it is obvious that the usual methods of work measurement could not accurately evaluate the strain produced by the work loads and by the environments nor the physiological cost and the time it takes to recover after work.

2. The influence of repeated work cycles and of increasing dry bulb temperature is illustrated by the following experiment.

Subjects wearing shorts were pedalling a bicycle ergometer against a standard work load. The heart rate was recorded continuously. The test consisted in working for five minutes, waiting long enough for the subject to recover to a heart rate of 110 beats per minute and then performing another five-minute work period. In this experiment the "rest allowance" between two successive work cycles was not determined, as usual, by the stop watch but by a physiological reaction; namely, the time necessary to return to a heart rate of 110 beats per minute.



Heart rate and recovery time for a standard amount of work performed under similar conditions at two different temperatures.

Figure 2

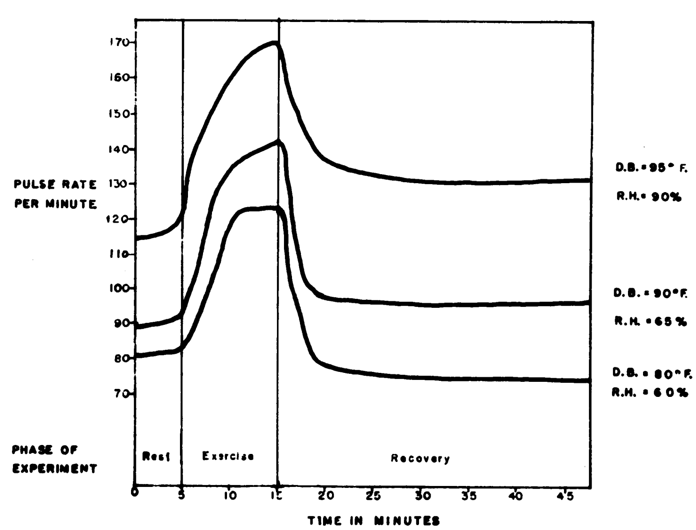
A total of ten successive work periods was performed, keeping the humidity constant at a relative humidity of 50 per cent and with a dry bulb temperature of 72° F and 100° F respectively.

Figure 2 gives the average heart rate curves obtained under these two environmental conditions. The heart rate during work is definitely faster and the recovery time longer when the temperature is higher. For performing the same total amount of work and recovering to the same physiological level after each work period, it takes about fifty-five minutes at 72° F and seventy-seven minutes at 100° F. When the recovery times alone are compared, their total is 5.5 minutes at 72° F and 27.3 minutes at 100° F. In industrial situations where similar factors are involved no work measurement based on time study alone would be sufficient either to estimate the difference in physiological strain or to adjust adequately the rest allowances when the temperature in the shop varies from 72° F to 100° F.

3. When humidity increases, evaporative cooling decreases rapidly, thus reducing the ability of the body to dissipate heat. Under these conditions high heart rates, high body temperatures, and very slow recovery after work result in pronounced fatigue.

Changes in heart rate were observed before, during and after a standard amount of work at various temperatures and humidity. For the higher range of temperature and humidity the recovery from work was shown to be incomplete and to remain so for as long as thirty minutes after the end of work. Complete recovery is impossible when the surrounding atmosphere is too warm and too humid, and fatigue appears rapidly under such conditions (see Figure 3). Here again

HEART RATE BEFORE, DURING, AND AFTER A STANDARD EXERCISE FOR VARIOUS ENVIRONMENTAL CONDITIONS

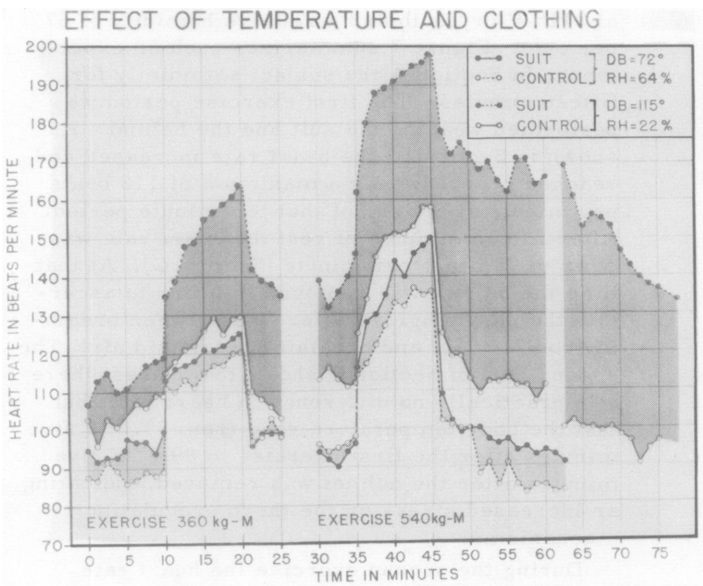


Heart rate before, during, and after a standard exercise for various environmental conditions.

Figure 3

physiological data are needed in order to evaluate properly the additional stress produced by high humidity.

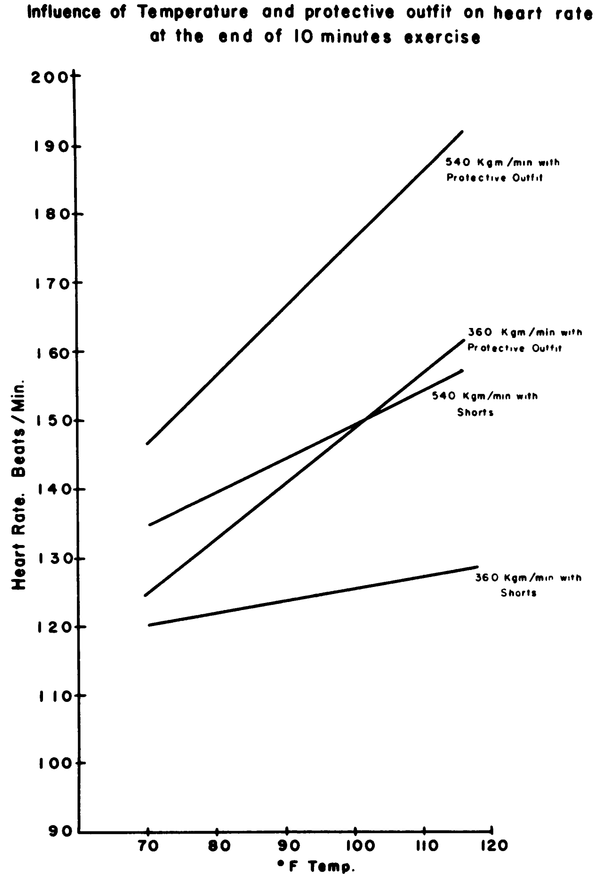
4. The additional stress produced by wearing a special kind of protective clothing was also studied. The subject performed two ten-minute periods of work at 360 and 540 kilogram-meters per minute, respectively, separated by a fifteen-minute resc period. Various environmental conditions were used and two tests were run under each of them. In the first the subject wore only shorts and in the second he wore the protective outfit. Heart rate was recorded continuously during work and during the recovery periods.



Relation between heart rate, environmental temperature and clothing during two grades of muscular work.

Figure 4

Figure 4 compares the results that were obtained at the two extreme environmental conditions tested with and without the protective clothing. The lightly shaded areas between the two lower curves represent the stress added by the clothing at 72° F dry bulb and 64 per cent relative humidity for the two grades of work. One can see that, during the second exercise period with a heavier load, the difference in heart rate observed with the two types of clothing became definitely greater than during light exercise. The heart rate recovery was definitely slower when the protective outfit was worn. The darkly shaded areas between the two upper curves show the same phenomenon under the most adverse environmental conditions explored in this research; namely, 115° F dry bulb and 22 per cent relative humidity. The stress produced by the protective outfit was considerably greater than under less severe conditions and particularly so with the heavier load and during the following recovery period. In addition to the difference in cardiovascular reactions it was also found that body temperature increase and sweat loss were always definitely greater when wearing the protective outfit.



Relation between heart rate, environmental temperature and clothing during muscular work.

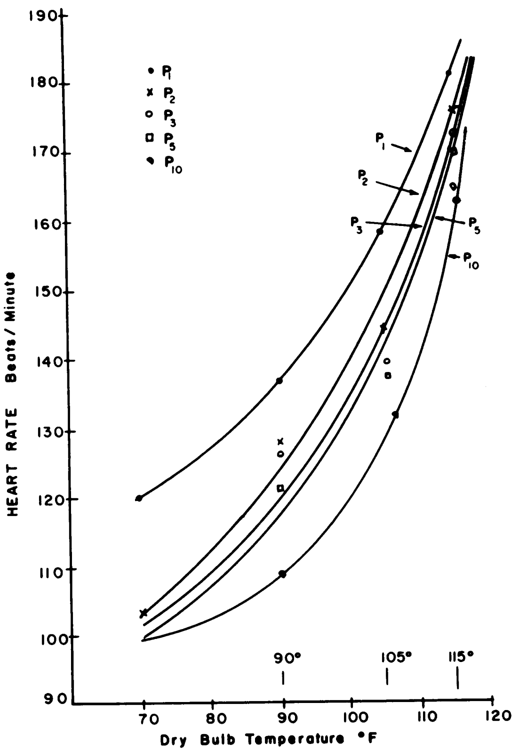
Figure 5

Figure 5 summarizes the results obtained in all the preceding experiments when the maximum heart rates observed during work are plotted against temperature. It shows a rectilinear increase in peak heart rates with increasing temperature for light and medium work while wearing shorts or the protective outfit. The slopes are considerably steeper for those experiments in which the outfit was worn, indicating that the "clothing stress" becomes a more and more important factor in determining the physiological reaction of men working in progressively warmer environments.

Figure 6 shows the relation between temperature and the pulse rates measured during recovery one, two, three, five and ten minutes after cessation of work. These latter are designated by P_1, P_2, P_3, P_5 and P_{10} respectively. It appears that the relation becomes curvilinear and that the recovery processes immediately after work become rapidly slower and more costly as the temperature increases.

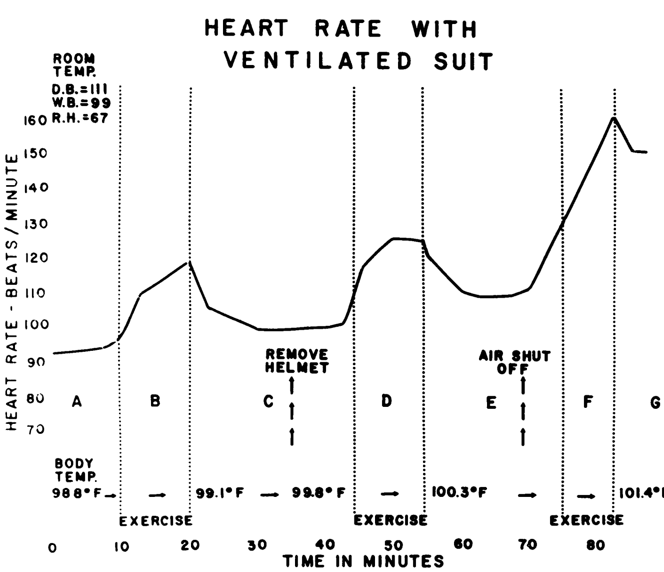
These experiments show clearly that physiological measurements are needed in order to evaluate the stress produced by clothing during work and during recovery in various environmental conditions.

Influence of Dry Bulb Temp. on Heart Rate Recovery Curves



Relation between heart rate and environmental temperature during the recovery period after work.

Figure 6



Variations in heart rate and body temperature during work and recovery with the ventilated suit and helmet, without the helmet and without the ventilation.

Figure 7

5. Physiological measurements are also essential to evaluate the stress reduction obtained by improvements of the working conditions.

The following experiments illustrate this statement. In certain industrial operations in which the workers are exposed to high heat, it is often impossible to improve sufficiently the situation by shielding the sources of heat, increasing the ventilation or cooling the area. Research carried out at Haskell Laboratory led to the development of a permeable ventilated suit and helmet designed principally to protect the workers from extreme heat.(9)

A series of tests were made in the Laboratory at 111° F dry bulb and a relative humidity of 67 per cent. Figure 7 summarizes such an experiment. In Section A the subject sat quietly for fifteen minutes. The first exercise period was performed wearing the suit and the helmet. As shown in Section B, the heart rate increased and reached progressively a maximum of 118 beats per minute at the end of that ten-minute period. After fifteen minutes of rest the heart rate was down to 98 beats per minute (Section C). At that time the helmet was removed in order to ascertain the physiological difference between breathing cool dry air and breathing hot humid air. The second part of Section C shows that at rest there was practically no difference in heart rate, but that the body temperature rose from 99.1° F five minutes after the first exercise to 99.8° F five minutes after the helmet was removed, indicating an increased stress on the thermoregulating mechanisms.

During the second exercise the heart rate reached a maximum of 125 beats per minute (Section D). During the recovery period (Section E) the heart rate went down to 108 beats per minute in fifteen minutes, i.e., 10 beats higher than after the first exercise. Body temperature rose to 100.3° F five minutes after exercise. Higher heart rate during exercise, slower heart rate recovery and higher body temperature indicate that the stress was greater without the helmet than with the helmet.

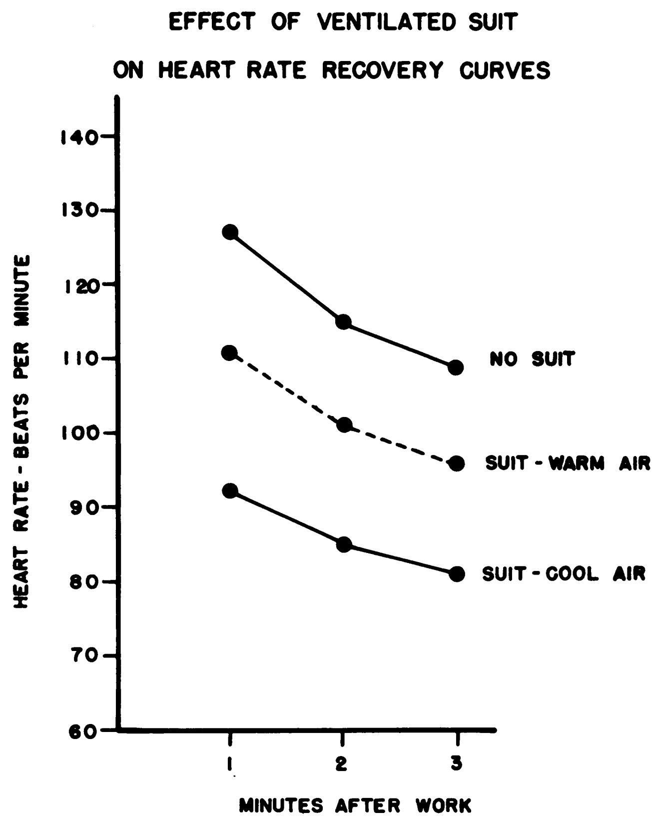
After fifteen minutes' rest the air ventilating the suit was shut off and the subject suited but without helmet, was exposed to the environmental conditions of the room. The second part of Section E illustrates the immediate increase in heart rate that occurred while the subject was sitting motionless. From 108 beats per minute the heart rate increased steadily to 130 beats per minute before the start of the third exercise period. Exercise produced a further and very marked increase in heart rate reaching a maximum of 162 beats per minute at the eighth minute of exercise. The work became so uncomfortable that the subject was unable to complete the ten minutes of the regular exercise period. (See Section F) The heart rate remained at 150 beats per minute for five minutes after the end of exercise. At that time the body temperature had reached 101.4° F, and the subject, feeling dizzy, was taken out of the hot room.

This experiment showed that with the helmet and the suit ventilated the work could be done easily and the recovery was satisfactory. Removing the helmet and allowing the subject to breathe hot and humid air definitely increased the stress on both the cardiovascular and thermal-systems. Eliminating the air supply to the suit increased the stress considerably and made the work so uncomfortable that the test could not be completed.

On the basis of these experiments, the air-conditioned suit was tested in industry. Successful trials were made in various jobs involving manual labor and exposure to extreme heat.[9] Figure 8 gives an example of the reduction of heart rate reactions obtained by using the ventilated suit. Here again it is obvious that without physiological measurements no accurate evaluation could be made of the strain experienced by the workers under these various conditions.

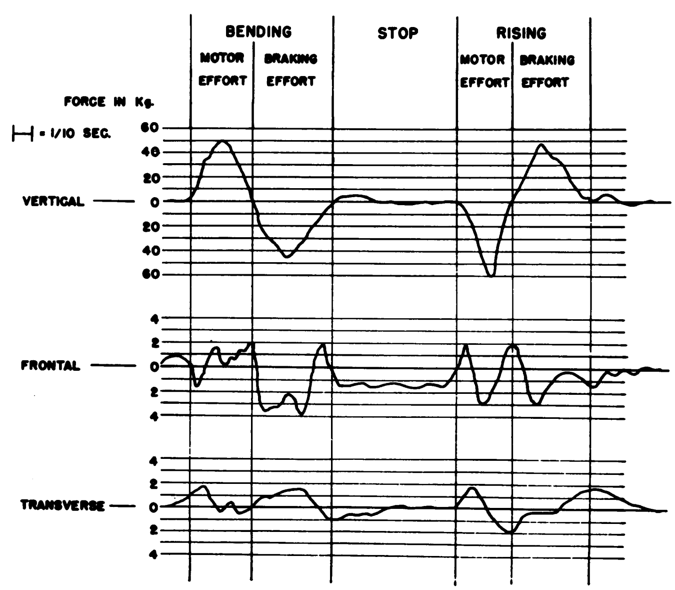
From the point of view of work measurement the general conclusion of such experiments is that time studies combined with good judgment will not enable one to evaluate the physiological reactions of the worker to the job when variables such as temperature and clothing enter the picture. Even if the energy expenditure can be assessed within reasonable limits from existing tables,[1] the true physiological cost remains unknown unless physiological measurements are made during the recovery period. A simple method for making such measurements has been previously described[8][10] and has been successfully used over the last fifteen years to estimate the physiological strain in a number of industrial operations.

The physiological considerations that have been discussed so far in relation to work measurement apply only to work of sufficient intensity and duration to produce reactions that are measurable by the usual physiological techniques. If the work is too short or too light, other methods have to be used. Among them the "force platform", designed by L. Lauru, has proved very valuable in measuring the efforts involved in performing motions.[11] These measurements are made through sensing elements which are piezo-electric quartz crystals developing a dielectric polarization when they are compressed. The compression of the quartz crystals is only a few microns and forces from a fraction of an ounce to several tons can be measured. A triangular and very rigid platform permits the location in space of the various quartz crystals so that they can simultaneously pick up force phenomena arising vertically, frontally and transversally. These are amplified and recorded. With the subject on the platform, the whole system is balanced to zero. As soon as the subject moves, the piezo-electric quartz crystals registering in the three dimensions are submitted to pressure variations. The pressure variations are proportional to the forces applied to the body by the neuromuscular system, and these forces are a measure of the effort required to perform a specific work.



Average heart rate recovery curves of workers performing the same operation in very hot surroundings with their usual work clothes, with the suit ventilated with air at 90° F and with the suit ventilated with air at 70° F.

Figure 8



Forces involved in bending the knees and straightening up as recorded by the Lauru Platform in the vertical, frontal and transverse components.

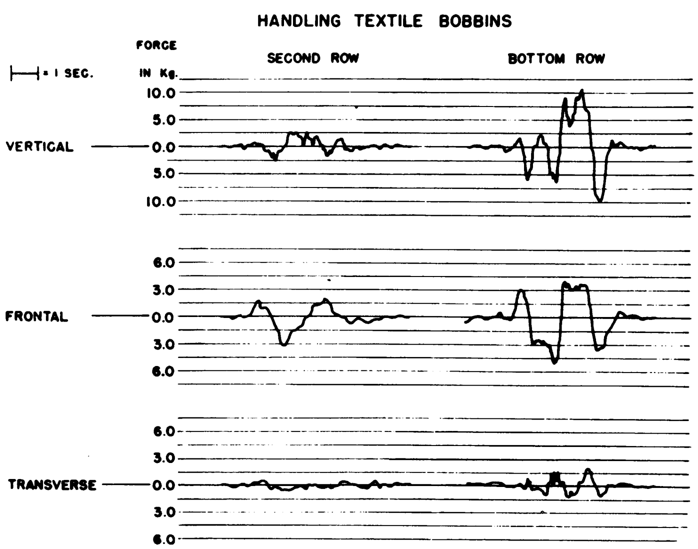
Figure 9

Figure 9 shows a record obtained for the three components: vertical, frontal and transversal, when the subject bends the knees, stops and then straightens up to an upright position. It may be seen that bending involves active forces from muscles displacing the body downwards and braking forces from the antagonist muscles which control and finally stop the motion. Straightening up also involves an active effort and a braking effort which produce a typical diphasic curve. During any motion the apparatus continuously and quantitatively records all the dynamic forces and shows all the elements of the motion studied. It is possible to demonstrate by this method of analysis that, of the various motions capable of producing the same final result, some require less expenditure of bodily forces than others. For any mechanical work performed, there is one motion which is the most efficient and which is physiologically the most economical. By adopting these economical motions, jobs can be improved and solutions can be found which in each case represent the best functional conditions. The workers can then accomplish their task with a minimum expenditure of physiological effort, thereby experiencing less strain and fatigue. In jobs involving repetitive motions, it is possible to determine the most economical speed. It is the one at which the various muscles are functioning at the lowest cost as indicated by the least force required. When a motion involves weight transport, the weight helps the motor forces or the braking forces according to the direction of the motion, and the mechanical work produced is not proportional to the physiological effort resulting from the muscular contractions. A given mechanical work expressed in foot-pounds may correspond to muscular efforts that are quite different according to the way of doing the work, according to the weight involved and according to the speed of motion. Such experiments demonstrate that the external work produced is only one factor in the study of fatigue and that "fatigue allowances" based exclusively on external work are misleading. By definition they do not take into account the braking forces acting in every motion. These forces which represent a mechanical loss in the total performance participate, nevertheless, in the physiological cost of any muscular activity and are, therefore, a contributing factor to fatigue and to the duration of the recovery period.

When the various motions performed in a job are studied, a complex curve is obtained which is always the same under identical conditions of performance. The amplitude of the recorded forces is proportional to the corresponding efforts, whether they are producing or braking the motions.

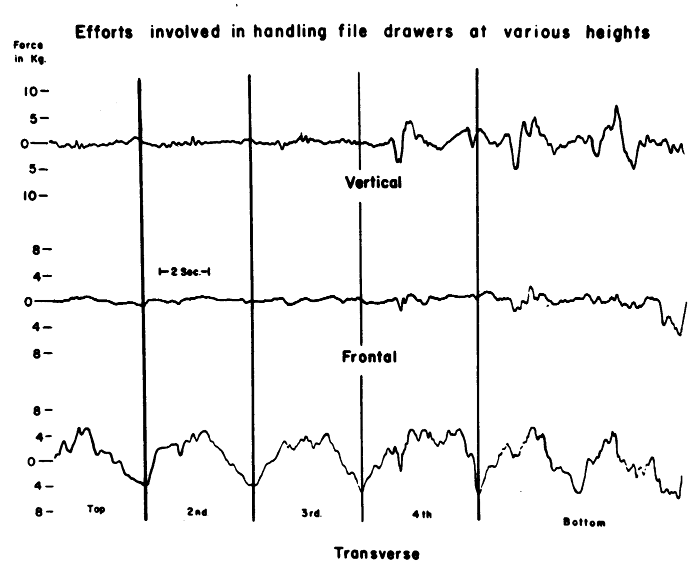
The geometrical conditions under which motions are performed to achieve a specific result have a definite influence on the forces involved. As an example, Figure 10 shows the efforts produced in the three dimensions while loading textile bobbins at various heights on a special buggy mounted with five rows of pegs. As recorded, loading the second row does not require much effort and comparable results are obtained while loading the first, the third and the fourth row. On the other hand, loading the fifth row at the bottom of the buggy involves bending the knees and straightening up. It is clear that the forces involved in that motion are considerably greater and consequently, loading the fifth row is not economical. It requires more energy expenditure than loading the other four rows and is an important factor of physiological stress and fatigue in the over-all operation.

Another example, given in Figure 11, compares the efforts needed for opening and closing the five drawers of a standard filing cabinet. The efforts necessary to accomplish these operations vary according to the height at which the drawers are located. The total efforts calculated from the three components are the same for the top and for the second drawers and amount to 16 kilograms. They increase to 21 kilograms for the third, 30



Forces involved in handling textile bobbins at various heights.

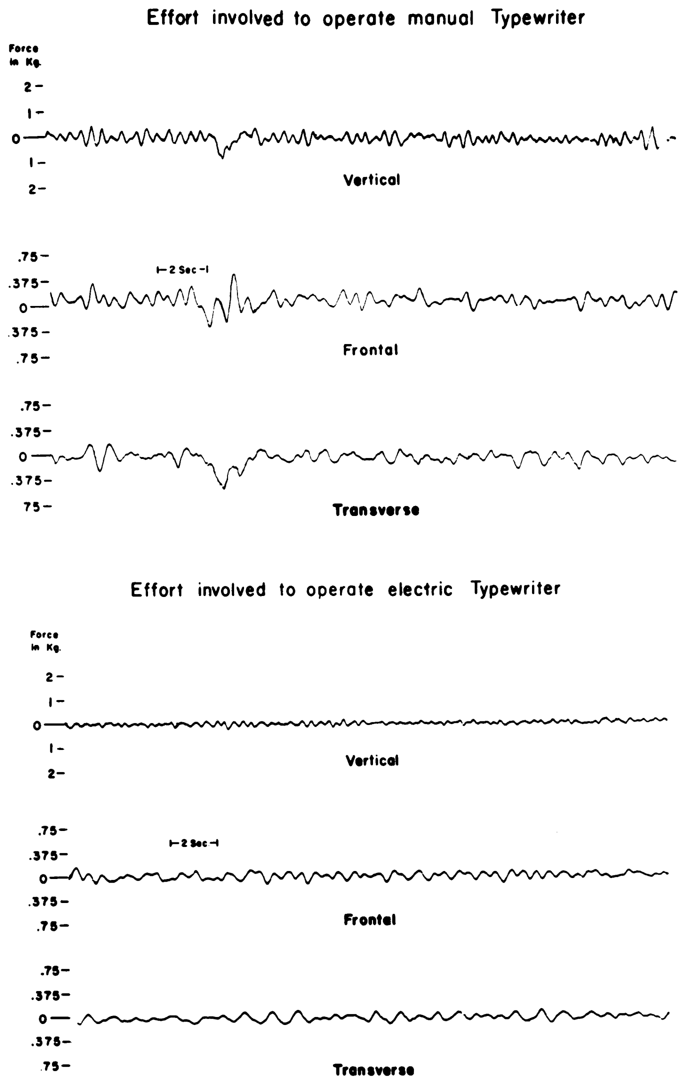
Figure 10



Forces involved in opening and closing filing cabinet drawers at various heights.

Figure 11

kilograms for the fourth and 42 kilograms for the bottom drawer. Consequently, using the bottom drawer is definitely the least economical. It necessitates stooping and rising which require the action of important forces and a comparatively large expenditure of energy.



Forces involved in operating a manual and an electric typewriter. Same typist and same text.

Figure 12

In order to show how delicate the method can be, Figure 12 compares two records of the forces developed by the same typist, typing the same text on a manual typewriter and on an electric typewriter. The total efforts calculated from the three components are reduced by approximately 50 per cent when the electric machine is used.

The preceding examples lead to the conclusion that physiological techniques should be introduced in work measurement. It should be realized that from a practical point of view, the problem is not simple. It will be solved only if a well coordinated and systematic program is developed to determine, first, the physiological cost of basic industrial operations. Later on, more specialized jobs and environmental conditions will have to be studied so that, progressively, the physiological cost of most occupations will be known. A new branch of the scientific study of man must be built up; namely, "industrial physiology" or, in an even broader scope, "occupational physiology." When that is done we will be able to evaluate precisely the human element in any given job and to establish, on a sound basis, the time sequence of work cycles and rest periods that achieve maximum efficiency at minimum physiological cost. The results will prove, disprove or correct the basic values of predetermined motion time data frequently used in work measurement. In due course it will be possible to replace the notion of "mechanical work cycle" by the concept of "physiological work cycle." The latter includes not only effort per unit of time multiplied by duration of operation but also the physiological recovery time. This will give a more accurate picture of the effort required by the worker and will furnish quantitative data for estimating fatigue which remains an essential factor in the utilization of human labor. When more information is available, it will be possible to formulate laws of physiological economy of performance which may not necessarily coincide with motion economy as it is now understood.

As long as work organization and production standards are established without considering the physiological reactions of the workers, no real solution to the problem of human labor will be found. It should be pointed out that frequently grievances and strikes originate in poorly established work standards. The judgments of the industrial engineers and that of the workers are not always in accord as to what should be considered a "fair day's work." In the absence of factual data permitting precise evaluation of what a worker can do within safe physiological limits, time consuming discussions arise. They usually end in a compromise which quite often is unsatisfactory to both management and labor.

On the other hand, when information on the physiological reactions of the workers to a given job is available, there is a sound basis for discussion, and scientific facts can be used to reach a reasonable solution. Such situations have occurred and the use of physiological data has led to job reorganization that has been well accepted by the employers and the employees. The adoption of physiological techniques will help work measurement become a science rather than an art.

BIBLIOGRAPHY

1. Passmore, R. and Durnin, J. V. G. A., Physiological Reviews, Vol. 35, page 801, 1955.

2. Hill, A. V. and Lupton, H., Quarterly Journal of Medicine, Vol. 16, page 135, 1923.

3. Bock, A. V. et al., Journal of Physiology, Vol. 46, page 149, 1928.

4. Dill, D. B. and Brouha, L., Travail Humain, Vol. 5, page 1, 1937.

5. Johnson, R. E., Brouha, L., and Darling, R. C., Revue Canadienne de Biologie, Vol. 1, page 491, 1942.

6. Brouha, L., Graybiel, A., and Heath, C. W., Revue Canadienne de Biologie, Vol. 2, page 86, 1943.

7. Brouha, L., Fradd, N. W., and Savage, B. M., Research Quarterly, Vol. 15, page 211, 1944.

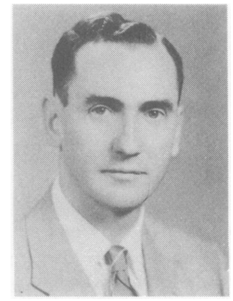
8. Brouha, L. and Ball, M. V., Revue Canadienne de Biologie, Vol. 7, page 479, 1948.

9. Brouha, L., Transactions 12th Meeting of the Industrial Hygiene Foundation, Pittsburgh, Pennsylvania, November 1955.

10. Brouha, L., Advanced Management, January 9, 1954.

11. Lauru, L., Travail et Methodes, December 1953, January 1954.

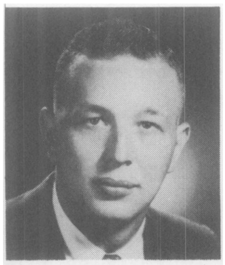
SEMINAR ON AUTOMATIC DATA PROCESSING



Richard G. Canning
Canning, Sisson and Associates
Los Angeles, California

BERKELEY PANEL

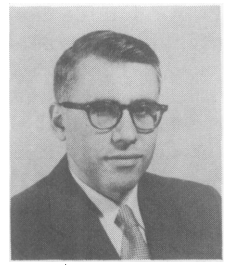
Richard H. Baker
Stanford Research Institute
Stanford, California



John W. Haanstra
IBM Engineering Laboratory
San Jose, California

Jay H. Herrett
California Packing Corp.
San Francisco, California

LOS ANGELES PANEL



Andrew J. Clark
The Rand Corporation
Santa Monica, California

Harry T. Larson
Aeronutronic Systems, Inc.
Glendale, California

Bruse Moncreiff
The Garrett Corporation
Los Angeles, California

Both panel sessions were concerned with answering questions posed by the audience. Following is a brief resumé of some of the questions discussed.

1. What is control data? How to determine what is the necessary data and how much of it will be needed?

During the course of the discussion, it was pointed out that this question might better be posed to a panel on Operations Research than to one on automatic data processing. Someone in management must determine what actions the organization must take, and set up the rules for deciding on those actions. Procedures are needed for measuring the action actually taken by the organization, and comparing it with the prescribed action. Operations Research studies are generally concerned with an analysis of these decision areas, to the extent that the necessary types of information can be identified.

A systems study for installing electronic data processing helps to determine the necessary control data. The systems engineer, in drawing flow charts of the information flow within the organization, actually is creating a model of the organization. This gives him an understanding of the workings of the organization, so that he begins to see requirements for control data, among other things. However, this definition of control data is possibly not as accurate as would be developed under an operations research study.

2. What are the advantages and disadvantages of paper tape and punched cards for EDP input?

The main advantage of paper tape is that it is suitable for use on existing communications channels. Its major disadvantage is that data cannot be rearranged easily. Punched cards have the advantage of easy manipulation of unit records (such as sorting) and well established verification procedures. They are not as well suited for use with existing communications systems.

The question apparently was brought up in the hope of obtaining a good general answer, picking one means over the other. The discussion pointed out that the systems plans would determine which would be selected. And the systems plans should be developed after a thorough study of system requirements. There is no general answer as to which is best.

In fact, it was pointed out that other forms of input, such as direct to magnetic tape or direct to the computer, must also be considered.

There was a brief but interesting discussion of random access memories, with the IBM 305 RAMAC as the center of discussion. For such operation, input data need not be sorted but may be taken in the sequence (in-line) in which the data is generated. In such a system, however, an index must usually be employed, and the method of sorting the index in the 305 was discussed.

3. How do you go about selling an EDP program to management?

Again, the discussion brought out the desirability of making a systems study, to determine the data processing requirements of the organization. Knowing the requirements, it is then possible to lay out a new system to meet those requirements. The problem of how to sell management on authorizing a systems study in the first place was not discussed.

It was pointed out that, once the overall systems plans were developed, it is usually desirable to break the installation up into phases, and then try to sell management one phase at a time.

4. To what extent may middle management be employed as systems analysts?

The result of the discussion was that middle management could be used effectively as systems analysts. However, there is a real need for training such men, before they can become effective systems analysts. The value of an outside agency to aid in the selection and training of the company "team" was discussed. In other cases, special in-plant courses were given.

California Packing Corporation used several methods for the training of their EDP personnel. An outside lecturer was brought in for a series of lectures on the subject. Selected personnel attended courses presented by computer manufacturers and by universities. Personnel were selected from within the company, and most had over five years prior experience with the company. During their interviews with other company personnel, these people helped to spread interest in the electronic system.

5. Can EDP be used for medium and small businesses?

The discussion brought out that prior to the IBM 305 RAMAC, monthly rental on a complete electronic data processing system would run in the neighborhood of $15,000 per month for single shift usage, and the preparation costs for such a system would be in the neighborhood of $600,000 before savings would begin to materialize. The larger systems would cost many times more, with rentals up to about $60,000 per month and preparation costs of well over $1 million. For the smaller systems, a rough rule-of-thumb might be that there should be 150 clerical jobs that the electronic system might affect, of which about 75 might be replaced by the electronic system, if the major costs of the system are to be paid by clerical savings. These factors imply at present that not many medium and small businesses will install their own EDP systems until costs come down.

It was pointed out that preparation costs might well be brought down through greater use of standard programs—e.g., input, output, editing, and similar procedures.

6. How can EDP be used for production control, and what cost reductions might be possible?

This question was too broad for any detailed discussion. It was stated the computers could be used for production control applications. In fact, AiResearch Manufacturing Division of the Garrett Corporation has such a program underway.

There was a brief discussion of inventory control, and how more efficient inventory stocking policies might be developed through study.

It was pointed out that the big advantages of EDP will lie in the area of improving a company's competitive position, rather than in the area of direct clerical savings.

7. What effect will EDP have on management philosophy?

There was a brief discussion of two companies who are known to be approaching EDP from the "let's do it right" point of view. In each case, about 18 months were allowed for the systems study and the development of systems plans. Another 18 to 24 months were being allowed for procurement of equipment, and an additional 8 to 12 months for file cleanup and conversion. Undertaking studies of this duration certainly involves a change in management philosophy, in many companies.

There was a discussion of the role of the skilled programmer who is brought in to become part of the company's EDP team. It was pointed out that the professional programmer is a necessity almost, since the company personnel newly trained in programming do not know many of the powerful techniques possible. The company personnel, on the other hand, knowing the operation of the company, might spend their energies on developing the systems plans.

In both the Berkeley and Los Angeles sessions, there were many specific questions from the audience which it is not feasible to discuss here.

REDUCING COSTS THROUGH THE USE OF CAPITAL

H. Thomas Hallowell, Jr.
President
Standard Pressed Steel Company
Jenkintown, Pennsylvania

The long-run inflationary trend has been going on with its ups and downs for many hundreds of years throughout the whole world, and it seems that we are playing a game that works like this: real wages will tend to go up faster than real prices; therefore, people increase their standard of living.

It almost sounds like pulling yourself up by your boot straps and at times I wonder whether it really works; however, let me give you the trend in our country since 1900: yearly wages have gone up about seven times, while in the same period the value of the dollar has gone down to about one-third.

So you can see that people, even with the inflation, are now able to buy more than twice as much as they could in 1900. That's an increase of about 1-1/2% to 2% per year in our standard of living. (Our American set-up is perhaps working in a way that's better than some of us would expect!)

The only way we can account for this amazing phenomenon is by the fact that the productivity of our economy has been increasing. Increasing productivity is not an accident. It is done by management working as an organization having plans and using better methods, better tools and all of the enlightened things that a modern management must do.

By an "increase in productivity", I mean that a greater amount of goods and services must be produced per unit of time, floor space, material, machine effort, human effort, light, power, heat, and so forth. This is quite different from "efficiency".

The word "efficiency" infers the whip-cracking era of the 1920's, whereas "productivity" is a thoroughly American concept that should be substituted whenever there is a tendency to use the work "efficiency".

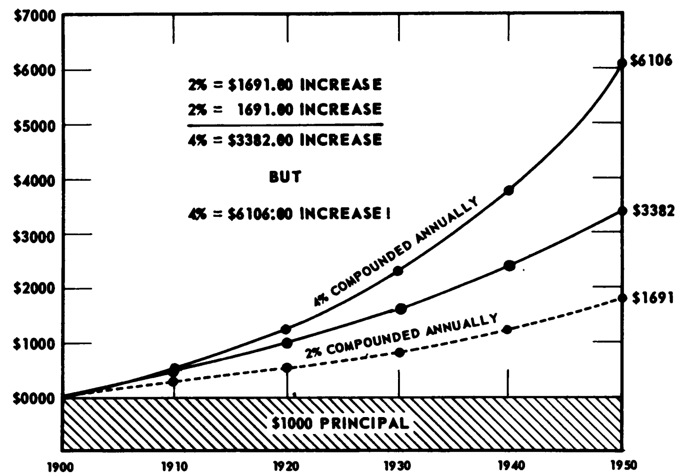
Increasing productivity requires greater and greater amounts of capital and less and less amounts of human effort, but greater amounts of human cooperation.

It is well to remember in this country where we believe in and practice competition, that no war, no strike, no depression can so completely destroy an established business or its profits as new and better methods, equipment and material in the hands of an enlightened competitor.

Therefore, with competition at work, there will always be a pressure upon management that will force it constantly to improve productivity over a period of time if it is to stay in business.

Now let me show you some of the things that are going on about us. I will start in a very simple manner, demonstrating that two and two does make four under certain conditions and under others it does not make four!

CHART #1



If we take $1000 principal (Chart #1) and compound it annually at the rate of 2% for 50 years, we will have an increase of $1691. If we repeat this process it would seem that we should then have an increase of $3382—or just double.

We find, however, that when we take $1000 principal and compound it annually at the rate of 4% (2% plus 2%) for 50 years, instead of $3382 ($1691 plus $1691) we have an increase of $6106!

I am sure that we are all aware of the tricks we can play with figures, but I am not so certain that we recognize the dramatic difference between multiplication and addition. It seems that our minds tend to work and react in terms of addition, whereas conditions actually going on around us today are progressing in terms of multiplication!

In Chart #2 I have attempted to set down some of the conditions under which we are living in approximate terms of multiplication.

CHART #2

SOME APPROXIMATE TRENDS EXPRESSED IN COMPOUND INTEREST RATES
(Compounded Annually)

Increase in Population	1 to 1-1/2%) 3%
Increase in Living Standards	1 to 1-1/2%)
Decrease in Working Hours	1/2%
Gain in Physical Output per Worker in Industry	3% - 4% - 5%
Increase in Worker Cost per Year	4%
Increase in Worker Cost per Hour	5%
Decrease in Purchasing power of U.S. Dollar	3% - 4%
U.S. Government borrows money	3% - 4%

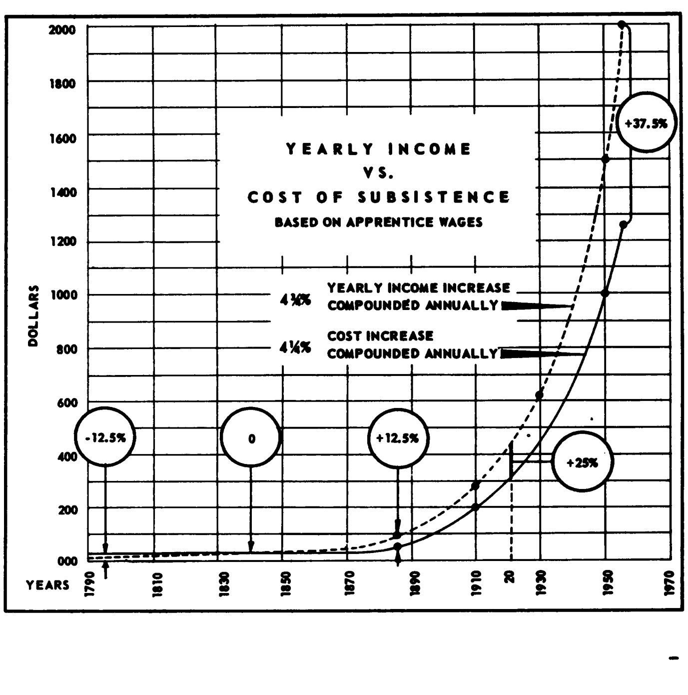
CHART #3

DECREASE IN PURCHASING POWER OF MONEY (1946–1956)*

Country	Indexes of Value of Money 1946	1956*	Annual Rate of Deprec. (compounded)	Country	Indexes of Value of Money 1946	1956*	Annual Rate of Deprec. (compounded)
Switzerland	100	86	1.5%	Sweden	100	65	4.3
Germany	100	72	3.2	United Kingdom	100	65	4.6
India	100	72	3.2	New Zealand	100	59	5.2
United States	100	71	3.4	France	100	58	6.5
Venezuela	100	70	3.5	Mexico	100	47	7.4
Netherlands	100	67	4.0	Australia	100	46	7.5
Canada	100	65	4.2	Brazil	100	26	12.7
South Africa	100	65	4.2	Chile	100	5	25.3

*Latest month available.
Source: First National City Bank

CHART #4



You will note that the purchasing power of our dollar seems to go down at about the same rate as the government long-term interest on bonds. This coincidence might lead us to the conclusion that the government borrows money for nothing!

Decreases in the purchasing power of a currency are not unique with the United States, as Chart #3 shows.

Some time ago I was talking to one of my elderly friends and he told me that in 1890 he started as an apprentice roofer and was paid $2 a week ($100 a year). I asked him if he could save any money and he said that he did manage to save a little after he paid for his food, clothes and lodging.

This started me thinking, so I compared his yearly wage with that of an apprentice in 1950 (Chart #4) who was paid approximately $1500 a year. (75¢ an hour, 40 hours a week, for 50 weeks—minimum wage.)

Now somehow we progressed from $100 to $1500 a year in 60 years (1950). Using these as two points on the curve, we found that the progression was at the rate of 4-3/4% compounded annually.

I then assumed that my elderly friend saved about 1/5th of his income after his cost of subsistence, compared to an estimated 1/3rd saved by the 1950 apprentice.

This assumption gave us two points for another curve which we found progressed at the rate of 4-1/4% compounded annually. One thing was quite obvious—it showed that the lines were getting much closer together as we went back, and being a bit curious, we decided to run the figures back for another 100 years!

When we had gone back as far as 1790, we thought something was wrong because believe it or not, it showed quite clearly that the apprentice was definitely in the red at that time! In other words, his cost of subsistence was more than he received in wages!

A closer study showed that this is just about what was going on at the time. (You will recall that James Watt came from a poor family which did not have enough money to pay someone to show him how to be a machinist.)

Though Chart #4 is full of assumptions, each of which could be questioned, it does show that there are certain definite long-range trends which can be approximated by using the compound interest formula. The difference between 4-1/2% and 4-3/4% is surprisingly large when extended over several hundred years.

We have taken the liberty of projecting out to 1960 the Apprentice Wage versus Cost of Living (Chart #5).

If nature takes the same course as it has in the past, we should have the condition represented in Column 4 of Chart #5. If, by some strange coincidence, the cost of living should not go up, which I rather doubt, or merely go up at the rate of 2% compounded annually from 1950, the amount remaining over a bare cost of living becomes 51% of the total wage.

CHART #5

PROJECTED APPRENTICE WAGE vs COST OF LIVING				
	1950	1955	1960	
	@ 75¢/Hr	@ $1/Hr.	@ $1.25/Hr.	
Income:	$1,500 (4-3/4%)	$2,000 (4-3/4%)	$2,500 (4-3/4%)	$2,500 (4-3/4%)
Cost of Living:	$1,000 (4-1/4%)	$1,250 (4-1/4%)	$1,525 (4-1/4%)	$1,225 (2%)
Saving:	$ 500	$ 750	$ 975	$1,275
% Saving:	33.3%	37.5%	39%	51%

CHART #6

$1,000 COMPOUNDED ANNUALLY

	Start	50 Years Later	Gain in 50 Years	Gain In Relation To Orig. Invest.
1%	$1,000	$ 1,644.	$ 644.	.6 X
2%	1,000	2,691.	1,691.	1.7
3%	1,000	4,383.	3,383.	3.4
4%	1,000	7,106.	6,106.	6.1
5%	1,000	11,467.	10,467.	10.5
6%	1,000	18,420.	17,420.	17.4
7%	1,000	29,457.	28,457.	28.5
8%	1,000	46,902.	45,902.	45.9
9%	1,000	74,357.	73,357.	73.4
10%	1,000	117,391.	116,391.	116.4
15%	1,000	1,083,657.	1,082,657.	1082.7

CHART #7

EFFECT OF 4% COMPOUND ANNUAL PRODUCTIVITY INCREASE IN 10 YEARS			
	Now	10 Yrs. Later	Change
Employees	100	100	Same
Physical Output	100	150	+ 50%
Physical Output	100	100	Same
Employees	100	67	- 33%

This further illustrates the need to express the trends of things going on around us in a more accurate way than we have in the past. This makes the mathematics in Chart #2, due to its extremely approximate nature, not very accurate in long-range prediction. It should, however, serve to stimulate our thinking.

We next have a compound interest table (Chart #6) showing the results after 50 years of varying rates of progression. The magnitude of the forces at work are amazing, especially when we get into the higher percentages.

The average yields on common stocks listed on the Stock Exchange have ranged between 4% and 5% for the last several years. Things increase pretty fast at that rate.

Since we hear a great deal these days of the increase in productivity in industry, I would like to illustrate an increase of 4% compounded annually over a ten-year period (Chart #7). (I have taken 4% because I assume that this is the minimum expected increase where operations can be highly mechanized.) It must be understood, however, that there are many industries not able to do this type of thing due to the nature of their set-up (such as railroads).

Next let us look at the trend of the cost of capital as compared to the trend of yearly wage costs since 1900 (Chart #8).

CHART #8

	1900	1950-51	1956
INTEREST RATE	6%	3.6%	4%
$1 M CAPITAL COST PER YEAR	$60,000.	$36,000.	$40,000.
YEARLY WAGE COST PER PERSON	$600.	$3,600.	$4,500.
PERSONS PER YEAR	100	10	9

It seems hardly believable that in 1900 the interest on a million dollars would approximate the yearly wages of 100 persons, whereas 55 years later the interest cost of $1 million would approximate the wages of only nine people!

From this it seems to be pretty clear that doing things by using capital should be more economical than doing the same things with human effort.

Let me show you in Chart #9 how we have put to work the ideas of using increased amounts of capital to help us at SPS.

CHART #9

	1945		1950	
	$4,500 Machine (1.25 Wage)	$4,500 Machine (50¢ Wage)	$45,000 Machine (1.50 Wage)	$45,000 Machine (3x Wage)
Machine Cost	$20.00	$20.00	$36.00	$36.00
Operator	10.00	4.00	12.00	36.00
8 Hr. Cost	30.00	24.00	48.00	72.00
Production	80 Pcs	80 Pcs.	800 Pcs	800 Pcs.
Unit Cost (Each)	37-1/2¢	30¢	6¢	9¢

The first column in Chart #9 shows a set of cost elements which produce a part for 37-1/2¢ each. (Our uninformed competitors were using this production method and were selling this part for 25¢ each!)

The second column in Chart #9 shows the projection of what would happen if we assumed that our 1950 wages were too high, so by paying the 1950 operator the assumed wage of one-third the present rate (1926 wages), the cost of the part went down to 30¢. However, remember that the competition was still selling it for 25¢.

It occurred to us that perhaps we were using too small an amount of capital, so we set out to find a larger, better, more complex machine ten times as expensive, having a 50 hp motor instead of a 5 hp motor. Column 3 in Chart #9 illustrates what happened to the cost. (Please note that while the production went up ten times, the operator did not have to work as hard and still our cost went down to 6¢!)

In Column 4, Chart #9, we have attempted to look ahead and assume that the trends of wages may continue to increase, so we have hypothetically tripled the wage. Our cost then becomes 9¢!

If you will compare Column 2 in Chart #9 where we paid one-third the 1950 wage and arrived at a cost of 30¢, with Column 4 in Chart #9 where we paid three times the 1950 wage with a cost of 9¢, you will see that it dramatically illustrates the benefits of using capital to reduce costs. The difference reflects ten times the amount of capital at work!

Remember that the capital comes from the savings, so the increase of profit which we received by selling the part at 25¢ with the lower cost, will now go back into paying for the larger and better machine, which will in turn permit us to raise our wages and buy another machine when this one is worn out.

The next illustration, Chart #10, shows a comparison between a 1950 large machine and the present 1955 medium-sized machine. (The medium-sized machine does the work of the large machine, due to its increased rigidity and the improvements in present late model machine tools. Machine costs in these examples cover the cost of supervision, depreciation, small tools, cutting oils, property taxes and other factory overhead charges.)

CHART #10

	$45,000 Large Size 1950 Machine	$36,000 Medium Size 1955 Machine	- 20%
MACHINE COST	$36.00	$36.00	N/C
OPERATOR	12.00	16.00	+ 25%
8 HOUR COST	48.00	52.00	+ 8%
PRODUCTION	800 pcs	1250 pcs	+ 56%
UNIT COST	.06¢ ea	.042¢ ea	- 30%

For the sake of comparison, it is actually not necessary to have exact figures because one can readily see that if we were even to double these charges in the illustrations in Chart #10 where we used the larger amounts of capital, the resulting increase in unit cost is still quite small in comparison to the original high unit cost where we used the low capital investment method.

It is possible to "efficient" yourself completely out of business and the following mathematics show that, at times, lower end costs are produced with a lower efficiency and vice-versa. This is merely a definition of waste, and sometimes it is more wasteful to run at too high efficiency. (We perhaps should have substituted the word "productivity" for "efficiency", because it is more acceptable and often clears up the thinking.)

Referring back to Chart #9, Column 3, the output of 800 pieces per day on the $45,000, 1950 model machine, was based on operating at an output rate of 80%. That is producing 800 pieces per day out of a maximum possible output of 1000 pieces per day.

By way of comparison, using the $36,000, medium-sized 1955 model machine (Chart #10, Column 2) the output rate assumed was only 62-1/2%, or an output of 1250 pieces per day out of a possible maximum output of 2000 pieces per day.

In other words, it is sometimes more important to use the right machines on a job even at a lower productivity rate, than it is to use second-grade equipment at a higher productivity rate.

In Chart #11 it is possible to compare the results of the various machine cycle times, productivity rates and net piece cost used in the preceding three illustrations (Charts #9 and #10).

To show that we have not reached the end of the line, I have made a projection to 1960, as can be seen on Chart #12, and though wages in this example go up 25% higher, the unit cost drops another 19%.

CHART #11

PRODUCTIVITY vs EFFICIENCY	A	B	C (Projected)
Time per Piece:	28.8 sec.	14.4 sec.	9.6 sec.
8 Hour Maximum Possible Output:	1000	2000	3000
Efficiency of Operation:	80%	62.5%	58.5%
	800 pcs	1250 pcs	1750 pcs
Machine Cost/8 Hours:	$48.00	$52.00	$60.00
Cost Per Piece:	.06¢	.042¢	.034¢

CHART #12

	$45,000 Large Size 1950 Machine	$36,000 Medium Size 1955 Machine	- 20%	Projected $45,000 1960 Mach.	- 25%
MACHINE COST	$36.00	$36.00	N/C	$40.00	+ 11%
OPERATOR	12.00	16.00	+ 25%	20.00	+ 25%
8 HOUR COST	48.00	52.00	+ 8%	60.00	+ 15%
PRODUCTION	800 pcs	1250 pcs	+ 56%	1750 pcs	+ 40%
UNIT COST	.06¢ ea	.042¢ ea	- 30%	.034¢ ea	- 19%

While my remarks are concentrated on improving productivity through the greater use of capital, it is extremely important to keep in mind that the successful operation of any business today depends more and more on management's ability to use human efforts more effectively and to get along with the people in the organization.

Now then, just where does the capital come from? Capital comes from savings—both personal and corporate, which in turn can only come from a profit—either personal or corporate!

When we start to use capital in our private enterprise system as we know it, we are not dealing with sets of small figures such as 5%, but let us look at what the records show for the return on stockholder's investment of all manufacturing companies, as taken from recent SEC reports. (Remember, among the companies there are included some very poor ones which tend to diminish the figures as shown!)

At the bottom of Chart #13 it can be seen that perhaps the problem ahead of management today is how to use more capital and less human effort!

Any new process has sufficient unknowns in it to make it advisable to use the approximate ratios in Chart #13 as base points.

New processes and equipment should be carefully studied so that any surplus personnel made available by better methods can be trained to use their skills effectively in other jobs in the same organization, either in

CHART #13

CAPITAL REQUIRED TO RELEASE ONE WORKER FOR OTHER WORK
(Data Taken From SEC Report)

Return on Stockholders-Equity (All Manufacturing Companies)

	1948	1949	1950	1951	1952	1953	1954	1955
Before Taxes %	25.6	18.5	27.8	27.9	21.8	22.3	18.7	23.8
After Taxes %	16.1	11.7	15.4	12.2	10.2	10.4	9.9	12.5

	1950	1956
Increase in Investment of $10,000. To release one person for other work - Cost Per Year:	**$3,600.**	**$4,500.**
Return on Investment - Before Taxes:	**36%**	**45%**

research and the development of new products or in producing more goods to fill the increased demand brought about by lower prices resulting from the new methods.

Certainly it is a management responsibility to face intelligently the problem of apparent unemployment resulting from the installation of new methods; however, we must pick up the increase in productivity over a period of time if we are to stay in business. At present when we are at a high point of the business cycle and there is a great shortage of labor, installing new methods is a very worthwhile and patriotic thing to do.

To show you the magnitude of the figures we are using as management and the possibilities of using capital, I have projected the yearly percentage return on net worth onto our compound interest table (Chart #14).

CHART #14

$1,000 COMPOUNDED ANNUALLY

		Gain in 50 Years	Gain In Relation To Orig. Invest.
	5%	$ 10,467.	10.5 X
	6%	17,420.	17.4
1954 (9.9%)			
1952 (10.2%)	9%	73,357.	73.4
1953 (10.4%)	10%	116,391.	116.4
1949 (11.7%)	11%	182,861.	182.9
1951 (12.2%)	12%	286,968.	287.0
1955 (12.5%)	13%	448,045.	448.0
	14%	696,881.	696.0
1950 (15.4%)	15%	1,082,657.	1082.7
1948 (16.1%)	16%	1,665,462.	1665.5
	18%	3,917,254.	3917.3
	20%	9,088,385.	9088.4

You can see that if the net return after taxes from the stockholder's investment in all manufacturing companies is 10%, it would mean that there is a potential for dividends and reinvested profits of 116 times the original investment in 50 years! Of course in good times if the return should get as high as 12% after taxes, this figure goes up to 287 times!

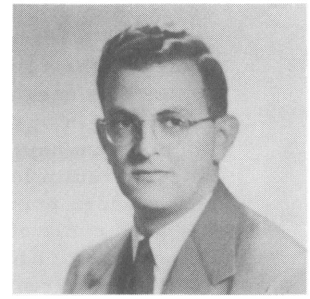
In the face of this evidence I question very much the prophets of doom and defeatists who tell us, upon occasion, that there is no opportunity in this country of ours! Let me ask you, Mr. Fellow Management, just how much opportunity do we want?

In conclusion, I strongly feel that our lives as management are separate from our lives as private citizens in which we spend such a great part of the time listening to the newscasters, reading sensational headlines and worrying over so many things over which we have absolutely no control.

As management we should not be optimistic nor pessimistic but completely realistic. To do this we must recognize the atmosphere of long-range trends under which we operate, and plan and act accordingly.

There are great management opportunities ahead for those organizations and people who lead this kind of a management life.

AUTOMEASUREMENT - MECHANIZING TIME STUDY



Charles W. Lake, Jr.
Vice President
Engineering, Research & Development Division
R. R. Donnelley & Sons Company
Chicago, Illinois

INTRODUCTION

Today I would like to discuss how industrial engineers are going to improve their techniques to cope with productivity problems in automated factories. I am particularly concerned with an area of work measurement which we have all recognized as troublesome; namely, the application of conventional time study techniques to other than short cycle, highly repetitive operations. There are indications that the age of automation, which is already upon us, is going to aggravate our problem significantly.

SHORT AND LONG CYCLE OPERATIONS

Fifty-four years ago, F. W. Taylor first presented his classic paper on the study of a pig iron loading operation. You will remember this experiment involved picking up the pigs, carrying them fifty feet and loading them into a box car. This was an early application of time study. Taylor chose an operation that had high volume, on which methods could be standardized, and on which a performance rating could be set. This was an example of what we will call a "short cycle, repetitive operation".

But "short cycle, repetitive operations" do not account for all of the work that we industrial engineers are required to measure. Other operations, which generally require a higher level of mental activity, can be classified as "long cycle, non-repetitive operations". For example, in the printing industry, the set-up or makeready of a press may require from 1 to 30 hours. Here, a skilled craftsman has control over the sequence of elements to be performed and perhaps also the method of performing these elements. This type of operation is usually concerned with a much greater number of variables, many of which are not readily predictable.

OUR "WEAK LINK"

You can find examples of both the "short cycle" and "long cycle" types of operations in every company. Usually, however, one type or the other will predominate in a particular industry. It is in the "short cycle" type operations that the original time study techniques with subsequent refinements have been applied very effectively. The largest proportion of the efforts to apply and develop time study techniques has been directed toward short cycle operations. Applications of these same techniques have been made on long cycle, highly skilled operations, but due to the high degree of complexity of these operations, the results have left much to be desired. Work measurement application to "long cycle" operations is a "weak link" in our present industrial engineering programs.

AUTOMATION IS HERE

With the age of automation upon us, we find that many of the short cycle operations are being absorbed into integrated systems of machines. The principles of automation provide that job functions which are basically cyclical and which require a low order of reasoning and low order of memory can be performed by automated devices of one type or another. Among the tasks which can be so performed are the automatic positioning of materials in and out of machine tools by power transfer units, automated devices with small memory systems which will program the cycles of a multi-cycled operation, or instruments with the capabilities of feed-back mechanisms such that adjustments can be fed back, thus eliminating the necessity of manual adjustment.

All this further indicates that the proportion of short cycle operations will tend to decrease as engineering moves toward a concept of production in the automated phase. It should be noted that in "long cycle" operations the required skills come in non-repetitive patterns. It is impractical in these operations to stand with stopwatch and board in hand and record fixed time as we would for repetitive short cycles. Automation is bringing job enlargement through technology and it is this vision into the future which sets up the warning signal to the alert industrial engineer. A glance at his current work measurement tools shows him that he is, with present techniques, inadequately prepared to cope with these changes in production methodology.

In simple language, automation will increase the proportion of "long cycle" operations in industry. Therefore, our problem is, how shall we as industrial engineers cope with this increasing proportion of long cycle operations when we recognize that it is the weak spot of work measurement?

WHAT ARE THE OBSTACLES?

Before we consider possible answers to our problem, let us review the obstacles which have stood in our way:

1. The "long cycle" operations include very many variables, some of which are not readily predictable.

2. If we agree that no standards should be set without adequate sampling, we face the situation where both the observation and the computing time would be increased beyond the point of reasonable cost return. In many cases, the observation time

would be multiplied many fold in order to obtain an adequate sample in the non-repetitive work cycles of the automated age. For example, sixty cycles of a one-minute repetitive operation can be studied in one hour. The data can be analyzed in one more hour, and an accurate standard can be prepared in less than half a day. The set-up on a modern printing press, however, involves the work cycle of perhaps ten hours of a highly skilled crew of four or five people. Here sixty cycles would require 600 hours of time study, and careful observation of each of the members of the crew would increase this by a factor of four or five. This would bring the time study problem up to 2400 or 3000 hours of observation time alone merely to get a standard on press set-up that is as accurate as the standard on the one-minute work station.

The computational time would go up at least in geometric proportion to the increase in observation time. These factors should not only frighten the average time study observer, but make it impractical for management to spend the kind of money necessary to insure wholly reliable standards.

You may say that industrial engineers have been setting standards successfully on these kinds of operations for years. Careful analysis of situations of this type will show that in nearly every case the work measurement procedures result in rather wide tolerances associated with the standard. Doubt about the accuracy and a desire to be fair to the worker causes the standard to be established on the loose end of the tolerance range. Such a standard is almost always better than no standard for production management, and for this reason these practices have been accepted to date. Standards which are consistently on the loose side are not going to be acceptable when more accurate standards can be developed by the application of the principle of automeasurement and statistical analysis.

3. In order to obtain reliable standards with our present work measurement methods, the industrial engineer would have to spend his time on these endless data collection and processing activities. This fails to utilize available talent properly and has an adverse effect on the engineer's morale. Under these circumstances we cannot hope to recruit and maintain an adequate staff in the face of the present shortage of engineers and well trained technicians.

HOW CAN WE OVERCOME THE OBSTACLES TO EFFECTIVE APPLICATIONS OF WORK MEASUREMENT ON "LONG CYCLE, NON-REPETITIVE OPERATIONS"?

Today the industrial engineer is the man on the management staff responsible for conducting the studies to optimize the factors of production. To do so he has used the tools now in his possession; namely, time study including rating, methods of standardization, right and left hand charts, and so forth. In the future, faced with a different set of production factors, he will have the choice of either developing new tools to cope with new kinds of production methods or he will leave the field open to other engineering and scientific groups who will develop the techniques to optimize production in the new type of manufacturing set-up. Evidence of this is already seen in the work of the Operations Research group and in the work of the Institute of Management Sciences and others. Bluntly, the industrial engineer can either let these groups cut the ground out from under him, or improve his techniques to meet the challenge.

Certainly we can't spend our careers and our employers' dollars with a stopwatch in hand when the returns of such time may not be profitable. Instead, our solution lies in harnessing the very thing which is accelerating the change. <u>Time study itself must be automated.</u>

Manufacturing methods have changed drastically since the birth of time study. Pig iron loading today can be performed with fork truck and palletized loads, or by a conveyorized materials handling system. Thus the job on which Taylor conducted his original studies has been outmoded and replaced by new methods. Perhaps endless time study data collection and processing activities by manual methods are now becoming obsolete. Developments that may be applied to our field have far surpassed the usage to which the industrial engineer has put them. The fields of quality control, opinion sampling, and economic forecasting point out what we can achieve with these tools. We must make our data collecting and processing conform to the statistical sciences.

WHAT IS AUTOMEASUREMENT?

At Donnelley's we have coined the term automeasurement, and we define it as the system and techniques involved in the automatic collection and processing of data for purposes of measuring productivity in a satistically scientific manner. We believe that a science of automeasurement must be developed to handle the productivity studies arising in integrated systems of machines, processes, and crews for automated or mechanized production. The principal tools of automeasurement are automatic data collecting devices, computers to process the data, and the mathematical principles of statistics.

I do not believe that the instrumentations for the measurement need be limited to a stopwatch or a gauge to measure time. Our instrumentation program for measurement must include more than just gauges to measure volume output and time. We must include measurements of all production variables which significantly affect productivity in order to: (1) decrease the amount of unpredictable variation, and (2) improve analyses of operations aimed at pointing out the areas which need improvement.

WHY AUTOMEASUREMENT?

Why will automeasurement be a necessity in the future?

Since the beginning of time, the productivity of people has been important. It is the productivity of people basically that determines the standard of living. It was the problem of productivity of people that Taylor dealt with in his early experiments. It is the productivity of machines and people that industrial engineers today currently deal with and will deal with in the future. We will find that productivity and increased costs will continue to be one of the foremost management problems.

If we agree that time and productivity studies of people will continue to be vitally important, we must also agree that the industrial engineer must accelerate his developments in at least certain work measurement areas. We all recognize the importance of accurate time standards for purposes of incentive, cost estimating, and production planning and control. As stated before, I believe that work measurement techniques which were applicable in the past will not necessarily apply in automated mass production. Seldom do we consider work measurement in terms of the production process. I suggest that the failure to do so has been responsible for some of the difficulties we have experienced.

I would now like to discuss three pictures which illustrate the difficulties of work measurement techniques in modern mechanized production. These pictures were taken from the automation article appearing in the March 19, 1956, issue of TIME Magazine.

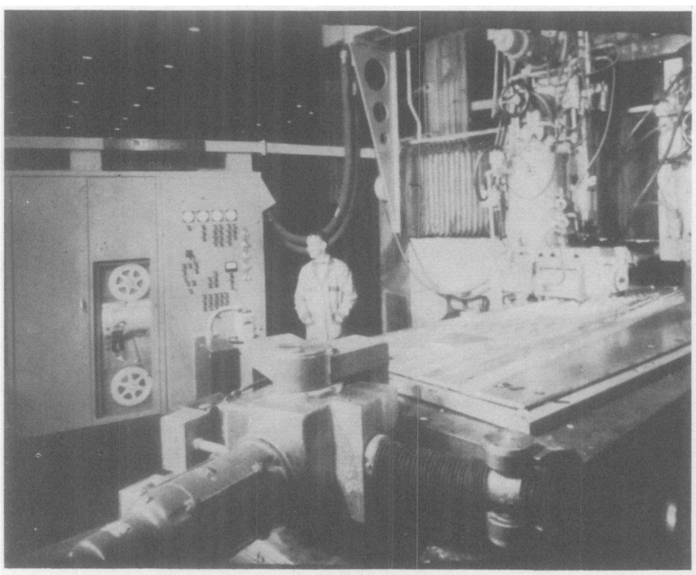


Figure 1

In Figure 1 we see an automated Giddings & Lewis skin milling machine used to mill intricately contoured air foils for supersonic aircraft and guided missiles. All directions and instructions are supplied by the tape recording. I would like to direct your attention to the attendant shown in the picture. How shall we, the industrial engineers, using today's accepted short cycle technique of performance rating, rate this man's attention activity? Will right and left hand charts showing every reach and every grasp have an economic place in this picture? Do we propose to use laboriously prepared simo charts of this man's non-cyclical random activity which is controlled almost entirely by external, seemingly unpredictable factors? What stopwatch techniques might we use in order to measure this man's analysis time, which in case of trouble will be his primary function?

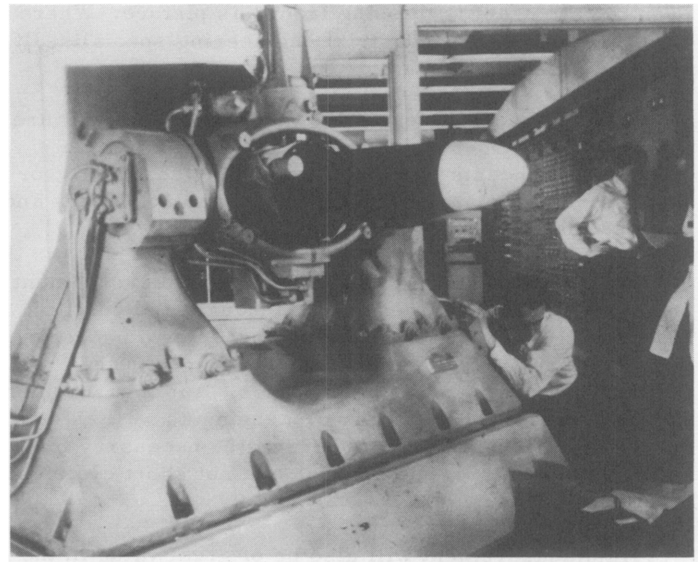


Figure 2

Figure 2 shows a Flight Simulator built by Bendix Aviation for U. S. Navy testing of electronic missile guidance systems. We see a crew of technicians at work with the equipment. Complicated operations of this type seem to defy the time-tested techniques of measuring short-cycle, highly repetitive operations.

In Figure 3 we see a Jones & Lamson turret lathe. This lathe is controlled by instructions on punched tape.

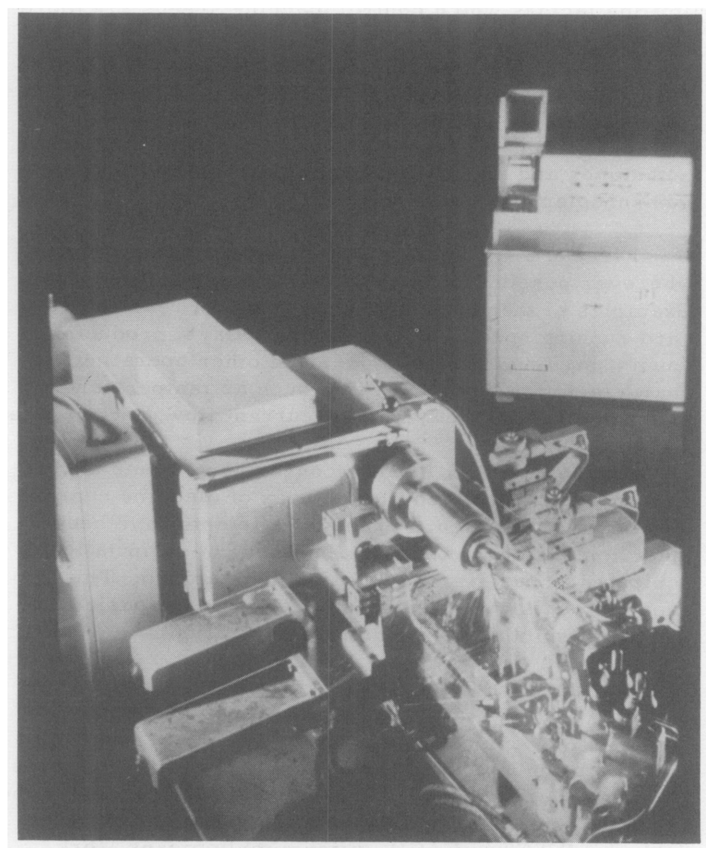


Figure 3

Even the attendant is missing from this picture. Where does the short cycle industrial engineering specialist fit into this picture?

These are only a few of the many examples that are with us today. Doesn't it appear that we must either modify our concepts to meet the changing conditions, or be prepared to join the thinning ranks of blacksmiths and harness makers?

I submit once again that present work measurement techniques are sometimes both inadequate and costly. Mechanization and instrumentation becomes a necessity if the engineering profession is to keep up with the mechanization of production facilities. Automeasurement allows a higher order of data processing as well as data collecting, and this higher order will be necessary for analyses of new operations which are not short cycle and highly repetitive.

Automeasurement will also be of great value in the managerial field. A manager must be able to measure his performance in all key areas of a business. These measurements must be clear and rational, and must direct attention and efforts where they will do the most good. And these measurements must be timely.

Automeasurement will also serve an expanded concept of production control and process optimization. With much of our work controlled by equipment, our time study men could determine optimum speeds of machines to maintain the highest net productivity. Stopwatch time study is not very effective here. A tachometer, an ability to determine real reasons for delays, and a knowledge of limiting factors which control machine speeds are more valuable.

METHODS, TECHNIQUES AND APPLICATIONS

Let us consider some of the fundamental methods, techniques and applications of our new concept of automeasurement.

First of all, I believe that all desired data should, wherever possible be collected by automatic recorders. Examples of these are instruments which read and record running speeds, elapsed time, delays, production counts, material performances and other operating characteristics of the process, such as temperature, pressure, rate of flow, weight, current flow, and the like.

Another need will be the conversion of time study data to a form in which the methods of machine computation may be applied. Whenever attempts have been made to consider putting data on modern computational equipment a basic problem has always arisen. This problem deals with the cost of setting up the basic data in a form suitable for machine computation.

"WETARFAC"

It is appropriate at this time to describe a machine that has been developed for us by International Business Machines Corporation. When we originally conceived the specifications and requirements for the machine we dubbed it "WETARFAC", which simply means Work Element Timer and Recorder for Automatic Computing.

I would now like to show several pictures in order to describe this first building block in our automeasurement laboratory.

Figure 4 shows a picture of the machine that IBM built. Now, what does this machine do? As previously stated, we believe that data collection must be mechanized. We believe that data processing must be done on mechanical computing equipment, and that the industrial engineer has to have a job structure that will permit him to exercise professional judgment a higher percentage of the time. And to do this, he has to be relieved of the tedious routine of data collection and processing.

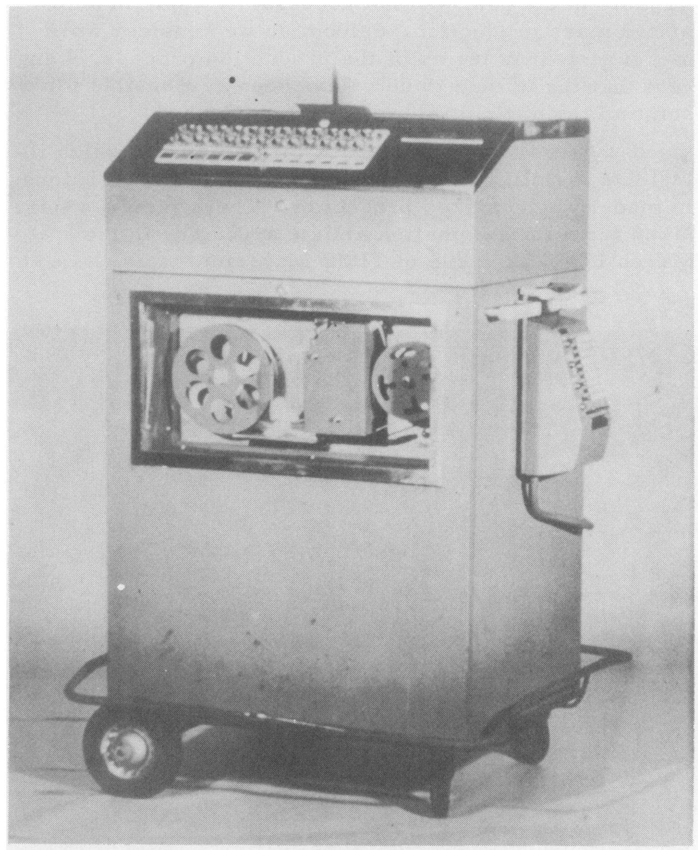


Figure 4

The industrial engineer is always faced with measuring the factor of time. It became evident that we needed a machine to measure time, the results from which could be piped into computing equipment now available such as the data processing equipment manufactured by IBM, available in our accounting division. WETARFAC is a machine capable of making time studies and producing its results in the form of five-channel paper punched tape which then can be fed into an IBM tape-to-card converter and reproduced in the form of a deck of IBM cards.

Figure 5 shows a piece of the five-channel tape.

In Figure 6 you see the tape coming out of the production recorder.

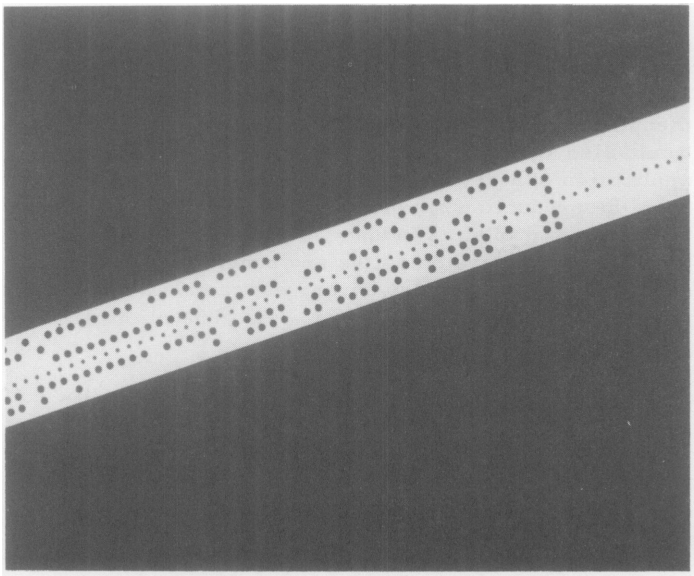


Figure 5

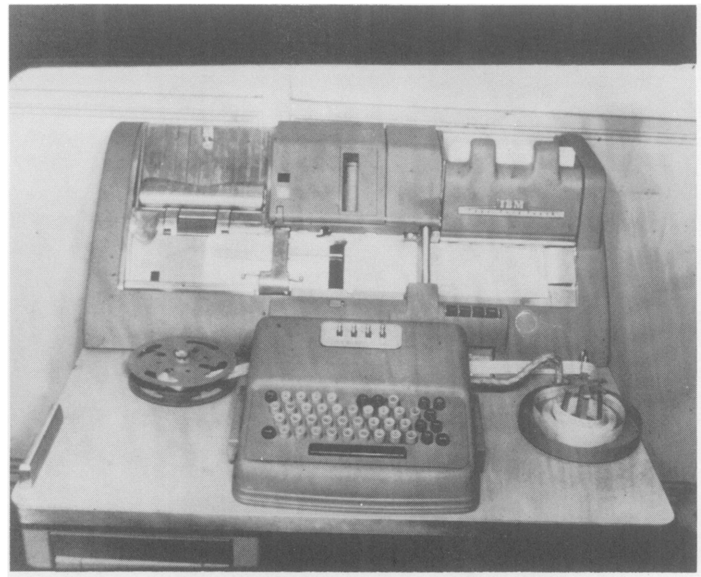


Figure 7

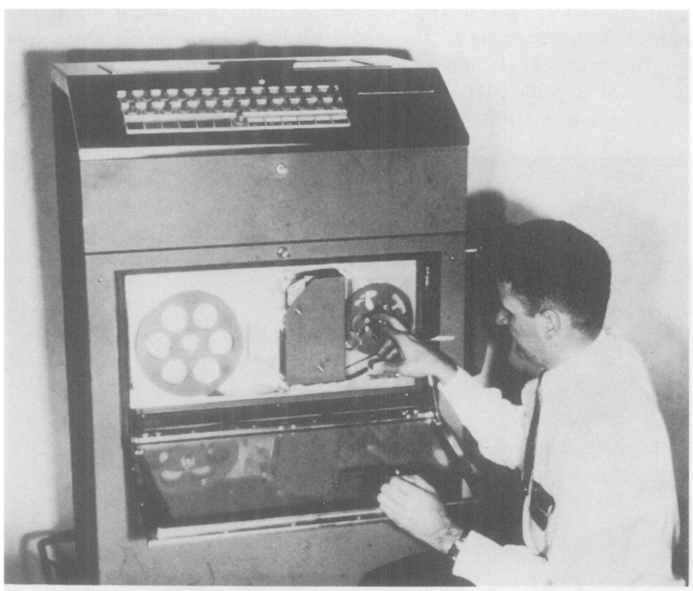


Figure 6

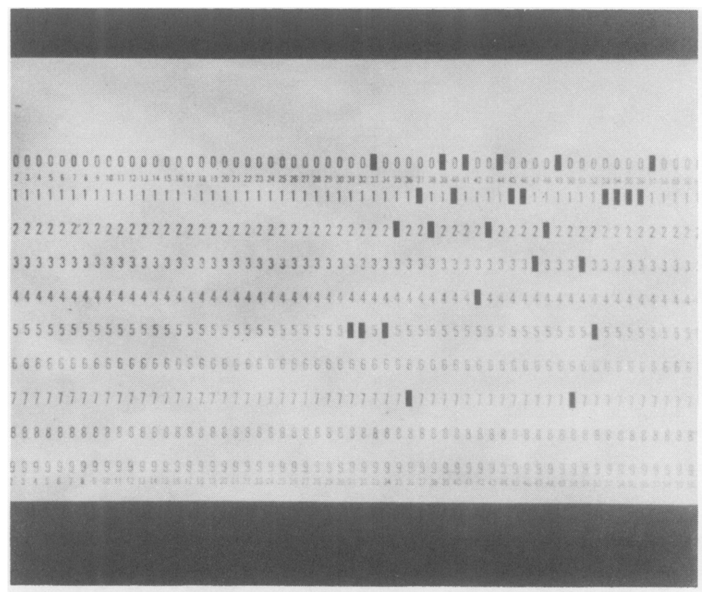


Figure 8

Figure 7 is a picture of the tape-to-card converter in the process of transferring data from a tape to cards.

Shown in Figure 8 is an IBM card that has been punched in accordance with the data on a tape. A deck of these cards can then be processed for data calculation in any manner that the engineer elects to program the data.

HOW DO WE MAKE A STUDY?

The next question you are likely to ask is, how do we make a time study? At the present time the time study engineer feeds in his element codes, delay codes, rating factors, and frequency through a manual keyboard.

Here is what the keyboard itself looks like (Figure 9).

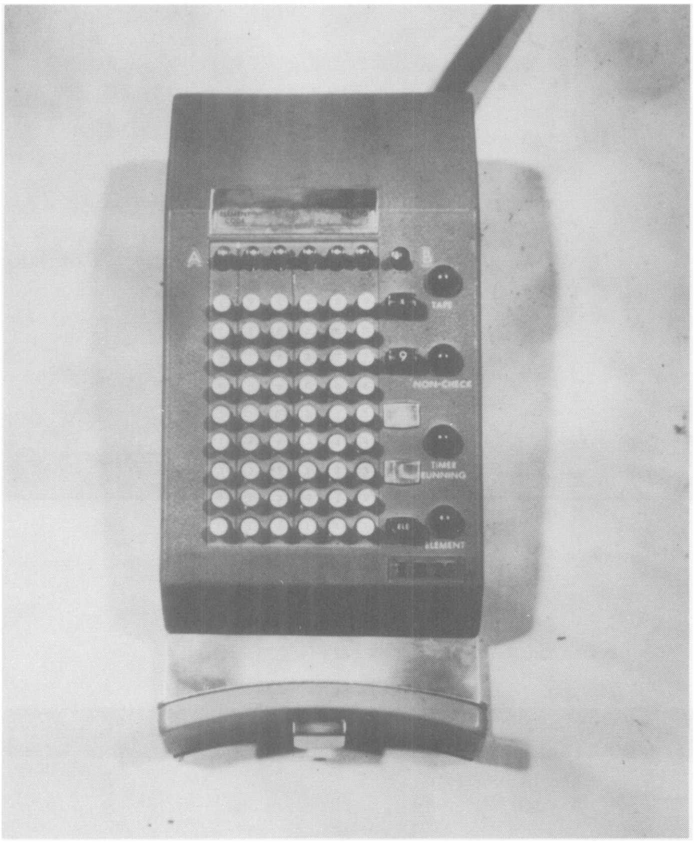


Figure 9

Figure 10

Figure 10 is a picture of the engineer actually making a time study on the production floor using this equipment. We think that the WETARFAC is an exceedingly important device, and are pleased that IBM has worked with us in this initial contribution to automeasurement. Their engineers and their applied science staffs have devoted many hours of their time to our problems. I think you will agree that it is important to be able to measure time in such a way that the data can be processed automatically. This is one element of mechanization that is fundamental to the automeasurement concept. I believe you would also agree, however, that the requirements for the application of a device of this type will vary depending upon the production operation that we are trying to measure. For example, as industrial engineers we might look at a time study man doing the key punching of data on a certain operation and ask ourselves, can we automate the input of data into the WETARFAC and thus eliminate the job of time study technician?

OTHER AUTOMEASUREMENT BUILDING BLOCKS

We are working with developments to fit our own particular needs to cause feed-back from the machines themselves to enter the signals into the WETARFAC.

Toward this end we have designed and are building a time-counting device, shown in Figure 11. This instrument will automatically accumulate and store multi-time machine elements and element frequencies for future processing. With minor engineering changes this equipment can be used to automate WETARFAC, thus eliminating the technician.

However, each application of automeasurement differs. You must have the skill and ability within your own engineering staffs to know how best to use such a machine. It is not a pink pill, which if swallowed, will bring relief to your work measurement headaches on the following

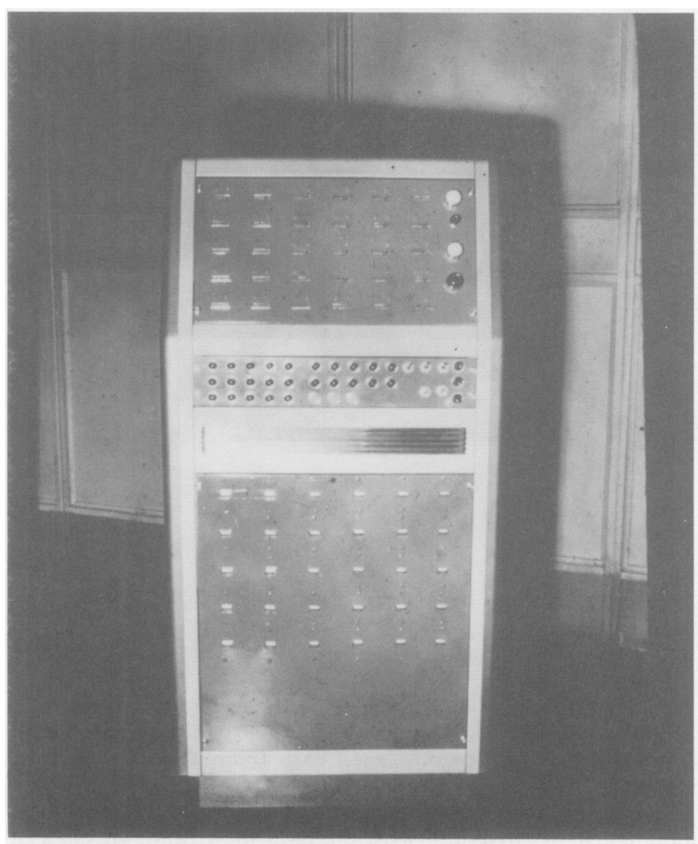


Figure 11

morning. You are not going to buy any machine that will build an automeasurement program into your own plant over night. It just is not that easy.

At Donnelley's we have made other important applications of automeasurement. An example of these is the control panel shown in Figure 12 which automatically records the small increments of no-work time at 24 stations along a converyor. Time will not permit us to discuss other applications in detail today. Besides, most of these are only applicable to our own specific industry.

The results of our efforts to automate work measurement have been very encouraging. We are now in the process of establishing a well-equipped automeasurement laboratory (shown in Figure 13) to provide the necessary equipment for our continued growth in the field.

We hope eventually to equip this laboratory with measuring devices that will measure all of the important factors of mechanized production which are necessary for an intelligent optimization study. We would like each of these measuring devices eventually to have certain common characteristics:

1. The collection of data should be automatic.

2. The read-out of the data should be in a form suitable for entry into a computer.

3. The various "automeasurement building blocks" should be capable of integration with each other in any combination necessary to solve any specific automeasurement problems.

4. The accuracy of the measurements should be within tolerances acceptable to the needs of each study.

5. The building blocks must be capable of simple interlock into production machinery for purposes of automatic recording.

Here are a few automeasurement building blocks we foresee as being necessary. You will add to this list yourselves as you analyze the needs for the better measurements necessary to optimize production and quality in mechanized production situations.

1. Time increments—we need to be able to measure increments of time related to certain characteristics of the work process. This we can now do with WETARFAC. The data is ready for the computer. The input to WETARFAC, however, is still manual.

2. Weight.

3. Count.

4. Temperature.

5. Current Flow.

6. Pressure.

7. Color (particularly important in our industry).

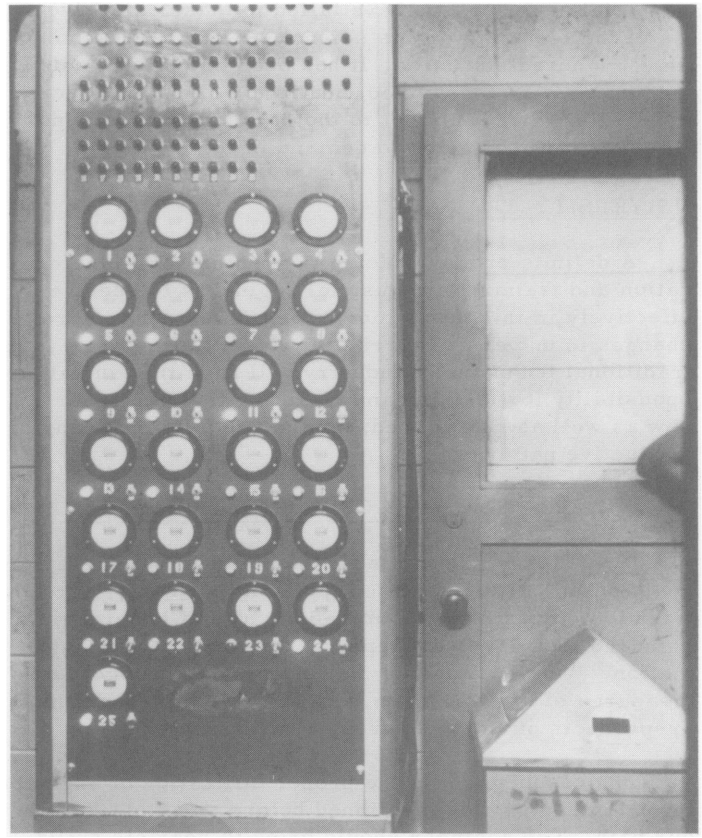


Figure 12

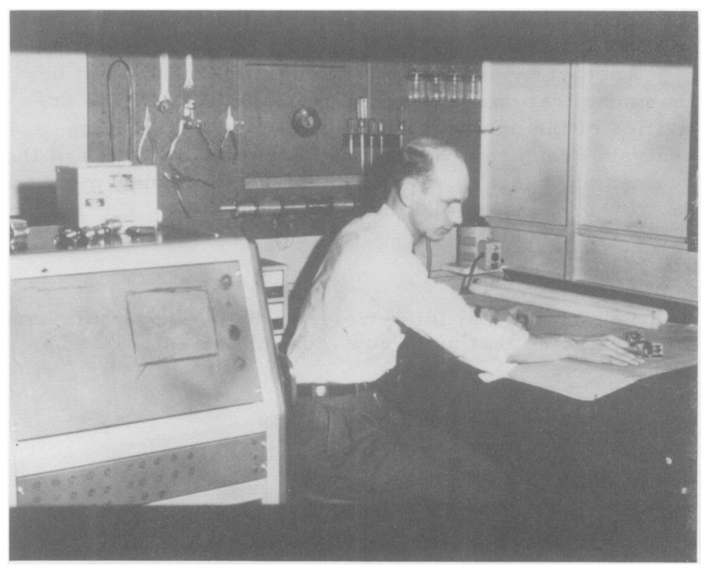


Figure 13

THE IMPORTANCE OF MATHEMATICAL STATISTICS

Another characteristic of automeasurement is that it will call for broader applications of statistics. Mathematical statistics has been proven to be an effective and powerful tool for the handling of numerical data. Yet as industrial engineers we have failed to make extensive use of the elements of this science. We have not completely ignored statistics. It has been one of our tools and has been so recognized, but have we applied it scientifically? Certainly not to the degree it demands nor to the degree it is going to demand in the future.

UNIVERSITY TRAINING

A definite problem facing the profession is the education and training of industrial engineers to operate effectively in this new atmosphere. This will require changes in university curricula where the emphasis is on traditional techniques. Industry will have the mutual responsibility for training and orienting their engineers, new as well as established, for the needs of the changing productive patterns.

THE ULTIMATE GOALS OF AUTOMEASUREMENT

I would now like to discuss some of the ultimate goals of an automeasurement program. We have already tried to demonstrate the immediate aim of keeping time standard techniques in step with progress toward automation. We all recognize that industry needs accurate measures of its work pace, but I believe many additional by-products of automeasurement will result.

One of our goals is the proper utilization of engineering talent. This was mentioned before as an obstacle in our path. The engineer should bring to bear his skills and ability in analysis, judgment and interpretation, rather than spend his time in endless data collection and data processing activities. This goal will mean a greater utilization of talent on hand, and will lead to greater job satisfaction for the engineers in the profession.

Another by-product of automeasurement might be the consolidation of information concerning all the activities of the company. A management engineering analysis group can reduce information in all areas of the business to chart form, and present it to management for day to day decision making.

SUMMARY

To summarize, let us review what we have said here. We have noted that up to now most of our emphasis has been placed on short cycle, repetitive operations. This resulted from our production oriented desire for job simplification as a means toward increasing productivity and reducing costs.

However, mechanization and automation have entered the picture. Their introduction is tending to force job enlargement due to its very nature. The short cycle, repetitive operation is the one most susceptible to becoming automated, which means that less and less people will be engaged in jobs of this type. The industrial engineer should recognize the importance of these changes since some of the areas which have been served by our techniques of the past will no longer need many of the services in work measurement that we offer today.

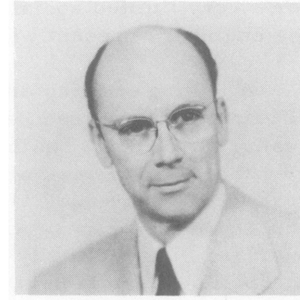
In order to meet this challenge, we too must automate. We must apply to our own industrial engineering methods the electronic controls, the mechanization and the feed-back principles that we are so energetically recommending for production processes.

Our data gathering and processing methods must be streamlined. We cannot apply the techniques that were unswervingly applied to the short, fixed, repetitive operation. We must turn our sights toward the science of statistics. Our data must become amenable to the automatic computer. Our non-professional tasks must be performed by machine; automatic computers must displace the slide rule and desk calculator. The chore-boy duties of the industrial engineer must be given to the electronic chore-boys of the future. This is not merely a nice idea—this is essential for the survival of the profession.

No one is going to transform all this for you. The success of tomorrow depends on your acceptance of this responsibility today. You must recognize the importance of automeasurement to industrial management and should sell management on the contribution that such measuring techniques can make to industry's basic objectives: cost reduction and increased productivity. The necessary research and development work will require active support of and participation by industry. You, as industrial engineers, must feel the responsibility for seeing that these needs are satisfied.

MOTIVATING SCIENTIFIC PERSONNEL

Dwight Palmer
Owner - Manager
Dwight Palmer and Associates
Management Consultants
Los Angeles, California



Mr. Chairman, and ladies and gentlemen: We are concerned today with the problem of motivating scientific or engineering personnel. This is a two barrelled question as you are well aware. I suspect some of my remarks may at first blush sound rather snide, critical and pointed for I am going to talk as bluntly as I have the wit to do about what I think the engineering mind and personality is and the problems they create administratively. This may seem to you a perilous adventure.

Before I launch out upon the thin ice, I would like very much to pay my respects sincerely and frankly to the engineering profession. Having taught at M.I.T. and at Cal-Tech and having engineering friends among my coterie of acquaintances, I have a profound respect for these people and their kind of approach to the problems which typify the twentieth century. We live in an era where invention and development, new products and processes are increasingly central to the success of our expanding economy. We live in an epoch in which the word research is renowned and held high and it is in the name of research that engineering and scientific work obviously is accomplished. Much of the sales of the Du Pont Company last year were products which were unknown at the beginning of World War II. This is how fast we move, and it is the engineering mentality and point of view, creativity and imagination out of which most of this comes.

I would be foolhardy in the extreme not to remember both now and during the later discussion, the kind of tribute we all feel due to the engineering profession. Now I want to define the engineer, or scientific personnel, as meaning those people who are devotees of the physical sciences. I think this otherwise innocuous truism makes sense if I say I am in this way contrasting you in this room as a group with two other groups in the populace. One, we lesser mortals who have simply social science up our sleeve and two, those really numerous people who have no science at all, and who outnumbered you 50 to 1.

There are a number of ways of approaching this problem of ours. Fortunately, there are some excellent studies which I can call upon and which I wish to share in part with you as a background to my present point of view and approach. A very fine psychologist, a woman by the name of Anne Roe, has described the background, childhood, training, interest patterns and so forth of a group of physical scientists. The titles of her studies read like this: "A Psychological Study of Eminent Physical Scientists". "A Psychological Study of Eminent Psychologists and Anthropologists". Then there is Lewis Terman's article "Are Scientists Different?" in the Scientific American. This is the kind of background data which I am going to bring before you as a stereotype of the engineering mind at work and as an introduction to the administrative dilemma that sometimes follows in its wake. I have five staff associates and I have asked their opinion on these matters too, to get a cross-section at least from a consulting point of view, as to what the word "engineer" typically means as a person, as a phenomenon, yes if you will pardon it again, as a problem and conundrum as we must confess they frequently become administratively. I am also calling on my own observations, both at M.I.T. and Cal-Tech, and later in the years of consulting work. I think perhaps I have at least a partial insight into these individuals whom I like to describe as exhilarated with a slide-rule approach to life. This may perhaps serve as the keynote of my remarks.

I want then to present, if I may, an opinion—one man's opinion—about a special profession. This can be a dangerous thing to do, for all of us in our special groups differ from the population. Industrial relations people also have their foibles and perhaps at some suitable time an engineer might set us to rights. It is my pleasant privilege, however, to take the administrative point of view in evaluating or at least describing for you some of the challenges of the engineering mentality in the administrative sense. I am not asking you to agree with this, but I do ask you to re-examine the problem.

In contrasting the physical with the social sciences then, I will call upon such library materials as I have delved in to obtain from Anne Roe and Lewis Terman a stereotype, a picture, a profile, a cross-section of what I think it is not unreasonable to say is the engineering mind.

I want to take some direct quotations on about eight different topics from these sources. One has to do with our relationship to work, to the job we do. Speaking of physical scientists, Miss Roe has said, "Most of them are happiest when they are working—some only when they are working. In all these instances, other aspects—economic return, social and professional status—are of secondary importance."(1) On a feeling of independence, again to quote Miss Roe: "More of these men (the physical scientists) than not, as boys, pursued rather independent paths—playing with one or a few close friends, instead of with a gang, following their own particular interests . . . and such interests were more often intellectual than not."(1) On personal contacts, another basic part of corporate life, the pattern of the physical scientist provides "a pattern of general avoidance of intimate personal contacts, a considerably later than usual development of heterosexual interests or at least of their expression, and even at the present time, a decided preference for a very limited social life."[1] Perhaps the wives of the engineers present will recognize all this.

A feeling of being different colors these engineers, of being separate from, away from, different from the rest of the world. "In the life histories of many of these men there are factors which indicate a feeling of apartness from others . . ."[1] On the matter of learning, education, the process which we associate with the campus, ". . . in practically all of these homes, whatever the occupation of the father, learning was valued for its own sake."[1]

On distance getting, being away from people on purpose if you will, "Both biologists and physicists (and others of the engineering type) are much less interested in inter-personal relations, generally, and more inclined to handle them in distance-getting ways than are the social scientists, although many of the latter are uneasy about them. But the unease is of a different sort and a manifestation of considerable concern with such relations, rather than a dislike for them."[1]

On isolation again: "Both the physicists and the biologists early developed ways of life which involved very much less of personal ineraction and neither group shows anything like the rebelliousness and family difficulty that the psychologist and anthropologist show."[2] On interest patterns, Miss Roe speaks of the physical scientists: ". . . almost all of whom displayed early interest in mathematics, chemistry, physics or gadgeteering, and very few of whom are interested in literature or the humanities."[2] Having myself taught humanities in two of the top engineering schools in the country, this strikes home to me.

On the non-social aspects of the engineer, Lewis Terman wrote, "Yet it is true that the bulk of scientific research is carried on by devotees of science for whom research is their life and social relations are comparatively unimportant."[3]

Here then is a stereotype, a profile, a picture. And I think that with due regard for inaccuracies, you will find it does present a picture which is sufficiently startling so that it might be worthwhile exploring it for just a few moments. May I summarize what I think all this means in defining scientific personnel, the engineering mentality within the American community? There are six points that I would like to summarize as being one man's opinion of the essential thing that makes up the scientific, the engineering mind at work. First, these people have a far higher I.Q. than that of the average populace. They are an exceptionally intelligent, highly mental, highly intellectual group. They are the best problem solvers we have where physical problems are involved. Second, they have by definition a much narrower field of interest than is true of the rest of us. They dig deep, but they dig narrow. They are specialists, perhaps more extremely so than is true for any of the other professions. Third, they have a strong pride in, and an identification with science, research and its achievements. They feel themselves to be a part of that movement and are very pleased to be a part of it, and quite fitly so. Fourth, they are motivated largely by immediate problem solving. One administrator said, "When I ask my engineer a question he gives me a six volume answer." They are concerned with that kind of detail, thoroughness, competence, insight into the problem once it is presented to them—because problem solving is their meat and they chew into it with all the vigor of their good minds, and the intent and drive they represent. Number five, they are strongly individualistic, and do not think in terms of group motivation, but as persons, individuals, isolated, apart, alone, different on purpose, for this is their wish and this is their pleasure. Sixth, and last, and to me perhaps most challenging of all, these people by definition (and by my own personal observation) find personal contact, cooperation and sociability highly repulsive. The grease on the corporate wheels they find nauseating.

Now this picture, if it be at all accurate, portrays a group in the total community with a vital role to perform, but with certain characteristics which make it at least in part a challenge to the rest of us in terms of getting along harmoniously.

May I try to contrast two stereotypes? May I picture the engineer on the one hand and the average citizen on the other, and show you the kind of variations that I think separate them? The engineer likes work, the average citizen likes fun, sociability and mixing. The engineer likes independence, the average citizen likes social groups, belonging, being one of the boys. The engineer dislikes personal contacts and feels apart from other people. The average citizen lives on and for them, and wants to be one of the crowd most of the time. The engineer respects learning. The average citizen takes tips on uranium stocks from the elevator operator. The engineer builds distance between himself and people around him, keeping them away from him, because he doesn't want them any closer. The average citizen bridges gaps and joins clubs by the millions to get in with other groups and be part of them quickly, permanently, consistently. The engineer prefers isolation. The average citizen fears being alone too long (twenty minutes might be a fit period). The engineer likes mathematics and physics. The average citizen finds them totally nauseous. The engineer finds social relationships distasteful, the average citizen dies unless he finds them and soaks in them daily. Now this is a rather stark contrast, perhaps, you may feel, unfairly stark. Water it down by half. The contrast, whatever size and magnitude you judge it to be, I think constitutes to us in corporate administration a tremendously complex, challenging kind of daily problem in terms of using our engineering friends, working with them, cooperating fitly with them in order to accomplish our joint purposes.

Probably the key difficulty is that the very language we social scientists are trying to develop, by the very vagueness of its definitions is repulsive in the extreme to the engineers, who look upon anything to less than four decimal places as being beneath contempt, even if we know the whole number is twelve per cent wrong in the first place. This kind of bar between us, sinister, persistent, challenging, dynamic, overwhelmingly powerful, continues to create suspicion and havoc between the two groups.

Now for the second part of my topic: the <u>motivation</u> of people of this kind. I have a talk I give on the motivation of employees in which I try to reduce this extremely complex field to six basic questions that I think most employees have on their minds. May I use that same skeleton outline for just a moment, but stressing the eccentricities, the unusual uniquenesses of the engineering motivation?

My first question on the employee's motivation is "What's my job?" and usually I talk about job descriptions, job evaluation, job title and so forth in ways you would expect. Now from the engineering point of view, it seems to me, the difference is that engineers are particularly precise about job title. They want the thing to be exact, right on the button, and this changes it a little. They want their job descriptions to reflect their work, but they want to work alone, and so they are much more likely to respect the paragraphs on the isolated part of their work, than the relations with others that the rest of us feel have to be there. On job instructions, the engineer again tends to be precise, but perhaps a little stingy with his words. And he gives the right answer, but to the uninformed listener it may be bafflingly brief and therefore need amplification. And in the employee selection process, the engineer with his high I.Q., his fine background and training, tends to be a precise kind of a guy (or gal) to place, rather than a modifiable one who could fit in with this or that job. And to us in the employment function, this necessitates a more precise, higher accuracy, lower tolerance of error kind of a job than is usual in placing other people.

The second question is, "Who's my boss?" And I usually discuss here authority and single line of command, span of control and so forth. Now to the engineering point of view, these things, I think, have some rather interesting innuendo beneath them. On the matter of authority, the engineer is more likely to think of truth with a capital T, as being his boss, rather than the corporate president who happens to sit in the chair in the front office. He has a moral purpose, a problem to solve and in this corporate setting his loyalty is to science or problem solving. As a consequence, these other things seem simply energy wasters—distractions. An organization chart to the engineer is likely to appear as a plaything of those odd chaps over in Business Administration. And on this matter of having one boss and one boss only, the engineer may be quite likely to reply, "That's fine, but, if at all possible, keep him out of my sight; I know what I am doing."

This loyalty to their "cause"—to "problem solving"—is often the highest loyalty they know. And quite understandably too, when viewed against their background and training. But it makes for corporate strain and misunderstanding, administratively.

A third question that I think employees, all of us, reflect about is this, "How am I doing?" What sort of advance or progress am I making personally in my own career? Now to the engineer, the usual answers again must be treated a little differently, with a different slant, a different stress, and with much more administrative imagination and creativity. To the engineer, "merit" often means scientific achievement, the publication of an article or something which has aided the advancement of science. These are the things he considers meritorious. Maybe his department is dying on the vine or his turnover rate is atrocious, or the things he does may be bothering the company, but he got an article out which his colleagues find highly worthy. He may feel he's had a very merit-worthy year but you may have a different opinion about it, and the boss upstairs may too.

Another phase is counseling. People, most of them, need counsel occasionally. But the engineer, by definition, if my picture is at all accurate, by being different, apart, not liking to turn to counsel even though he may in your judgment need it, is very loath to take it even when it is made available to him. So, to counselling techniques which many administrators find helpful for others, the engineer is quite likely to turn a cold shoulder. Now this may be good or bad; I am trying only to describe.

A fourth question from my six is, "What's my pay rate?" Now engineers are not unmindful of money, and in this present labor market, if some of you are hiring some of them, you may think they are unduly concerned about this matter. But now from the picture we have drawn, the engineer is again a little different from the run of employees and supervisory people. He is likely to put work above pay in a general sense; although when he bargains, he is pretty ruthless about it. Candid, cold and calculating, with "slip stick" in hand, he is a notoriously elusive character to pin down to a nice easy labor bargain. This may be realistic for the labor market; it also has some repercussions for wage administration and salary plans.

Now maybe I've handled these things in too cavalier a fashion. These first four questions and the two to follow in a moment are the areas where looseness of language is altogether too prevalent and I can be accused of using generalizations which may shock some of you beyond decent acceptance. May I read a paragraph from a book which I greatly revere which points out how much more important the few basic underlying elements are than all the superficial, extraneous elements? The book is a challenging one which I think you may want to get from the library. It was written from the masculine viewpoint. You must forgive this please; it could have been written by a couple of women, but it wasn't; it was written by men. It has a challenging title, this book; "Is Sex Necessary?" The answer, in case you're intrigued, is in the affirmative. You will see the masculine bias in the very first paragraph: "Let us go back a little way. There are two fundamental urges in nature: the desire to eat and the desire to reproduce one's kind. Which of these two impulses is the stronger depends somewhat on the individual and somewhat on the circumstances surrounding the individual—that is, it is apt to vary with the quality of the food and of the women. There are, Zaner shows, men who would rather eat than reproduce, and there are isolated cases of men who would rather reproduce than eat."(4) I hurry on. "What I shall try to show, without carping, will be that there is a very good reason why the erotic side of Man has called forth so much more discussion lately than has his appetite for food. The reason is this: that while the urge to eat is a personal matter which concerns no one but the person hungry, the sex urge involves, for its true expression, another individual." "I use the word 'involve' advisedly. Just the minute another person is drawn into someone's life, there begins to arise undreamed-of complexities, and from such a simple beginning as sexual desire we find built up such alarming yet familiar phenomena as fêtes, divertissements, telephone conversations, arrangements, plans, sacrifices, train arrivals, meetings, appointments, tardinesses, delays, marriages, dinners, small pets and animals, calumny, children, music lessons, yellow shades for the windows, evasions, lethargy, cigarettes, candies, repetition of stories and anecdotes, infidelity, ineptitude, incompatibility, bronchial trouble, and many others, all of which are entirely foreign to the original urge and way off the subject, and all of which makes the person's existence so strangely bewildering that if he could have foreseen these developments his choice would have been the 'eating' urge, and he would have just gone quietly out somewhere and ordered himself a steak and some French fried potatoes as being the easier way out."(4) Like Thurber's two basic urges my six key questions must carry a tremendous load of superficial impedimenta. These "extras" you must hang on the key questions as your experience dictates.

The fifth question is this: "How do I move ahead?" How do I advance? Now I usually stress, when I talk about employees in general, that very few of them really want to get ahead. What, get a supervisory job and ulcers?; no thank you, I'd rather live happily and longer. This kind of revulsion to the administrative problems is a quite normal one for employees in general. Only a few of them want this moving ahead business. But now to the engineer, with his devotion to science and truth and problem solving, getting ahead is essential all the time. If he's any good at all he's constantly going to be thinking out how to do this, trying to move ahead in ways he feels important to scientific achievement, the discovery of truth. He will seek personalized training where he can use it to his own individual advantage in this problem solving, counseling for the job ahead only in small amounts because of his apartness and revolt against this social contact business, but needing it at times and very avidly grateful for it if it can be put in non-personal packages and somehow de-individualized in transmission. The engineer causes a constant challenge, because his yen to get ahead is so intense, so continuous, of such a high order; and the things that baffle him organizationally are likely to continue to do so, because he finds mastery of them so personally repugnant.

And lastly; "How can I belong?" This is my sixth question in dealing with employees in general and now you see it kicks me right in the teeth. Engineers don't usually want to belong. They want to be off in a corner by themselves, chasing truth with professional esteem at the end of the rainbow and accepting corporate skullduggery only in modest doses. So my sixth question backfires heavily on the very thing that I think many of us feel is probably the chief motivator for employees in general. And this is a problem of immense import; the magnitude here is beyond all description. To me the critical question for most employees, the desire to be part of the group, to participate, to share, to be in on the know—these things the engineer, if my picture is at all straight, finds repulsive. I did a job for one of the Armed Services recently in an installation where 4,000 people in an isolated town are administered by an astro-physicist on alternate Thursdays during his lunch hour. When a man finds the things he is supposed to accomplish administratively so utterly repugnant the havoc and chaos can only be imagined. These are the problems that I think we face when the engineer starts to administer.

If I am correct in this analysis, the supervisory engineer, the supervisory scientist, is from our point of view doubly damned. First of all, if these described traits are real, I put them before you as a challenge to your own thinking. The engineer is by definition not a very easily administrable character himself, and when he starts to administer other people, this aloofness, this apartness, this non-sociability begins to be a tremendous handicap to him, which he frequently cannot see, accept, understand or overcome. It baffles, it maddens, it corners, it frustrates him. He lashes back with his superior mind, with sarcasm and the rest of it, and the whole thing comes to a grinding halt. The engineering supervisor, unless he is a very exceptional case, is plagued by these very traits of which I speak. He has an unlikely group to run and he himself by definition, emotionally, temperamentally, and interest pattern wise is almost unfitted for the job.

The supervisor over engineers tends for obvious reasons to be himself an engineer. This means he was probably promoted for his technical competence and/or availability. But the supervisor's job is, approximately, three-fourths administrative to one-fourth technical.

And on the administrative front, the engineering supervisor (unless he is a most unusual case) is characterized as follows:

1. Used to working mainly in isolation.

2. Highly specialized in a rather narrow technical field (without wide human and political interests),

3. Usually lacking both familiarity with and respect for the organizational and administrative problems of dealing with groups of people. And,

4. Not usually versed in the basic techniques of semantics, communication and inter-personal relationships.

Let me in closing summarize the main points for our discussion period:

1. The engineer—the scientific employee—is <u>not</u> like other employees. He has traits of his own through which his job motivations work.

2. The kinds of basic queries on the average employee's mind run:
   a. What's my job?
   b. Who's my boss?
   c. How am I doing?
   d. What's my pay rate?
   e. How do I get ahead?
   f. Do I belong?

3. For engineers—scientific employees—these main questions must be thought through again, modified with care and applied at times almost with reverse English.

4. This makes the job of supervising such employees particularly elusive, demanding and confusing.

5. If the supervisor for such workers is himself an engineer, the difficulties are twice compounded. Faced with unusually motivated demands, he is by definition under-equipped personally (by training, background and individual motivation) to cope with them.

6. Solving this critical need is one of the most challenging management problems of our times.

7. The Russians too must solve this problem while wading through blood baths, hewing to the party line and debunking ex-heroes. If we can lick it first and best we will not only have aided American management thinking, but will have added a new element to our strength.

REFERENCES

1. Anne Roe, "A Psychological Study of Eminent Psychologists and Anthropologists and a Comparison with Biologists and Physical Scientists", Psychological Monographs, 1953, 67, pp. 1-55.

2. Anne Roe, "Psychological Study of Research Scientists" Psychological Monographs, 1953, 67, no. 2, pp. 22 and 25.

3. Lewis Terman, "Are Scientists Different?", Scientific American, Jan. 1955, Vol. 192, pp. 25-29.

4. Thurber & White, Is Sex Necessary? 1944, pp. 160-164.

PLANT WIDE COST REDUCTION PROGRAMS

Irwin A. Rose
Vice President - Manufacturing
The Maytag Company
Newton, Iowa

Cost reduction is vital to the future of an organization in a competitive economy. Management personnel frequently make certain assumptions concerning this subject which may or may not be well founded.

Members of management in a well run business organization would probably agree that any change or cost reduction that would improve the competitive position of the company should be enthusiastically endorsed. This proposition suggests that the importance of serving the end purpose of the organization might lead to acting in concert, and no doubt, this actually does happen many times without being noticed by the parties to the accommodation.

Let us assume, as a condition, that one of the parties involved finds or suspects that the change could have an adverse effect on his personal interest. Is it unreasonable to assume under these circumstances that in the absence of some compelling reason to favor the proposed action, or unusual maturity or confidence on the part of the persons to be persuaded, that the party adversely affected might not see the merit of the action under consideration? Cost reduction frequently involves change and since change at times affects the status of people, a conclusion based upon the expectation that everyone required to collaborate will see the wisdom of the proposal, might be in error. Self interest under the circumstances could result in inability to appreciate the merit of the proposal.

This is in no way intended to imply that productivity is not directly influenced by the way people in an organization feel about the work situation. The way people respond bears directly on the cost of production but it does not follow that they act favorably or unfavorably merely because of a great need or because of being informed as to the importance of cost reduction under certain conditions.

This whole area of how people feel and how they respond, of how persons are influenced or why they resist or comply and, in general, of interpersonal relationships and intergroup reactions is, in my opinion, most fundamental to the character, design, and implementation of any activity. In other words, we are recognizing the very real importance of the individual and the composite of individuals, the fact that these individuals must be induced to participate effectively and constructively and in short, that this involvement is at the back of any vital and effective program, cost reduction or otherwise.

There are requirements to be met if the benefits of participation by all of the people in an organization are to be tapped in a continuing cost reduction effort. Being a member of an organization does not assure willingness to contribute. The presence of indifference to, support for, or resistance to a cost reduction requirement has to be taken into account in planning the program.

Having recognized the necessity of involvement of all people identified with an organization, the responsibility for establishing the ultimate cost goals must rest with the management group, who also must obtain the involvement noted above in the attainment of these goals.

Cost reduction, because of the very nature of our system of business enterprise is a matter of concern to every qualified manager and is regarded as an important criterion in appraising his performance. In fact, he may be so much concerned about his immediate performance that he will lack the vision to conduct his operation to the best advantage of the total organization.

In considering creative work of the cost reduction type the accomplishments of the small business operator are often overlooked. The individual who conducts a small business is frequently a highly skilled specialist. Operating as an individual, he has every reason to excel in his field and may require very little in the way of resources in order to achieve remarkable results. The urge to produce at the lowest cost consistent with the other demands attending the operation of a business is always present; it obtains in the small as well as in the large company.

The urgency may vary depending upon conditions, and this very fact that variable conditions place cost, in one light, under one set of conditions, and subsequently require the cost issue to be viewed in a totally new light, requires adaptation that is unlikely to be achieved by any random means.

Cost reduction, organized as a part of the job of the manager—from line foreman to the highest level in the division—not only offers the possibility of a more orderly operation: it specifically affords attractive opportunities for the development of skills and the satisfaction that attends helping others develop. The development of the superior skills and the maturity acquired by taking responsibility for self development, impart a spontaneity that generates fresh interest in tackling new assignments, but only when full responsibility has been delegated and support provided, with consistent interest in performance evidenced by supervisors.

Discussing cost reducing practices regarded as collaborative with delegation of responsibility in operations involving the use of labor, material and overhead seems unwieldy at this point. Activities that operated to bring costs into line at the Maytag Company and which I wish to discuss are:

1. Industrial Engineering, including the consideration of incentives.

2. Employee Idea Plan.

3. Research Surveys to evaluate specific relationships with emphasis on Incentive Payment Plans, Productivity, Communications, Union-Management Relationship, Employee Idea Plan, Safety, etc.

4. Methods Time Measurement.

5. Expense Control Program.

6. Maintenance Planning and Measurement including Tool Maintenance.

7. Tool Engineering.

8. Value Analysis.

INDUSTRIAL ENGINEERING AND INCENTIVES

Our methods and labor standards are so related that it seems logical to treat the whole subject as one, including the administration of the incentive system by the operating personnel.

Practically all direct labor in the productive departments is covered by an incentive payment plan, which means that all operations have been standardized, that they have met the requirements of the time study engineer and that the rate was approved by the foreman.

All substandard earnings are scrutinized and observed until satisfactory earnings have been achieved under an earned hour system of payment. Upon installation of the incentive system there was an increase in earnings and output. Both group and individual incentive rates are used, depending upon the job.

The supervisory staff was drilled intensively on time study fundamentals. A program of instruction was worked out with the assistance of the state university and a complete manual of instruction was developed for use in this connection.

The union officers and stewards were given instruction.

Provisions were made to facilitate computation of earnings and any objections known to apply to incentive plans were anticipated and provided for in advance. A formal grievance system was agreed upon to provide easy, prompt communication in order to achieve understanding.

Revisions in layouts and processes were made when required before final approval of the method. After the installation of our incentive payment plan further refinements were developed in planning operations which will be discussed later in this paper.

EMPLOYEE IDEA PLAN

The employee idea plan, which has been used for the past eight years, invites any qualified employee to submit a cost saving idea for which he will be compensated if it is accepted and installed. The processing of the proposal is under the direction of the Manager of Industrial Engineering. The ideas are submitted to the foreman who is encouraged to assist the employee in developing an acceptable proposal, and the foreman may register his comments on the proposal form for the consideration of the industrial engineering investigator. The investigator immediately upon receipt of the proposal, visits the shop and discusses the idea with the employee and the foreman to determine in a preliminary way whether the proposal merits processing or should be revised.

We not only want the foreman to participate; we want him to regard free participation on the part of the employee as a measure of his ability as a leader.

Before an employee is entitled to submit ideas he is required to be on the payroll for six months, after which period he takes a ten hour course of instruction consisting of four two-and-a-half hour sessions within a one month period.

The first day, his group of approximately twelve or fifteen employees meets either an officer of the Company or a division head, who will, in a very informal way, discuss the program. The employee is given first hand information concerning the importance of employing the total resources of every man employed. Every effort is made to indicate the extent of management's sincere desire to provide the means whereby ideas can be submitted, as well as its interest in the employee's viewpoint concerning his job. An effort is made to encourage him to develop and use his creative ability. The group, under the direction of a leader, then covers the material and demonstrations described as Job Simplification.

All management personnel, including the president and all company officers, took a twenty hour course in the same subject before it was offered to employees.

Management personnel are not compensated for the ideas which they submit. The recognition, along with the convenience of having engineering assistance and service in the processing and installation of ideas, seems to account for the use made of this channel by supervision. Acknowledgments in the form of personal visits by various officers and division heads are made use of in an effort to recognize all outstanding performance by supervision.

The product of the idea program is impressive. During 1956 there were 530 ideas submitted, of which 275 have been accepted and installed. The gross annual cost reduction realized from these installed ideas is $474,583.00, which after deducting installation costs of $18,150.00 leaves a net cost reduction of $456,432.00.

While the savings are attractive, a by product of the activity, in the opinion of many of us who have observed the results, is of even greater importance; that is, the improved relationship that develops and continues on the job after a man has participated in this training and in a successful idea experience.

RESEARCH SURVEYS

Treating plant wide cost reductions with the intent to take into account the interests and beliefs of people working in an organization compels me to give consideration to material which might be classified as personnel administration.

The purpose of our own research was to develop understanding by drawing on the very best experience available so that we could improve our operations. While it may appear to be oversimplification, there is some merit, when attempting to determine the extent of needs for and the means whereby improvement is to be attained, in reporting accurately on the pertinent aspects of the existing conditions. Convictions to this effect were the basis of our decision to collaborate with the Institute for Social Research at the University of Michigan in the conduct of an attitude survey. The methods employed are familiar to an audience such as we have here and therefore warrants no further comment at this time.

The benefits to be derived by anyone interested in improving understanding and the effectiveness in modifying practices because of the development of insight and sensitivity through the "feed back" is impressive. The understanding acquired by the entire organization through sharing this experience, together with the learning which took place in the "feed back", resulted in improved administration of the incentive system and contributed to the growth and maturity of the organization.

The following extract from the reports used for training illustrates the kind of material used to retrain in this field.

"It will be noted that the highest percentage of satisfaction with the incentive system is found among workers who reported: (1) that their foreman tries to get the men to follow the method described in the labor standard sheet; and (2) that their foreman does a very good job of explaining the reasons for changes in labor standards. Conversely, the lowest percentage of satisfaction occurs among people who said: (1) that their foreman tries to get the men to follow the prescribed method; but, (2) that their foreman doesn't try to explain the reasons for labor standard changes."

Communications and numerous management practices took on new importance after this study was completed and the experience has been of great value in training because we are able to agree on some common values.

METHODS-TIME MEASUREMENT

I mentioned earlier that after incentives had been installed and were working satisfactorily, further refinements were developed in the planning of operations for lower cost production.

We felt that there were two major needs. The first was the pre-planning of manufacturing installations to provide lower cost operation and, as a corollary, the elimination of frequent changes in methods after production had started. Such changes usually result in confusion and ill effects on employees' attitudes. Our second need was to examine our existing operations for improvement in quality and cost reduction possibilities.

It was felt that the use of a predetermined time system would be of assistance in meeting these needs. After a thorough investigation, we selected Methods-Time Measurement because it offered the following possibilities:

1. Development of effective methods in advance of production, selection of effective equipment and development of the best tool designs.

2. Training supervisors to become highly methods conscious, enabling them to organize and expedite the training of operators.

3. Balancing production lines and setting production goals before starting production.

4. Determination of labor costs in advance of production.

5. Assistance in developing more consistent labor standards.

M.T.M. as you know, is defined as "a procedure which analyzes any manual operation or method into the basic motions required to perform it and assigns to each motion a predetermined time standard which is determined by the nature of the motion and the conditions under which it is made."

Our approach to obtaining cooperation from all groups concerned in our Line & Staff organizations was to select members from these various groups for the initial M.T.M. Training. The initial phase of our Methods-Time Measurement program was completed in 1952 when 105 hours of training was provided to our first groups which were composed of a mixture of industrial engineers, technical engineering staffs, and production supervisors. The theory was that we would all start off together to learn this new technique. Indoctrination conferences of six hours were provided our top executives, from the president on down.

After some application experience was gained, we recognized that to fully utilize the potentialities of M.T.M., training of all shop supervision in the use of the technique would be necessary. Consequently a 70-hour training program for line and general foremen was developed. This training was directed toward providing each foreman with sufficient technical knowledge to make an M.T.M. analysis which would be adequate for him to use in planning his operations and making methods improvements. We were of the opinion that this would result in immediate cost reductions, as well as having him become much more methods conscious generally. During the 70 hours of training, each foreman was required to submit at least one cost reduction project based on the use of M.T.M. For the last group of approximately 100 supervisors who completed the training, the annual cost reduction from the M.T.M. projects started during the classes was approximately $45,000.00. We do not anticipate that this is a "one-shot affair", for once a foreman has used M.T.M. to install a better method, he usually recognizes it as a practical tool in his continuing job of cost reduction.

The use of M.T.M. in developing methods in advance of the beginning of production has been very effective. It has resulted in much more satisfactory operator training as well as eliminating many of the manufacturing problems normally encountered when a new product is put in production. M.T.M. was used to establish the methods to be used at each assembly station, and in the determination of the types of conveyors, the equipment requirements, material handling methods, etc. The layout was complicated by the requirement of sufficient flexibility to accommodate the four current models of machines, as well as six new models which, at the time, were not in production.

The "team" approach was used and a project group was formed consisting of the manufacturing department superintendent as chairman and representatives of various staff departments to assist him in planning and installation. Having had M.T.M. training, these individuals were better prepared to handle the project from the detailed analysis of each work station, through the final construction and erection of the equipment, to the installation of wage incentives.

Finally, we have also found that M.T.M. is of great assistance in establishing standard data. This is true not only in production operations, but also in the area of indirect labor such as material handling, and Maintenance Department work. We have used M.T.M. extensively in developing standard data for these purposes, and particularly for maintenance activities.

M.T.M. has become a common language which is used by all members of our manufacturing divisions in planning and evaluating our work.

EXPENSE CONTROL

Overhead is an item of cost which if carefully evaluated can be reduced. In our company this is a most attractive area for cost reduction. Budget performance in our plants has been taken out of the once a month category and has been rated as a day to day matter of importance. The organization has been divided into cost centers. Each department head, acting as chairman, holds a weekly meeting for the purpose of reviewing the previous weeks performance. Our cost department furnishes up-to-date information on all items of variable expense. The meetings are attended by the cost man, industrial engineering representative, manager of manufacturing, the plant superintendent and any representatives of staff or other departments that the chairman elects to call. I also attend these meetings. The people in attendance at the meeting are there to assist the chairman in improving his performance.

Every effort is made to permit everyone concerned to concentrate on problems rather than to attempt to rationalize or defend any given solution. The mere examination of the performance under these conditions is, in some cases, sufficient to indicate correction. Getting fresh viewpoints on organizing activities for future operations encourages the individual to contribute effectively, and the example set by various members of the group provides a pattern of behavior that is frequently reflected on the job. Increased identification with the over-all goals of the company is apparent.

In addition to the weekly meeting each department head schedules meetings with his general foreman and line foreman to attack the various problems brought out by the evaluation of current data in comparison with the budget. In other words, the weekly meeting held by the department head provides material for problem-solving meetings within the department. Sectional budgets and daily records in the larger departments permit a more accurate delineation of responsibility. Following these meetings, the department head could report action taken by his group to meet budgets, or he could suggest lowering the budget standards when the study of conditions so indicated.

Consistent progress has been made in reducing overhead cost since using this approach. Even with rising prices and wages for the current year, our management group has made a commitment to reduce these costs another ten per cent, which amounts to about one and a half million dollars.

MAINTENANCE PLANNING AND MEASUREMENT

Maintenance of equipment and property in the absence of standards is apt to be viewed in the light of downtime particularly during a period of high production. If this is the case, in addition to high cost in terms of inefficient utilization of skilled craftsman time, the maintenance job may also suffer, which increases cost still further.

In order to deal with this problem, standards have been established for maintenance work and large jobs are planned for the crafts. Cost of maintenance has been reduced as a result of this treatment and from all indications the craftsmen are better satisfied with the elimination of the delays which occurred when work was not planned.

The plant-wide cost of maintenance is being reviewed in much the same way that other expenses are examined. All items of expense applying to equipment are recorded and equipment which is subject to excessive repair charges is thoroughly investigated with a view to reducing the cost.

A substantial improvement has been made in the efficiencies of craftsmen to date and it is apparent that much of the cost which has been incurred in maintaining equipment can be avoided.

TOOL ENGINEERING

The tool engineering division designs tools, specifies equipment, takes part in deciding whether certain parts are to be made or purchased. Their services in an advisory capacity are made available to both the product design division of the company and to the operating section. All cost reduction items involving the use of tools or equipment clear through this group. Operation analysis information originates in this department. The men in this group have been trained in M.T.M. techniques in order to incorporate the best practices in motion economy. In addition to the creative resources in the organization numerous contacts are maintained with competent sources for tool and equipment design and tool and die making. Some excellent methods used in our plants resulted from the efforts of people on our staff collaborating with highly qualified suppliers.

Recognizing the possibilities for cost reduction and having the judgment and experience to appraise the qualifications of the supplier, the ability to utilize services and effectively handle the personal relations, are the important considerations in this type of transaction. A cost reduction program which excludes the vast knowhow that is available in these sources might do a fine job by certain standards but forego some long range benefits.

VALUE ANALYSIS

Value analysis as a sound business tool has been widely publicized as the formal action of a committee headed by a specialist. Our procedure is less formal, less time-consuming, yet it is quite productive.

Our value analysis activity starts with source determination for a new requirement, at the time the project engineer from the Research and Development Division and the purchasing personnel examine the requirement, prior to soliciting quotations for the component or assembly in its specified form or a suitable alternate. The recommendations of those quoting are carefully analyzed so that desirable features and cost reducing techniques can be embodied in the final specification.

On currently purchased requirements an effort is made to reanalyze periodically as new commitments are released. The purchasing department communicates information pertaining to improvements to the interested areas for further evaluation, after setting up a value analysis file to record all activity and decisions. Improvements requiring a specification change are referred to the Research and Development Division for formal action after preliminary exploration by that division. Quality and Inspection, Factory Engineering, and Production Engineering confirm the apparent merit. In cases which involve a change in methods a formal cost analysis must support the value of the change before a specification revision is initiated.

The Purchasing Department sets up a value analysis file on purchased items without regard to the origin of this seed, whether it be from a vendor suggestion, employee idea, purchasing personnel or group discussion. Not always as originator, but always as a contributor, the Purchasing Department undertakes the liaison necessary to pursue a project to conclusion, favorable or otherwise. Whether a formal committee, meeting frequently with an attendant loss of time to individuals and departments, would be more productive is debatable.

SUMMARY

From this discussion it should be evident that cost reduction, as a function, need not be set aside as the exclusive responsibility of a given group as a special project, but rather as one which is an integral part of the mainstream of the business activity. As such, it demands the attention, endorsement, and constant participation of the full management team, plus the involvement of employees in all areas so as to utilize the full resources of the entire organization.

In this situation, an attempt has been made to use the highly specialized skills which have been shown to be so vital to the furtherance of a cost reduction program, and further, to develop a community of interest by involving as many individuals as possible in this common experience. The needs for cost improvement have been satisfied to a degree sufficient to meet the requirements up to this time and there is evidence of opportunity for further improvement.

The character of our program is that of coupling a good technical and engineering job with the interest and participation of all employees in such a manner as to yield consistent improvement in the area of costs and, at the same time, permit the enjoyment of maximum satisfaction on the part of all participants. In addition to the immediate benefits secured, there is the development of those skills and capacities which assure the furtherance of the program and merit a confident attitude with respect to the future.

OPPORTUNITIES OF THE FUTURE

James H. Smith
General Manager
Central Foundry Division
General Motors Corporation
Saginaw, Michigan

I feel both honored and pleased to be here today. It is indeed a privilege to address the members of the 9th Annual Industrial Engineering Institute.

I am not sure just why I was chosen to address this group today. Usually men who make this type of presentation are considered experts in their subjects. Surely the most significant qualification I have for being an expert in this area is that I am quite far from home.

We Americans are sometimes accused of being too materialistic. Our critics say that we are too much concerned with the physical things—automobiles, television sets, bathtubs and the like—and too little with the nobler things of the mind and spirit.

I do not see why material progress and cultural and spiritual growth should be considered mutually exclusive. In fact, as a nation we have demonstrated that they are not. Our cultural activity is gaining momentum—we see it daily—in the fields of literature, music and drama, and we are attending our churches in greater and steadily growing numbers.

Therefore, I think it is fair to conclude that rather than being a detriment to the things of the mind, material progress is a prerequisite. A people preoccupied with scratching out a bare existence have little time or inclination to devote to cultural pursuits.

I wanted to make this point simply to emphasize the fact that when we improve technology we create an atmosphere favorable to the further development of our society in all its aspects. I believe, to provide for continued cultural development, the basic need is to assure that we have continued technological development.

This is also of the greatest importance because of the challenge presented by the world around us. To continue to exist we must be secure. Today we are. It may seem brutal to say it, but our present superior ability to retaliate and devastate is the prime deterrent to those who feel they would benefit from another world conflict.

We are now in the midst—or more likely at the beginning—of another great industrial revolution. Actually, what is taking place upon the industrial scene today can be described as an accelerating evolution, and this implies an orderly and salutary development toward a state of greater perfection. If, as a people, we would have more, we must increase our ability to produce more with the same amount of human effort. Today we are doing this by taking the cybernetics approach to production—what many people call automation.

I believe this latter word has created a good deal of confusion. It came upon the public suddenly a few years ago, and because of its root it has conjured up visions of push-button factories all but devoid of human beings. To some automation has become a fear word and even a smear word. This despite the fact that what it stands for—plentiful production—is our great hope for military and economic security as we look to the future.

Perhaps the reason so many people fear automation is that they think it is a threat to future job security. Yet it has been estimated, on the basis of present population and productivity trends, that unless we improve our productive efficiency the country will face a labor shortage beginning sometime in the mid-sixties. So our worry should perhaps be: can we automate fast enough?

Automation—the technique of continuous process production as distinguished from the batch method—is nothing new. It was not even new when R. E. Olds assembled the first automobiles on a moving conveyor line, about 50 years ago. We are now applying the continuous process idea to all types of production, including the industry with which I am most familiar—the foundry. This is being done not simply from a materials-handling standpoint, but to gain other important cost advantages inherent in the continuous flow of work from raw stock to finished product.

As we learn how to produce more efficiently, we can look with some degree of confidence to the task of providing for tomorrow's growing needs. It is estimated there will be 193 million Americans in 1965. When compared to today's 167 million, this unprecedented population pressure alone poses a challenge to technology. We would need to produce more merely to maintain our present living standard for a growing population.

But it is not in our tradition to stand still. Our people properly aspire to improvements in all aspects of their lives. We must provide these improvements on a sound economic basis and also maintain our superiority in defense technology.

As our production gets increasingly more efficient—and thereby technically more complex, we are creating unlimited opportunities for the future. Not only for the technically trained man, the engineer and the scientist, but for all men. We are all influenced by the chain reaction of industrial progress!

I am sure most of us are impressed with the industrial progress our country has made to date. We are especially so, when confronted with comparisons of our way of life and that of numerous foreign peoples. Let us take a look at today's American—the 1957 model, in automotive terms, who is the actual beneficiary of this industrial progress and whose dreams of the future can only be realized through continued technological development.

What kind of "composite" could be drawn up from this population of some 167 million? First of all, I believe he should be drawn up facing westerly. Long before Horace Greeley said, "Go west, young man," the center of population had been moving in that direction. In 1790, the composite man would have stood 23 miles east of Baltimore, Maryland. The center has marched almost due west since that time, with a fairly marked veering toward the south during the past half century. Today he stands in the small town of Olney in southern Illinois.

Our westward marching man is 30.2 years old. That is the median age of all persons in the United States. The national health is so favorable that he may expect to live another 42 years, according to life insurance statistics. This median age of 30.2 is going upward even in spite of a tremendous growth in population of the very young. Since World War II, one in each six married women aged 15 through 44 bears a child each year. This, in itself, is an indication that our young men are making some progress.

This 1957 model American is blessed in a great number of ways by a high standard of living. He is far better educated than ever before. More than 90 per cent of those in the high school age group are actually in high school and more than 2 million 500 thousand are in our classrooms of higher education this year.

Our "1957 model" lives in one of more than 47 million households, blessed in large measure with material things which would be the envy, in increasing degree, of every past generation from the grandfathers of today on backward in time. He can move forward optimistically into his future. He has countless time saving devices in his home or on his farm, and for his movements from place to place he has automobiles, airplanes, buses, diesel-electric locomotives and, in some of the newer shopping centers, even moving sidewalks. All of these time saving devices in effect save his energy. Because of the progress in manufacturing technology, he no longer needs to work 60 hours a week and more. He now works 40 hours per week—even while sustaining the very high standard of living we enjoy in relative security as a nation. He is also eating better than ever.

Perhaps we should dwell a minute on food. It has been aptly said that ours is the only nation where a surplus of food is a major problem. We store it in neat granaries in various farm localities. I might also add a surplus is stored in not so neat forms on too large a number of our people.

In sum, today's American is blessed by the many fine things which are a result of a gross national product of over 400 billion dollars.

Our 1957 model American, although working 40 hours per week, still has time for quite a lot of recreation. He will spend over 15 billion dollars for recreation this year. There is a tendency for this sum to increase year by year and the efficiency factors in our economy enable his participation—up to the limits of equity—in paid vacations and holidays along with health insurance, pensions, social security, and other fringe benefits.

There are countless other facets to this composite man. Needless to say, he is immeasurably more complex in his personal outlook, his possessions, his goals, and his values than his counterpart of antiquity.

I am quite certain that we will succeed in greatly improving and making more broadly available those products our 1957 model American is familar with today. Better homes, automobiles, household appliances, improved medical care and expanded opportunities for education and cultural development are in his immediate picture. Ten years hence he will see scores of industries turning out entirely new products. Scientific farming will become the rule rather than the exception. Electronics, nucleonics, atomic and even solar energy will come into full being and take their places as part of his everyday life. There has never been a time in history when such vast new potentials for progress were available to him as there are today—and that holds true for every field of endeavor—agriculture, industry and the professions. Yes, our 1957 model American, more than 167 million strong, has it pretty good right now and every indication is that he will have it even better in the years to come.

Now many of the benefits enjoyed by our 'composite American' are a direct result of the efforts of some 400,000 employees in the metal castings industry—an industry on which I feel I am somewhat of an expert if only because of 42 years association—and—contrary to my opening remarks, the closer I get to home the more "expert" I become. I guess that goes with being the boss.

This industry had its beginning some 4,000 years before the Christian Era. The oldest known casting in existence, a copper frog found in Mesopotamia, is believed to have been cast about 3200 B.C. The casting of metals was not confined to the making of ornaments, however. Tools, household articles, and other useful items were cast in an increasing variety as man progressed through the stages of economic development. The demand for cast products stimulated the growth of the castings industry, which in turn developed skills and processes creating new uses for cast products. The industry contributed greatly to the industrial revolution.

Thus the metal castings industry has played an important part in the daily life of man and in the development of the industrial world of today. The importance of this industry in the economy is not fully recognized because most cast products serve as components rather than as end products.

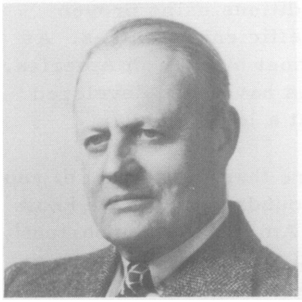
In the home, on the farm, and in industry practically every labor- and time-saving device and machine, or piece of equipment, contains one or more cast parts. Steel mills, farm implement and automobile manufacturers, the machine tool industry, the railroads, and almost every other industry in the United States rely on an adequate supply of castings. Castings are indispensable to the production of war material and as components of hundreds of manufactured products needed not only in wartime but also for meeting essential peacetime needs.

The castings industry is an important segment of the metalworking industry. There are over 5,000 foundries in the United States, with an estimated current annual product value of $8 billion—the fifth largest durable goods industry in the country.

The foundry industry has traveled the road of progress. Only in recent years has the rate of progress been accelerated through the implementation of technological and scientific knowledge. We at Central Foundry like to feel that we have contributed our share to this progress by developing a new concept of foundry operation—a concept which had as its foundation our belief that everything we do could be done better.

We resolved to make Central Foundry representative of competitive American industry at its best—people working together under good conditions using proven modern production methods and efficient machines. As a result, our foundries are the most modern in America. New techniques and new machines have been developed which produce a better product at a lower cost.

Nothing would please us more than to have all of you share our pride in the Central Foundry story. We know we too can offer our 1957 model American an opportunity for the future. We wish we could take each of you on a personal visit through our plants but since we can't do that, we are doing the next best thing. We are bringing the Central Foundry Division to you through a motion picture we have just completed. We hope you will enjoy it. It is entitled, "To Meet the Challenge".



HUMAN RELATIONS ON THE ASSEMBLY LINE

Charles R. Walker
Senior Research Fellow
and
Director of Research in Technology and Industrial Relations
Yale University

Henry Ford II, shortly after he was made President of the Ford Motor Company, gave a talk before the American Society of Mechanical Engineers. In that talk he touched on the subject of this paper:

> "Machines," he said, "alone do not give us mass production. Mass production is achieved by both machines and men. And while we have gone a long way toward perfecting our mechanical operations, we have not successfully written into our equation whatever complex factors represent man, the human element."

"Man, the human element," in mass production factories—that is what my colleagues and I at Yale's Institute of Human Relations have been studying for over ten years. We certainly haven't got him into an equation or a formula, as perhaps some people have hoped, but I think we have made some progress in understanding him within the dynamic work environment of modern industry.

In the past ten years at Yale, we, who are social scientists, have been very close to engineers of all kinds, because we have been studying the impact on people of the machines engineers have designed, built and installed. In doing so, we have looked at mass production work problems in machine shops, steel mills, chemical plants, in the automobile industry, even in banks and insurance companies. We will start today by going into that complex, somewhat controversial and thoroughly remarkable work place, the final assembly line of an automobile plant.

Many first-time visitors to an automobile assembly plant are not aware there are any human relations; they see the plant as a miracle of engineering ingenuity. And in a sense, they are right. The assembly line was one of the first, and it still remains a classic example of engineering analysis: the triumph of the principles of continuous work flow, of standardization of parts and of the reduction of complex operations to their simplest mechanical elements. The men, as has often been pointed out, appear as adjuncts to the machines. Here are typical comments of the adjuncts, of men working on the main line in a very modern plant equipped with the latest machinery:

> "There are a lot of good things about my job. The pay is good. I've got seniority. The working conditions are pretty good for my type of work. But that's not the whole story..... You can't beat the machine. They have you clocked to a fraction of a second. My job is engineered, and the jigs and fixtures are all set out according to specifications. The foreman is an all right guy, but he gets pushed, so he pushes us. The guy on the line has no one to push. You can't fight that iron horse.
>
> "The bad thing about assembly lines is that the line keeps moving. If you have a little trouble with a job, you can't take the time to do it right.
>
> "On the line you're geared to the line. You don't dare stop. If you get behind, you have a hard time catching up.
>
> "The work isn't hard; it's the never-ending pace... The guys yell 'hurrah' whenever the line breaks down... You can hear it all over the plant.
>
> "I dislike repetition. One of the main things wrong with this job is that there is no figuring for yourself, no chance to use your brain. It's a grind doing the same thing over and over. There is no skill necessary."

These were typical comments and could be duplicated hundreds of times. They are drawn from a study you may know called, The Man on the Assembly Line. It was based on exhaustive interviews with a carefully weighted sample of 200 workers, conducted in their homes.

Now, there are two or three things I would like you to notice:

First, the things that the men were complaining about were tied to their immediate jobs; that is, what they did with their hands all day. We have come in our studies to call that the "immediate job," as distinguished from other things about the total employment situation, such as wages or a man's relation to his foreman, and so on. As a matter of fact, a majority of these assembly line workers liked many other features of their jobs: their wages, economic security, often their own foremen, etc. But they disliked—hated, in many instances is not too strong a word—their work, or what we have called their immediate jobs. In fact, in all the assembly line interviewing we have done so far, 9 out of 10 workers disliked intensely their immediate jobs.

Now then, the next important point to notice is that what the workers disliked, namely, the pacing and the repetition or monotony, was inherent in the technology of the process; in short, features which had been created through rationalization and in the interest of efficiency by the engineer.

The next important point was raised for us by certain automobile manufacturers immediately after we completed this study. They said to us, "We're not surprised—but, of course, your findings have no general validity. This is a new plant, with new workers. Once the men get used to an assembly line technology, they'll like the work very much." So, we made an additive study—it took us another year and a half—of an older plant where all the workers in our sample had 10 to 15 years seniority. This is what we found: Ninety per cent (nine out of ten) of the workers disliked intensely their immediate jobs. As in the first plant, they liked many of the other features of working for this corporation. In short, we came up with the same findings.

By this time, the manufacturers had begun to pay attention, and especially to the next point, which it is very important to notice. The point is this: it was not simply the fact that several hundred workers in both plants were having disagreeable emotions about their work—about their immediate jobs—but that their emotions were making them behave in certain ways which worried management very much. They stayed away from work, or quit altogether the jobs they didn't like, or produced low-quality parts when they came to work. Let me make my point more sharply. What we demonstrated in this and other studies was a correlation between these unsatisfactory elements in the immediate job: pacing, repetition, lack of skill required, and other similar characteristics with absenteeism, turnover and very frequently, low-quality performance.

At this point not only we but management began to ask, what can we do about this? We can't go back to the way we made cars in 1900.

Before we turn to this question and possible answers, there is a very important step to be covered in our unfolding analysis. So far, it looks as if what we had been finding was that "pacing and repetitiveness" in a factory are things which people <u>always</u> dislike—and so, because of their dislike, they stay away from work too frequently, or if they come, they do a poor-quality job. This is, of course, an over-simplification—there are many examples in industry where people under certain circumstances prefer repetitive work and do it well—also the point so stated leaves out one of the most basic of all our findings; namely, <u>the psychology of the dislike</u> we have been analyzing. Let me see if I can make this clear.

Why did the men on the assembly line <u>not</u> like repetition and <u>not</u> like doing the same thing over and over again? It was monotonous; yes, boring. But this hatred of their work went deeper than that for many of them. Somehow the work insulted them. To do something over and over again for ten years that you had learned to do in three days is something of an affront to one's manhood. A man was created not as a single-purpose tool, as Peter Drucker says; his uniqueness is that he is very much a multi-purpose creature, even if he is unskilled. Put in another way, the average assembly line job in its repetitiveness is machinelike and impersonal.

Or take pacing: why does a man dislike being paced by a conveyor? Because he cannot keep up, because it tires him physically? Partly! But mainly because, as interview after interview indicated, it substitutes a mechanical coercion, or drive, for personal control; i.e., either for the supervisory control of one's boss or the internal personal control of one's own will. We found, in fact, some members of management who said, "The beauty of an assembly line is that the line is the foreman; it administers the discipline, it determines every man's output." That's it, exactly: impersonal control.

There are also other features of impersonality in the organization of an assembly line. You can't really talk to each other; the line moves too fast or makes too much noise. Nor can you rest or visit the toilet when your muscles on your abdomen suggest it, but only when a relief man can be assigned to your place on the moving line.

All of these elements of the impersonal, of the mechanical add up emotionally in a man over the years. And in the end he says in effect, "Top management who designed this thing and put me into it, clearly has no personal interest in me whatever—as a man. They see me only as something that keeps the line moving—so that more and more cars will drop off the end." So, it is impersonality which is important, not the pacing and repetitiveness, as such, rather its translation into an emotion. What is the emotion? It is a deadly resentment, compounded of many things, but reinforced and reaffirmed by the technology.

I don't know whether you have ever been in an assembly plant during the second half of the day shift. Every day at three o'clock exactly there is a yell—it is very startling if you have never heard it before—it relieves everyone's feelings. It isn't a bit impersonal.

Now, I think we are ready to turn to the question which management began to ask us: what can we do about it?

It seemed to us at this point that there were two major directions in which answers could profitably be sought. First, we found ourselves inquiring: how can management play against the sense of impersonality inherent in the technical process? In other words, what counterweights can be set up against pacing and repetitiveness and all the other nonpersonal, machinelike features of the work environment? That is the first direction in which to look for answers.

Second, how can the actual technology, including the design of the immediate job, be so modified as to fit better the physical and psychological needs of normal adult workers?

I will give you just a few of our first category of answers. They came out of a recent and very intensive study we made of all the foremen in Plant Number I, and they have upset, I am told, a lot of orthodox thinking about human relations on the assembly line. A simple way to sum up this kind of answer is to say: choose a management which acts toward its workers in all the possible ways in which the machinery in the shop and the moving conveyor do not! I will try to be more specific:

Every worker said a good foreman is a "shock absorber". He takes pressure and doesn't pass it on. Again: a good foreman establishes a personal relationship with each worker, which the airdrills and the moving belts never do. It might be added that a good general foreman and a good plant manager also does so.

Again: a good foreman acts as a leader of the work group under him. Here is an interesting point. Top management in the corporation we studied denied the existence of work groups or crews on the assembly line and strongly disapproved of any foreman trying to build up a close-knit work group or team under him. And yet, the foremen who by management's own rating were tops in efficiency and quality production were the foremen who had developed just this close-knit, self-conscious work group under them.

Men in such groups were absent less often, quit less often, did better work on the job. Why? Interpersonal relations within the work group and frequent personal interactions with its leader counter-balanced, at least in part, the cold impersonality of the line.

One further and important answer of this character follows. In Plant Number II a combined system of job training and inter-job rotation has been established. Advantages are many. Some small measure of variety now replaces monotony and impersonality. As workers move around, they talk more often to more people. They acquire more job knowledge, use more judgment; they increase their chances of promotion to become utility man or relief man or even foreman. Finally, from management's point of view, when a man is absent, another man is immediately available to step into his job.

These and many more partial answers can be and are being introduced today into parts of the automobile industry. Now, notice that these are all modifications in human behavior or in social organization and that all can be introduced with no change whatever in the technology itself. Many people have said to me that you can't do anything about such problems as I have posed without changing the technology entirely, putting in an automatic factory, for example; so I am stressing for the moment what can be accomplished by organizational and behavioral changes.

One exciting piece of evidence: my colleague, Robert Guest, is working on a very dramatic example of what imaginative human relations practice can accomplish on an assembly line. I will give you its highlights.

In 1953, Plant "Y", one of seven similar plants of a company producing a well-known automobile, had the lowest record of quality performance in the group. In 1956, it has one of the best records. In 1953, its efficiency record was the lowest of seven plants. In 1956, not only had it increased by 20 per cent, but it led all the others. Also in 1956, during three periods of major changes in schedule, efficiency in Plant "Y" dropped less than 14 per cent, whereas most of the other plants suffered from 20 to 40 per cent losses in efficiency (direct labor performance measured against standards).

In 1953, Plant "Y" had the lowest safety record for the group and was in the bottom quarter of all 125 plants of the corporation. In 1956, by contrast, it had gained top position among the group of seven similar plants and stood fourth among all plants in the corporation—a remarkable achievement, considering the nature of plant operations.

Three years ago Plant "Y" was second from the poorest in its ratio of formal labor grievances per 100 employees. During 1956 it had a ratio of less than three grievances per 100 employees on a monthly average. The other six plants ranged from 5-1/2 to more than 10 each month.

These changes did not happen by chance. They came about from a deliberate effort on the part of plant management to apply the basic principles of organization and human relations which we (in our assembly line studies), as well as other social scientists, have been developing over many years of research. The case study of this plant is only one example of the practical value, I believe, of systematic, long-term research in the field of mass production and human behavior.

The second direction in which the answer to impersonality on the assembly line, or any other kind of mass production factory, may be sought is in a modification of the technology of the worker's immediate job, a redesigning in the interest both of efficiency and the individual operator's personal satisfaction. This I call the direction of the future. We have only begun to turn to it, but here in California, through the research of your chairman, Professor Louis E. Davis, and his colleagues, a provocative beginning has been made.

The premise behind this research is that there are as yet no proven principles in job design regarding, for example, length and content of job cycle, composition and interpersonal relationships of the work group, etc., which combine all we know today about the behavior on the job of people and all we know today about the potentials of machines. And hence we are far less efficient than we can be; we have not, in fact, yet begun to release the full productive energy and imagination of the average work force.

Now, we will turn to a question which I suspect a lot of you have been wanting to ask for some time. Aren't we dealing with a technology which will soon be obsolete? With the advent of automation, isn't the assembly line on the way out? The quick answer is NO, the assembly line will be with us for many years, together with its human problems. Of course, it is technically possible right now to automatize every automobile assembly line in the United States, but unless the auto industry were given something like the billions which the government has invested in atomic energy, such automation is unlikely. It would cost too much.

Nevertheless, there is, as we all know, "Detroit automation," as it is sometimes called. Chunks of the auto industry are being automatized; in fact, nearly every industry is getting its share of automation. Some are getting a big share fast, such as the steel industry. Certainly any engineer who is interested in solving human problems connected with machines must be vitally interested in how automation is changing the conditions of human work.

At Yale we have just completed a seven-year study of a semi-automatic plant, a steel mill. And it shows, as our assembly studies did, that the engineers are in the thick of human problems again. The problems are different, but they are there in quantity. I am now going to tell you something about this study of automation or partial automation for several reasons:

It shows some of the crucial human problems that engineers are facing with the rapid installation of automatic equipment. It presents a good contrast, in types of human problems, to what we found on the assembly line. In fact, I have often thought if I had to pick only two factory work environments to cover the spectrum of work experiences and problems today, I might pick a steel mill and an automobile plant. Finally, this particular study of ours dramatized the importance of rethinking a problem right now in the lap of many industrial engineers—how to pay people, and especially, what kind of financial incentives are workable as we move into an age of automation.

Our steel mill study describes the automatization of an old process of seamless pipe making. I believe that in many ways this study is more typical of what is going on in this age of transition toward automation than many case histories of more completely automatic plants. Some parts of the mill to be described are completely automatic, others are partly automatic, and some are not automatic at all. This mixture will be with us for a long time.

In reporting to you on this study, I shall discuss two questions only. (1) What did automation in this case do to the organization of the plant and to relations between people? (2) What was its impact on the financial incentives?

Briefly, let me say a word first about the process itself. In making seamless pipe, the essential process is one of piercing, of taking a round steel billet, heating it to forging temperature and forcing a rod with a sharp point into the center of the billet. The hot steel flows around the point and the rod, like a sleeve, leaving the billet hollow. This is the central process in both the old and the new mill. But in the old process there were many steps before and after this central piercing process, all of which were performed in separate machine units. In the new process all the units are tied together in a single, continuous work flow.

In the old mill before automatization, each of these separate units was operated by small work groups, sub-work groups within the crew. They added up to 25 or 30 men per crew. Steel mills work around the clock, so that the total operating personnel of a single hot mill under the old process consisted of three crews, or 75 men. With automatization there are 9 men in the crew, or 27 for the three crews. With a third as many men, the automatic process produces four times as much pipe. This is not an atypical increase in efficiency for automation to effect.

Now, these technical changes have produced certain organizational changes which have produced certain human relations changes. First, there has been a reduction of one level in the departmental strucţure, so that communications are closer and easier. The size of the crew, as I have said, has been reduced. The area occupied by the crew has been enlarged, about tripled, I think. Communications now are no longer by signal or whistle but by a public address system. The internal structure of the work groups or the crews has changed. In the old mill there were five small sub-groups of from two to ten men. These are wiped out. There are no sub-groups in the new mill, unless you count the piercer operator and the piercer-plugger as a partnership. The interaction pattern has changed. Worker and supervisor are apt to talk to each other more frequently, for example. And finally, the average number of points for jobs under the job classification system: so much for skill, so much for hazard, etc., has fallen somewhat. Notice that a reduction in job points for any given job does not necessarily mean a reduction in skill, because job points stand for such factors as heat, hazard, and so forth. It might simply be that there are better working conditions, and so a job may have fewer job points. In fact, I want to register a note of skepticism here. I do not think our old system of job points necessarily reflects the skill or lack of skill in new automatic plants.

In making this study, I must say that our first very vivid impression from all the workers interviewed was that they were not simply leaving one mill and entering another, but were leaving one epoch in industrial time and entering a new one. Here is a man who said:

> "On the old mill I went home after work, rested, and my muscles were no longer tired. I also had nothing to worry about. On this new mill your muscles don't get tired, but you keep on thinking even when you go home."

Another man said:

> "I'd rather have to work hard for eight hours than have to be tense for eight hours, doing nothing with my muscles the way I do now."

In other words, for muscular fatigue technology has substituted tension and mental effort.

On the old process, where the men were really semi-craftsmen, close to the product and handling it with tools, the top man, who was the high mill roller, adjusted his rolls by hand as each piece went through. At every stage in the work there was manual control. In the new mill the machine controls the pipe. One man summed it all up by saying:

> "In the old mill you were on top of the machine, you controlled it; here, it is, or seems to be, on top of you."

Now, how did all these changes in the relation between people, and between people and machines affect the way everybody felt about their jobs—their immediate jobs? In answering that question, I will report a major finding from this study and one which contrasts dramatically with our assembly line finding. You will remember how nine out of ten of the assembly workers hated their immediate job, and that was true whether they were newcomers in a new plant or old-timers in an old plant.

In our semi-automatic mill, in the end, the opposite became true. At first, workers disliked their immediate jobs almost as much as the auto workers did; but after a year or two, when they became thoroughly acclimatized to the new technology, they became enthusiastic.

Here is a typical comment by a man who at first thoroughly disliked what he called the "automatics," then a year and a half later, completely changed his mind:

> "The automatics are bad. They worry me, and I don't like them. I get nervous when I'm on automatic. I always throw levers onto manual when I run the stuff. The regular bar inserter runs his job on automatic. When I take over, I go on manual. Every piece of equipment of this mill is more automatic than on the old mills. The automatics give you more responsibility. I'm getting older, and I don't want responsibility. Another thing, the tube in Number 4 goes through faster and a lot more can happen. I want to know what will happen."

A year and a half later, the same man said:

> "The automatics run very easy for me now, and I think it's very good. On this mill there is no very hard labor like we used to have, except maybe on the piercer plugger job...The jobs are very much better because of the automatics. I sure wish they had them thirty years ago when we had to run those machines by hand."

Now, I want to avoid giving an over-optimistic picture about jobs under automation. At a conference on automation and people we held at Yale last year, there was ample evidence that <u>some</u> installations of automatic equipment create <u>more</u> routine and repetitive jobs than interesting and varied ones. But I have given you one example, not atypical of one type of automation in which the trend toward the automatic has made jobs more desirable and lifted morale rather than depressed it. And in general I would say that the trend toward the automatic, apart from enhancing productivity, opens many challenging opportunities for a more satisfying work life for more people, if we have the wit to make the most of them.

So much for the effect of the technology of the immediate job on the way men felt, on their morale. Now, let us turn to the $64 question of the method of payment.

Strong dissatisfaction with the existing incentive plan, in our judgment, lost the company many thousands of dollars and doubled the time necessary to bring the mill to optimum efficiency. Our findings suggest that at the heart of the difficulty lay the simple fact that the incentive plan did not fit the new technology. That is a simple statement, but, oh, with such explosive and complex implications! To begin with, maintenance—electrical and mechanical—were vastly more important than in the old plant in determining the yield of the mill. And yet, at first only a handful of men, the nine production men on the core crews of the mill, were being paid on incentive. In the end, management put everyone on incentive: all of maintenance, the roll setup man and his assistant, the crane man and crane followers, even common labor. Production went up. Now I do not say this is a universal answer. I do say that this development which responded to popular demand did, in fact, reflect the interdependence of everyone on everyone else within the mill, and the absolute necessity of close collaboration and very high coordination, if a high yield of pipe was to be realized.

The most interesting data which turned up, however, can be summarized by this question: how does management measure the contribution of each production worker in an automatic, or semi-automatic, factory, so as to pay him fairly and motivate him to do his best?

Immediately, even as I say the words, "production worker", they raise a dilemma. For functions are changing and interpenetrating one with another in these new mills. When a production worker does repair work, how distinguish him from a maintenance man? And what are we to say when the job foreman of our mill insists he and the top hourly worker are really both engineers anyway, and that they are continually exchanging duties with one another?

But let that go. Time alone, perhaps, can clarify this question. We will go into the mill and listen to the regular crew members talk about their pay.

> "The engineers have been very fair in measuring what it was possible to measure. But how can you measure what <u>we</u> do? How can you measure the things which really count in lifting production in this mill, and how can you tie a price tag to them?"

There is an implied question here which management is now facing up to, "What can <u>we</u> do to provide the incentive or motivation, so that the workers and everybody else will do the things that <u>they</u> know (we don't know them all), yes, will do the things that <u>they</u> know will make this very complicated machinery productive?"

I have been giving you my composite translation of hundreds of conversations I have listened to. But perhaps you would like to hear the actual words of individual steel workers on an automatic mill:

> "All right, if we're only going to get paid for that part of our work which management can measure, then that's the only work we'll do. To hell with them!"

Now, part of the work they felt management was not measuring and paying them for was thinking.

> "You do less physically on this automatic mill, but you have to think more...I get my best ideas about my job and the technical changes we're making all the time when I'm in the can or at lunch or on the way home. But under the incentive plan, none of that is..."(Here he quotes from the incentive manual)... "None of that thinking is, quote, 'true work,' unquote."

All of such comments, while they do not provide us with the finished answers we would like, do point, I think, to one kind of challenge which automation presents—the challenge of how to pay and how to motivate. Baldwin and Schultz, the M.I.T. economists, put the point very well.

> "Automation challenges the still prevalent management philosophy, which says:
>
> ...(1) break the work process down into the smallest possible components, (2) fit jobs into a rigid structure that emphasizes <u>the duties and boundaries</u>

of the job rather than its part in the process, and (3) put everyone possible on an individual or small-group incentive system which gears pay to output on the particular job. This philosophy inevitably has tended to identify the individual with an even more narrow task, giving him positive incentives to restrict his interests and no incentive at all to think beyond his immediate work environment.''

And, again:

...''Automation is likely to challenge these habits of thought fostered by discontinuous and highly specialized methods of production...It requires a new way of thinking that emphasizes continuous movement of work through a total process rather than the stop-and-go progress which is the sum of independent operations.''

I am happy to say that although our study of this semi-automatic steel mill did not bring up final formulas for an age of automation, out of it did emerge some partial answers and some practical working procedures. These procedures we rolled up into an overall check-list for managers faced in the future with similar installations. This check-list covers not only the field of incentives, but methods of training and of preparing people psychologically for technological inventions like this one. We also threw in a careful month by month analysis of production for three years which showed when management acted ''right'' and when ''wrong,'' so to speak, and how its personnel policy was directly reflected in dips and rises in the productivity of the mill.

However, being social scientists who have worked closely with engineers for the past ten years, we are not satisfied with this kind of rule of thumb, ad hoc, guess and try procedure, even though it has been scoring some successes. We want rather more evidence in support of emerging principles; we want broader applications; we want rigorously controlled experiments in more work environments in American industry. For all these reasons we are setting up a five-year program of research at Yale, the first long-term research, I believe, ever focused on this field of machines and motivation. We will start by making an inventory of everything we have found out ourselves in our own ten years of research and whatever has been found out by other scholars at home and abroad in this particular field. There are small groups of research scientists working in this or related fields in England, Germany, France and other countries, and we are fortunate enough to be in close touch with them.

After we have made this inventory of existing knowledge, we shall try through field work to fill in the most important gaps in our knowledge. There will be many! I haven't time to tell you of all our proposed field studies. In fact, I do not know myself what all of them will be yet. But, as you may have guessed, one of them will be experiments in job design and job enlargement in an effort to help solve far more basically than we have hitherto, the problem of impersonality in mass production factories. And the other broad area for our field research, you may have also guessed. It will be the human problems of automation—automation in the office and automation in the factory.

You may say that this is a big order. It is; but I want to emphasize that this is a cooperative venture in which there will be three major partners, drawn from the operating brains of American industry, from the engineers with their analytic and designing intelligence and from representatives of the new but rapidly developing life sciences, all the way from psychology and physiology to economics. I can report that the engineers and the practical operators are enthusiastic about the proposal. Nothing fazes them. The social scientists—well, they are already at work on the program. And it is fair to say, I think, that we are all determined to make a start, at least, in meeting Henry Ford's challenge:

''Machines alone do not give us mass production. Mass production is achieved by both machines and men. And while we have gone a long way toward perfecting our mechanical operations, we have not successfully written into our equation whatever complex factors represent man, the human element.''

MANAGEMENT OPPORTUNITIES FOR SMALL BUSINESSMEN

Wilford L. White
Chief
Managerial Assistance Division
Small Business Administration
Washington, D.C.

It is a great privilege for me to join you today. For several years I have heard about this Institute which is of vital interest not only to the owners and managers of smaller businesses, but to top and middle executives of larger firms as well. The Small Business Administration, the Federal agency I represent, is interested in both groups. Unless larger businesses are successfully operated and profitable to their owners, the smaller firms who do business with them are adversely affected.

DEFINITION OF SMALL BUSINESS

To open the subject, "Management Opportunities for Small Business," let us begin with an explanation of what we mean by small business. In the legislation which established the Small Business Administration, is this statement: ". . . the small business . . ." is ". . . one which is independently owned and operated and which is not dominant in its field of operation."(1)

Probably none of us will disagree basically with this definition. It well describes a small business. But the Small Business Administration is a government agency with specific programs to carry out. For example, under existing legislation and administrative policy, when is a manufacturing business small in the sense that the agency can lend it money? For practical purposes, the statistical definition is based upon the number of employees. Any manufacturing business is small if it has fewer than 250 employees. It is large if it has more than 1,000. For those companies which fall in between these two figures, its technical size is dependent upon the characteristics of the industry of which it is a part. In case of the electrical appliance industry, the dividing line is 500; for the hand tool industry, it is 250.

In the field of distribution, the division is based upon annual sales figures. For wholesalers, a firm is small if its sales for the last year were less than $5 million. A retail firm is small, in terms of our loan program, if its annual sales are less than $1 million. The same figure holds for service organizations.

Using these definitions, which apply only to the loan program, we can conclude that over 96 per cent of the number of businesses are small and account for about 50 per cent of the number of employees, and for approximately 50 per cent of total business activity, measured in dollars.

We estimate that something more than four million of the 4,252,000 businesses in the United States are small by this definition. They are owned and operated by between six and seven million proprietors. These are the businessmen I am discussing today.

CHARACTERISTICS COMMON TO SMALL BUSINESS

Some small businesses prefer or are forced to remain small. Company "A" has been established and operated successfully as a small firm for many years, indeed, for several generations. It produces products or serves markets which do not require a large firm, which do not encourage growth. Company "B", knowing its limit of managerial ability, has wisely decided not to employ more than a given number of people or not to push sales over a certain predetermined figure.

Company "C" has inherited management which is not qualified to maintain the upward push, indeed it may not maintain current volume. "D" actually contracts in size because the industry of which it is a part is declining.

On the other hand, "E" has been started by new, young management and has the inherent capacity to grow large, provided it does not get the big head or use its talents unwisely or illegally.

Of course, a firm can start out small, grow for a time, level off, and then start growing again. A large firm can slip back, change management, and then start forward again.

Whatever the size trend of a particular firm may be, however, it often has certain characteristics in common with many other smaller businesses. Let us look at some of them.

Need for Continued Adjustment - No matter what the assets are in terms of materials, markets, money, know-how, and ideas, no one can be sure that a new business will prove to be a successful business. Experience must be accumulated. The management team must be granted time to show what can be done. As the tempo of business increases, timing becomes important. Bad timing becomes a great liability. Good timing produces amazing results.

One important characteristic of a small business, therefore, is that it must continually adjust itself to changing conditions. As a result of the passing of time and change the owner of a small firm must continually be alert to the effect of time on his policies and operations and change them promptly when it is advisable to do so.

Unbalanced Management - The owner or manager of a particular firm may be an experienced production man, a successful salesman, or be well informed on financial or credit problems, but be inexperienced in other aspects of administration.

An inventor may spend years perfecting his patent but with only a few moments' consideration, he may accept advice in the fields of selling or financing which spell failure. The salesman, on the other hand, may sell quantities of his product before he knows how he is going to manufacture it, to say nothing about having before him a schedule of costs. In short, many owners of smaller firms are specialists, perfectly competent to administer certain management functions but woefully inexperienced with others.

Small Staff - Usually a small manufacturing company has too small a management staff. In fact, some firms have no staff at all. The typical new small business starts with the owner. He IS the staff. Because of his foresight, ability and energy, however, the business grows. Or without them, it fails.

This single point is the great advantage or disadvantage of a small firm. The advantage lies in the fact that the owner can quickly arrive at a decision and act upon it. If his judgment is right in a majority of instances, he can, as we say, make a killing! On the other hand, if his judgment is poor or a vital decision involves a subject in which he is not experienced, his decision may be disastrous.

As a one-man business grows, its operation becomes more complicated and the number of its problems increases. At this point in the life of his business, the sole manager needs additional staffmen with complementary experience. The alert manager recognizes this problem and selects his second man with great care. The egocentric owner ignores the problem entirely and suffers the consequences.(2)

Lack of Time for Administering - At a recent meeting of the owners of medium and smaller-sized businesses, they were given a definition of the words "administering a business." Then they were asked, "How many of you fifty men administer your own business?" Not a single hand went up. They admitted that they operated their businesses, but they did not administer them. The definition of administering which had been given them was something like this: "To organize, staff, plan, direct, and control a business." In the discussion that followed, these men came to the conclusion that they were so busy operating their businesses that they had no time—they took no time—to administer them.

That situation is typical of a small firm. The owner of a small plant is often so busy selling an order, arranging a loan at the bank, getting an order out on schedule, in short, meeting the payroll, that he leaves himself no time or energy for the proper administration of his affairs. The danger of this kind of management is apparent. No matter how small a business is, it must be administered as well as operated.

One or a Few Products - Many new shops start manufacturing and selling one product. The item may be new and therefore without direct competition. It may be the result of a new method of production which produces a better quality or lower costs. But whatever it is, the new company has to face its customers and competitors with only one product. Since the product may be untried or unknown, or both, the problems of pricing, securing adequate and aggressive distribution, offering service when required, and developing user demand with the resources at hand, are almost insurmountable. Later on, the most successful operator often looks back and wonders what he was thinking of when he launched his new business.

These, gentlemen, are some of the more important characteristics of small business with which its management must cope, if it is to grow profitably and, in time, become a larger business.

OPPORTUNITIES FOR SMALL BUSINESS EXPANSION

Opportunities for the expansion of any business come about by changes in the economy surrounding a particular plant or by its own management decisions. Generally speaking, change favors small business. An alert, well-managed small business can be adjusted more quickly to meet change than can its larger competitor. Because the larger business has mass production and mass distribution, it has mass management. It is operated by committees, divisions, or groups. The term "chain of command" is a common one.

Irrespective of the quality of these men and their number, in a larger firm a management problem has to be realized, clarified, and presented to the proper committee, for example, before it can be evaluated. Once the committee reaches a conclusion, it is usually placed in the form of a recommendation. That, in turn, must be presented to some official or board before final decision can be reached. During this period, be it days or weeks, change has been taking its further toll.

In many instances, a smaller firm, without this benefit of management committees and highly specialized skills, has faced the same dilemma, reached a decision and acted upon it in the same period of time.

This ability to adjust quickly to change is essential to the owner of any business. Let me emphasize the extent of change in the world in which we live with a few examples. We read recently of a test missile which reached an altitude of 650 miles, traveled over 3,000 miles at a speed of almost 15,000 miles per hour. The press has carried a story of a man-driven jet plane which has flown at a speed of more than 1,220 miles per hour.

Only last December, I learned that a digit computer would comprehend all the information on a 45-column tabulating card in 17 millionths of a second, and it will not be long before a man-made machine can store indefinitely five million digits of information in what is called a random-access memory. We continue to hear new and startling stories about atomic and solar energy, automation, new metals, and rare earths.

Our concepts of time and space must be revised. In terms of tomorrow, we have wasted both time and space in the past. Competition will not allow such prolific waste in the future. As a result, the business executive, if he is to remain in business, must open his mind to new ideas, evaluate them impersonally, and act upon his evaluation promptly if he is to continue a profitable business.

Now, what does this have to do with small business? Exactly this: the smaller fellow, forced to be agile of mind and foot, who is his own decision-maker, who spends his own money, and who stands or falls upon his own decision, can find this speedup of action not only exhilarating but most profitable.

Let us look at some of the broader changes going on about us today and suggest—we cannot do more with the time allotted to us—how they might be of value to the owner of a small business.

Population Increase - Population figures increase, as you know, from births and migration. We know that the population of the United States is increasing rapidly. During the past 18 years, the total population of this country has increased by 37 millions. By 1975, this total is estimated to reach 230 millions.

In California, you not only have the increase brought about by births but that created by immigration from other parts of the country. California is already the second most populous state in the country and may well stand at the head of the list in another generation.

Here is an outstanding opportunity, that of feeding, clothing, entertaining, housing, and putting these people on wheels. These increases mean larger California markets. That means, among other things, that it is now economical to produce additional items here rather than haul them from other parts of the country. It is possible to produce in large enough quantities to get costs down to a competitive figure. And there will be a demand for a greater variety of the products already on the market as well as for new ones yet to appear.

Population Movement to Suburbs - Today, there is a rapidly increasing movement from the city to the suburbs. This mid-twentieth century phenomenon is not, as many people believe, peculiar to the larger cities. It applies to towns of only a few thousand as well. This movement is particularly important since it must be realized that the suburban family is not the same kind of an economic unit in a surburban ranch house on a quarter of an acre of land as it was in an apartment in the heart of a city.

One of the more important contributions of this suburbanite, which is sometimes overlooked, is that in the country he becomes more of an individual and less of a mass buyer. His thinking and living are more personal and less subject to mass psychology. His geographic location and his greater expression of individuality require many large shopping centers but also many small shops. This is an interesting situation although I suppose you have observed it for yourselves. The shopping center has slowed down the attempt of the supermarkets to become similar to our old-fashioned general store.

Opportunities are presented, therefore, to relatively small stores to provide for the wants of these people. They have need for increased transportation, they garden, they eat out of doors. They have houses to paint and keep in repair. Their needs are multiplying.

Increased Spending Power - Today, suburbanites as well as the other citizens of this country command substantially greater quantities of goods and services. Between 1950 and 1954—when prices were relatively stable—the number of families with incomes of over $4,000 after taxes, jumped from more than 12 million to more than 21 million. It has been estimated by Arno H. Johnson, Vice President of J. Walter Thompson Company, that by the end of 1956, the number of families with incomes of over $4,000, after taxes, reached 26 million, or more than double the number in that group even as late as 1950.(3) Thus, these millions of families have not only the desire and need for more and more goods and services but funds with which to buy them.

Increased Leisure - In addition to an increase in the total number of people, their movement to the suburbs, and their ability to buy more, they have more leisure time. This not only means that they have more time to work around their homes but also time to participate in different sports and travel. The mobility of the American family is most noticeable during vacation time and vacation time is no longer confined to the summer months.

The combination of greater leisure and the use of the automobile has created new industries and rejuvenated older ones. Take golf ranges and golfing itself, trapshooting, fishing, and other participation sports. Consider the variety of clothing men buy today as the result of more leisure. You cannot forget out here in California, that travel itself is a great industry made up of many small units called motels, restaurants, drive-in movies, roadside stores, gasoline stations, and automobile repair shops.

Educated Customers - You and I hear more and more about how hard it is today to sell. The explanation given by some is that competition is on the increase. What some of them should realize is that customers are being better educated—are more sophisticated. More and more of them are high school and college graduates. They subscribe to consumer organization services. They study the advertisements in terms of their needs. While this consumer knowledge may hinder or slow down the mass producer and distributor, it can be a boon for the smaller operator. The small merchant is close to his customers and knows better than any other businessman what they desire and what they will buy. The smaller manufacturer can be equally close to his outlets, the wholesaler and his dealers. A profitable market for a small firm may be a most unprofitable one for his large competitor.

Foreign Markets - A world in which countries tend to divide themselves into two camps is not the best environment for an expanding foreign trade. However, American business abroad is expanding as the threat of a world war tends to recede. The character of international trade is changing as have-not countries are attempting to industrialize. While such changes can be painful for a time, the total volume of trade between industrialized countries is greater than between industrialized and agrarian countries. Unless the current trend away from war reverses itself or unless we start back to a policy of high protective tariffs, we can expect a steady increase in opportunities for export and the creation of larger foreign markets for smaller firms.

These and many other opportunities are not imagined as possible sometime in the future. They are here now, and are available to the owner or manager of a small firm who has the imagination to see them and the wisdom to plan how he can take advantage of them.

CAUSES OF SMALL BUSINESS MANAGEMENT PROBLEMS

In spite of these opportunities which are very real and available today to every owner of a small business, we hear a great deal about the failure of smaller firms, mergers with larger ones, closings, and we know of many cases where a small operator is just getting by without even earning the equivalent of a good salary for himself. Why?

Last summer, at the University of Colorado, Dr. A. M. Woodruff, Director of the Bureau of Business Research, University of Pittsburgh, reported on a new study on the subject "Causes of Failures." He and his associates had made an intensive study of ten small manufacturers of metal products who had gone through bankruptcy and of ten similar firms which were judged to be successful.(4)

In studying the results, he came up with five major points of contrast between successful and unsuccessful small manufacturers. Dr. Woodruff learned that the successful ones had good records and kept them up to date; the unsuccessful ones did not. In the second place, he learned that the successful operators obtained accurate information on taxes, what had to be paid and when. Some of the unsuccessful ones failed to inform themselves properly and later action either pushed them toward or forced them into insolvency. Third, according to Dr. Woodruff, ". . . several of the unsuccessful firms allowed themselves to get beyond the technical depth of the management." Fourth, he found some managements which were technically competent, but had little or no concept of selling as it is carried on in our modern economy. And fifth, some of these failures exhibited little or no knowledge of administration: the planning, organizing, staffing, directing, and controlling of a business, as Professor Harold Koontz of your own faculty defines it.(5)

This investigation, carried out by trained research workers, emphasizes the fact that all these problems reflected upon the quality of internal management of the individual firms studied. This investigation supports the commonly accepted idea that over 90 per cent of all business failures are caused by unbalanced or inexperienced management.

SERVICES OF THE SMALL BUSINESS ADMINISTRATION

The Small Business Administration was set up by Congress in 1955 for the sole purpose of advising and assisting the small business firms of our country in meeting administrative problems such as the above.

This agency has three principal programs: Management and Technical Assistance, Procurement Assistance, and Financial Assistance. These programs are carried to the owners of smaller businesses through 15 regional and numerous branch offices, located in important industrial and commercial cities.

Management and Technical Assistance

To assist the owners of smaller firms to strengthen their own management abilities, a number of programs are available.

Administrative Management Courses - The agency cosponsors administrative management courses for the owners and managers of smaller business firms. The courses are organized and offered by educational institutions in all parts of the country for the purpose of improving the management knowledge of small business proprietors.

The courses relate to administration—planning, staffing, directing, controlling—rather than day-to-day operations. Such subjects as the following are frequently covered: planning for future growth, management use of records, sources of equity capital, decision making, and human relations and communications.

A typical course runs for eight weeks, one evening a week for two and one-half hours. Each session is divided into two parts. The first is a lecture by a businessman, banker, or university teacher; the second half is a discussion period. Typically, tuition fees range from $35 to $50. Enrollment generally ranges from 15 to 40.

While a majority of the courses are open to all classes of small business proprietors, some are open only to manufacturers. Discussions which follow the opening talk are quite important because they can offer opportunity for the exchange of personal experiences.

Substantial numbers of those finishing the courses desire more education of this type. In some instances, the businessmen organize for the purpose of conducting informal discussion meetings at regular intervals. A growing number of educational institutions also are offering follow-up courses for these business executives.

Last fall, our agency cosponsored five courses in California. UCLA offered two sections of the introductory administrative management course in Los Angeles and one in San Diego. It also offered an advanced course to the owners of small business in personnel relations. This spring, UCLA is expected to schedule courses in Los Angeles and San Diego. In the San Francisco area, Santa Rosa Junior College offered a course last fall. It will be repeated this spring. The University of San Francisco is also expected to repeat its course offered earlier.

Helpful Aid Leaflets - The Small Business Administration publishes three series of practical, helpful leaflets called Management Aids for Small Manufacturers, Small Marketers Aids, and Technical Aids for Small Manufacturers. These leaflets cover a wide range of management and production problems, telling how to recognize and deal with them.

A listing of the Aids is available from any Small Business Administration field office. Single copies of the Aids also may be obtained free upon request. New Aids can be received automatically through a request to the Washington office to be placed on the mailing list for one or all of the series.

Small Business Management Series - Management subjects are covered in more detail in the Small Business Management Series. These booklets are published by the Government Printing Office and sold at nominal prices. They cover management problems, such as "Reducing Office Expenses"; procedures, such as "Cost Accounting", "Industrial Advertising", and "Introduction of New Products". Other subjects include "Small Business Finance", "Executive Development", and "Sales Training". A complete list of these publications is also available upon request.

Products Assistance - The Small Business Administration provides experienced counsel to small business concerns and individuals in locating a marketable product or new line or type of product, and in locating a market for a product, which may include someone to make it and put it on the market. The program is designed to assist small firms in finding solutions to research and development problems regarding product improvement and new products as they arise from day to day. As part of this agency service, field offices maintain lists of government-owned patented products and processes which are available to small firms either free or with only a nominal charge for their use.

Help with Technical Production Problems - Production specialists in the Small Business Administration Regional Offices are available to help individual small business concerns with technical production problems. These problems frequently arise in cases where a firm is making items for the government not directly along the lines of its normal civilian business or in cases where the government specifications require operations which the firm did not understand when it undertook the contract. Production assistance often takes the form of locating tools or materials which are urgently needed.

Procurement or Contract Assistance

In the Small Business Act, Congress stated that "a fair proportion of the total purchases and contracts for supplies and services for the Government" should be placed with small business concerns. The programs developed by the Small Business Administration in this field are described below.

The Set-Aside Program - Under this program, Small Business Administration representatives at the principal military and civilian agency procurement centers, working with contracting officers, review proposed purchases to determine which of them should be set aside for exclusive award to small business.

Those purchases found suitable for supply by small business, if jointly agreed to by the Small Business Administration and the purchasing agency, are earmarked and reserved exclusively for competitive award to small firms. Either an entire purchase or a percentage of a purchase may be reserved in this way.

Small Business Administration field offices call to the attention of small firms in their areas purchases thus reserved which the firms are capable of supplying and on which they may wish to bid.

Purchases which have been set aside for small business also are listed in a separate section of the United States Department of Commerce publication, "Synopsis of U. S. Government Proposed Procurement, Sales and Contract Awards". This publication, issued daily, is available for inspection at Small Business Administration and Commerce field offices, or may be obtained, on a subscription basis, for $7 per year from the nearest Commerce office.

Certificates of Competency - The Small Business Administration offers what is in effect an appeal procedure for the small firm whose low bid on a Government contract has been rejected on the grounds that the firm lacks the necessary financial and productive capacity.

Under the Small Business Act, the Small Business Administration is authorized to certify that small firms or small business defense production pools are competent, with respect to financial means and productive capacity, to perform specific government contracts.

Procurement Publications - Two publications have been developed by the Small Business Administration to aid small firms in bidding on government contracts—the U. S. Government Purchasing Directory, a comprehensive guide to the items purchased by the military and civilian agencies of the federal government, and the offices which buy them, and the U. S. Government Specifications Directory, a complete guide to reference files of specifications and standards for products and services purchased by the government.

Each publication may be purchased from the U. S. Government Printing Office, Washington 25, D.C., or from field offices of the U. S. Department of Commerce, which are authorized sales agencies for government publications. The Purchasing Directory is 50 cents; the Specifications Directory, 25 cents.

Financial Assistance

The Small Business Administration authorizes loans from a revolving fund appropriated by Congress for this purpose. The loans are of two types—business loans and disaster loans. Business loans are made to finance business construction, conversion, or expansion, or the purchase of equipment, facilities, machinery, supplies, or material; to supply working capital; or as may be necessary to insure a well-balanced economy. Disaster loans are made to rehabilitate businesses or homes damaged or destroyed by storms or other natural catastrophes, or to aid businesses which have suffered substantial economic injury because of severe drought conditions.

Business Loans - There are three types of Small Business Administration business loans to small firms: deferred participation, immediate participation, and direct.

A deferred participation loan is one in which a bank or other private credit institution advances the capital needed, and the Small Business Administration agrees to purchase, upon notice by the lending institution, an agreed portion of the unpaid balance of the loan.

In immediate participation loans, either the Small Business Administration or the private lending institution agrees to purchase from the other, immediately upon disbursement, an agreed percentage of each disbursement made on a loan which both have approved. Agency participation in a deferred participation loan is limited to 90 per cent of the amount of the loan, with a maximum agency commitment of $250,000.

Direct loans are those made wholly and directly by the agency to the borrower with no participation by a private lending institution. The maximum agency loan to any one borrower is $250,000.

Participation by banks and other private institutions with the Small Business Administration in making business loans is encouraged. Loan funds available to the agency can assist many more individual firms when augmented by private capital available through banks and other private lending institutions.

All applications for business loans are filed with Small Business Administration field offices. The application may be filed by the business concern seeking the loan or by a bank which proposes to join with the Small Business Administration in making the loan. Loans can be granted if they are of such sound value or so secured as reasonably to assure repayment.

Since loans can be approved only if the financial assistance is not otherwise available on reasonable terms, it is suggested that a businessman first see his banker. If for some reason the bank cannot make the loan, then the businessman should call on the nearest Small Business Administration field office for advice and counsel in preparing a formal loan application to the agency.

Limited Loan Participation Plan - This plan provides for loans to small business concerns on a somewhat different basis from regular business loans. The plan is designed especially to assist small retail, wholesale, and service establishments (other types of business also are eligible) which are unable to pledge as much tangible collateral as is required for regular business loans, but which have a good earnings record, competent management, and a creditable record with local banks for meeting their obligations.

Financial Counseling - Financial specialists are on hand in the agency's field offices to counsel and advise small firms on financial problems, and to help them obtain assistance through private lending institutions. Services performed by field offices include: examination of financial conditions and recommendations as to reorganization; examination of working capital requirements; study of expansion needs; arranging for conferences with bankers, government purchasing officers, creditors and others in endeavoring to work out solutions to financial problems.

Addresses and telephone numbers of the Small Business Administration Field Offices may be found in the telephone directory.

REFERENCES

1. Small Business Act of 1955 (Public Law 268 of the 84th Congress, First Session) Sec. 202.

2. Cowan, R. G., The Small Manufacturer and His Specialized Staff. Small Business Administration. 1954. Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C.

3. Johnson, Arno H., "The Outlook for Economic Expansion and Increased Sales," July 23, 1956.

4. Woodruff, A. M., "Causes of Failure." Conference on Problems of Training Small Business Executives, sponsored by the University of Colorado School of Business in Cooperation with the Small Business Administration, July 1956, page 253.

5. Koontz, Harold, "A Preliminary Statement of Principles of Planning and Control." Speech delivered at Annual Conference, Academy of Management, Cleveland, Ohio, December 28, 1956.

ROSTER OF ATTENDANCE

BERKELEY

ABRAHAMSON, W.
Mare Island Naval Shipyard
Vallejo, Calif.

ADAMS, Alvin A.
Naval Supply Center
Oakland, Calif.

ALBANESE, John
Ampex Corp.
Redwood City, Calif.

ALBERT, G.
United Air Lines Maintenance Base
San Francisco, Calif.

ALEXANDER, P. M.
Colgate Palmolive Co.
Berkeley, Calif.

ANDERSON, HARRY
Naval Supply Center
Oakland, Calif.

ASHLEY-WING, H. Henry
Friden Calculating Machine Co.
San Leandro, Calif.

BAGNASCO, J.
Mare Island Naval Shipyard
Vallejo, Calif.

BALOG, Steve J.
Fibreboard Products Co.
Antioch, Calif.

BALDOCCHI, E. R.
Fibreboard Paper Prod. Corp.
San Francisco, Calif.

BARBER, Rex C.
U.S.N. Supply Depot, Clearfield
Ogden, Utah

BARNES, Fred R.
Montgomery Ward & Co.
Oakland, Calif.

BARR, Don
Lenkurt Electric Co.
San Carlos, Calif.

BARRATA, Michael
C & C Trailer & Body Co.
Oakland, Calif.

BEHRENS, Jack F.
Calif. Redwood Assn.
San Francisco, Calif.

BATEMAN, J. L.
Fibreboard Paper Prod. Corp.
San Francisco, Calif.

BEELER, Richard C.
Industrial Indemnity Co.
San Francisco, Calif.

BELLINGER, E. E.
General Electric Co.
Oakland, Calif.

BENTER, Clarence L.
Air Force, McClellan A.F.B.
Fair Oaks, Calif.

BERG, David G.
Ind. Engr., Hexcel Prod. Inc.
Oakland, Calif.

BERUBE, H. L., L/Cdr.
Mare Island Naval Shipyard
Vallejo, Calif.

BLAINE, J.
United Air Lines Maintenance Base
San Francisco, Calif.

BOCK, W. K.
Campbell Soup Co.
Sacramento, Calif.

BONN, John J.
Dalmo Victor Co.
Belmont, Calif.

BOOTH, John G.
Naval Supply Center
Oakland, Calif.

BOWEN, David E.
U.S.A.F.
Sacramento, Calif.

BOWYER, Olive A.
Naval Supply Center
Oakland, Calif.

BRACKING, Thomas G.
Food Machinery & Chem. Co.
San Jose, Calif.

BRADLEY, V. N.
Calif. & Hawaiian Sugar
Refining Corp.
Crockett, Calif.

BRADLY, F. L.
Calif. & Hawaiian Sugar
Refining Corp.
Crockett, Calif.

BRENNING, L.
United Air Lines Maintenance Base
San Francisco, Calif.

BROWN, Arthur H.
Sacramento Signal Depot
Sacramento, Calif.

BROWN, Marvin
U.C.R.L. (Rad. Lab)
Livermore, Calif.

BRYSON, George
Bethlehem Pacific Coast Steel Corp.
San Francisco, Calif.

BUCHLI, E. A.
United Air Lines Maintenance Base
San Francisco, Calif.

BUCHTER, Charles G.
U. S. Steel Corp., Pittsburg Works
Pittsburg, Calif.

BUCKWALTER, James L.
Butler Mfg. Co.
Richmond, Calif.

BUNCH, T. C.
Mare Island Naval Shipyard
Vallejo, Calif.

BUNNEL, Gordon A.
Aerojet-Genrl. Corp.
Solid Rocket Plant
Sacramento, Calif.

BUREGLIN, L. B.
Mare Island Naval Shipyard
Vallejo, Calif.

BUXTON, James M.
IBM Corp.
Richmond, Calif.

CABOT, E. S.
General Metals Corp.
Palo Alto (home), Calif.

CAHILL, J. A.
Mare Island Naval Shipyard
Vallejo, Calif.

CARTWRIGHT, S. P.
Puget Sound Naval Shipyard
Bremerton, Wash.

CHAFFEE, Charles W.
S.F. Naval Shipyards
San Francisco, Calif.

CHAPPELLE, R. C.
Beckman Instruments, Berkeley Div.
Richmond, Calif.

CLARK, W. W.
Mare Island Naval Shipyard
Vallejo, Calif.

CLARKE, Brandon
U.S.N. Air Station
Alameda, Calif.

CLAUSEN, Ervin H.
Consulting Engineer
Berkeley, Calif.

CLEMONS, H. R.
Military Sea Transportation Service
San Francisco, Calif.

CONTON, Lee E.
Nat. Seal Div. F.M.B.B., Inc.
Redwood City, Calif.

COONEY, Leo
Naval Supply Center
Oakland, Calif.

COX, Harry A.
Libby, McNeill & Libby
San Francisco, Calif.

CROCKER, Angus
Lenkurt Electric Co.
San Carlos, Calif.

CRANDELL, Everett E.
Fenestra, Inc.
Emeryville, Calif.

DAHL, O. H.
Mare Island Naval Shipyard
Vallejo, Calif.

DALLA, Emil
Fenestra, Inc.
Emeryville, Calif.

DAILEY, P. D.
United Air Lines Maintenance Base
San Francisco, Calif.

D'ANJOU, W. G.
Bethlehem Pacific Coast Steel Corp.
Alameda, Calif.

DAVIS, Richard S.
McClellan A.F.B.
Sacramento, Calif.

DAVIS, Thornton
Cutter Laboratories
Berkeley, Calif.

DAWSON, John D.
Jennings Radio Mfg. Corp.
San Jose, Calif.

DECHERD, E.
United Air Lines Maintenance Base
San Francisco, Calif.

DEROMEDI, Frank
Cutter Laboratories
Berkeley, Calif.

DERR, F. W.
Mare Island Naval Shipyard
Vallejo, Calif.

DEWBERRY, Daniel A.
Pittsburg Works, U.S. Steel Corp.
Pittsburg, Calif.

DIFFERDING, Charles
Mare Island Naval Shipyard
Vallejo, Calif.

DIMMICK, Walter
Lenkurt Electric Co.
San Carlos, Calif.

DOBSON, Arthur
Arthur Dobson & Co.
San Francisco, Calif.

DOWNIE, Hal
U. S. Steel Corp.
Pittsburg, Calif.

DRY-HENICH, John
U. S. Steel Corp.
Pittsburg, Calif.

DUANE, P.
Farmout Admin. Design Div., S.F.N.S.
San Francisco, Calif.

DUNCAN, James H.
The Standard Register Co.
Oakland, Calif.

EASTUS, CHARLES
Owens-Illinois
Oakland, Calif.

EARLE, Gilbert
Calif. Cas. Ind. Exch.
San Francisco, Calif.

EBLING, Charles W.
General Foods Co.
San Leandro, Calif.

EDWARDS, Arthur
American Pipe & Const. Co.
Hayward, Calif.

EDWARDS, Frank
U.S. Naval Air Station
Alameda, Calif.

EGERMAN, A.
S. F. Naval Shipyard
San Francisco, Calif.

EICHINGER, Stan
Pan American World Airways
International Airport
San Francisco, Calif.

EICHLER, Felix
Lenkurt Electric Co.
San Carlos, Calif.

ELLISON, H. G.
Bethlehem Pacific Coast Steel Corp.
San Francisco, Calif.

EMMANS, C. L.
Naval Supply Center
Oakland, Calif.

ENLOE, Robert
Crown Zellerbach
San Leandro, Calif.

EWICK, Ray
Owens-Illinois
Oakland, Calif.

EYERLY, Hugh A.
Cutter Laboratories
Berkeley, Calif.

FELZER, W.
S. F. Naval Shipyard
San Francisco, Calif.

FENTON, George
Mare Island Naval Shipyard
Vallejo, Calif.

FERREN, James
Guy F. Atkinson Co.
San Francisco, Calif.

FIELD, Sidney
Beckman Instruments, Berkeley Div.
Richmond, Calif.

FIL, Joseph F.
Ampex Corp.
Redwood City, Calif.

FISHER, B. B.
Standards Dept. Fibreboard
Paper Products Corp.
Stockton, Calif.

Ford Motor Co.
San Jose, Calif.

FOYIL, Jack
Owens-Illinois
Oakland, Calif.

FRENCH, E. R.
Mare Island Naval Shipyard
Vallejo, Calif.

FROST, J. R.
Calif. & Hawaiian Sugar
Refining Corp.
Crockett, Calif.

GARDISER, H. M.
Western Waxed Paper Div.
Crown Zellerbach Corp.
San Leandro, Calif.

GIFFRA, R.
S. F. Naval Shipyard
San Francisco, Calif.

GILES, Edmund N.,Jr.
Simpson Redwood Co.
Arcata, Calif.

GILES, James J.
12th Naval District
Public Works Office
San Bruno, Calif.

GILFILLAN, R. C.
Fibreboard Paper Prod. Corp.
San Francisco, Calif.

GILICKA, Sam
Caterpillar Tractor Co.
San Leandro, Calif.

GILLILAND, Jim H.
Simpson Logging Co.
Shelton, Wash.

GLICK, D. P.
Union Oil Co. of Calif.
Rodeo, Calif.

GRADY, John H.
IBM Corp.
Oakland, Calif.

GRAHAM, Fred B.
Matson Navigation Co.
San Francisco, Calif.

GRIFFIN, Dale E.
Standards Dept., Fibreboard
Paper Products Corp.
Stockton, Calif.

GRIGGS, F. H., Jr.
United Air Lines
Burlingame, Calif.

GUILBERT, Howard E.
Service Electric Supply Co.
San Jose, Calif.

GUNN, R. E.
Boeing Airplane Co.
Seattle, Wash.

HAGEDORN, Walter J.
Naval Air Station
Alameda, Calif.

HALSTED, Sam
Wilsey & Ham, Engineers
Millbrae, Calif.

HAMLIN, A. F.
United Air Lines,
International Airport
San Francisco, Calif.

HAMMOND, E. L.
Boeing Airplane Co.
Seattle, Wash.

HANSEN, William C.
Moore Business Forms, Inc.
Emeryville, Calif.

HANSON, F.
S. F. Naval Shipyard
San Francisco, Calif.

HARBAND, Charles
Continental Vogue Luggage
San Francisco, Calif.

HARRIMAN, William H.
Naval Air Station
Alameda, Calif.

HARRISON, Terry D.
The Adhesive Products Inc.
Albany, Calif.

HAWLEY, John D.
Diamond Match Co.
California

HEATH, Clinton
Lenkurt Electric Co.
San Carlos, Calif.

HELM, Jack E.
Fulham Brothers of Calif.
Santa Rosa, Calif.

HILL, George S.
Naval Air Station
Alameda, Calif.

HOARD, D. H.
Naval Supply Center
Oakland, Calif.

HOBDEN, R.
Magna Power Tool Corp.
Menlo Park, Calif.

HOFFMAN, Howard
Lenkurt Electric Co.
San Carlos, Calif.

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

HOUK, R.
United Air Lines Maintenance Base
International Airport
San Francisco, Calif.

JARVIS, Josh
Industrial Indemnity Co.
San Francisco, Calif.

Jennings Radio Mfg. Corp.
San Jose, Calif.

JENSEN, Allen
U. C. Radiation Laboratory
Livermore, Calif.

JENSEN, P.
Western Waxed Paper Div.
Crown Zellerbach Corp.
San Leandro, Calif.

JENSEN, Walter
Naval Supply Center
Oakland, Calif.

JOHNSON, Wm. K.
Container Corp. of America
Emeryville, Calif.

JONES, Wilbur W.
Glass Containers Corp.
Antioch, Calif.

JOSSIS, S. A.
Grove Valve & Reg. Co.
Oakland, Calif.

KAHN, Irwin W.
Malsbary Mfg. Co.
Oakland, Calif.

KANE, Donald E.
National Cont. Corp. of Calif.
Oakland, Calif.

KEYES, W. Reed
Underwriters' Lab. Inc.
Santa Clara, Calif.

KINSER, Robert W.
Naval Air Station
Alameda, Calif.

KNAPP, F. W.
Pan American World Airways
International Airport
San Francisco, Calif.

KNAPP, Sinclair
Bethlehem Pacific Coast Steel Corp.
Alameda, Calif.

KOPAS, Geo. A.
Pacific Jet Corp.
San Francisco, Calif.

LANE, Frederick W.
Lane Metal Finishers, Inc.
Oakland, Calif.

LANPHEAR, Robert M.
Owens-Illinois
San Francisco, Calif.

LARSEN, James W.
Moore Business Forms, Inc.
Emeryville, Calif.

LASHBROOK, Thomas S.
Owens-Illinois
San Francisco, Calif.

LATIMER, Louis W.
IBM Corp.
Richmond, Calif.

LAUKKANEN, Ray
Naval Supply Center
Oakland, Calif.

LEACH, F. H.
United Air Lines Maintenance Base
San Francisco, Calif.

LEAVENWORTH, Jack
United Air Lines
International Airport
San Francisco, Calif.

LEE, Sherman H.
Lenkurt Electric Co.
San Carlos, Calif.

LEE, Robert W.
Ind. Indemnity, Co.
San Francisco, Calif.

LILLIS, J. H., Cmdr.
Mare Island Naval Shipyard
Vallejo, Calif.

LINDSAY, Rex L.
Cutter Laboratories
Berkeley, Calif.

LINDSEY, Geo. H.
Naval Air Station
Alameda, Calif.

LINEHAN, Frank
Tri-Valley Packing Assoc.
Stockton, Calif.

LORAIN, Dan L.
Westinghouse Electric
Sunnyvale, Calif.

LOVE, Virgil C., Jr.
U. S. Naval Air Station
Alameda, Calif.

LUNDQUIST, Larry E.
U.S. Naval Supply Depot Clearfield
Ogden, Utah

MAGUIRE, John H.
Naval Air Station
Alameda, Calif.

MALGOIRE, M.
S. F. Naval Shipyard
San Francisco, Calif.

MANGELS, Warren
Naval Air Station
Alameda, Calif.

MANN, W. L.
Union Oil Co. of Calif.
Rodeo, Calif.

MANWARING, F. W.
Columbia-Geneva Steel Div.
U. S. Steel Corp.
San Francisco, Calif.

MARTINEZ, E. W.
Mare Island Naval Shipyard
Vallejo, Calif.

MARTZLOFF, Thomas H.
McKinsey & Co., Inc.
San Francisco, Calif.

MAYER, Donald
Schlage Lock Co.
San Francisco, Calif.

MC ALISTER, Chas. K., Jr.
12th Naval Dist. HQ.
San Francisco, Calif.

MC ANDREWS, Don
Lenkurt Electric Co.
San Carlos, Calif.

MC CAMBRIDGE, Tom
Owens-Illinois
Oakland, Calif.

MC CLURE, R. D.
Mary Ellen's Inc.
Berkeley, Calif.

MC CULLOCH, Marian
Naval Supply Center
Oakland, Calif.

MC GEE, Henderson E.
Corp. of Eng., U. S. Army
Sacramento, Calif.

MC INTOSH, Cromwell
General Electric Co.
Oakland, Calif.

MC INTYRE, Stanley G.
S. McIntyre & Assoc.
San Francisco, Calif.

MC KILLEN, Bruce A.
Towmotor Corp.
Oakland, Calif.

MERKER, A. H.
Jacuzzi Bros. Inc.
Richmond, Calif.

MERRILL, F. M.
Mare Island Naval Shipyard
Vallejo, Calif.

MESSENGER, Miles
General Metals Corp.
Oakland, Calif.

MEYERS, Dan
The Standard Register Co.
Oakland, Calif.

MIDDOUGH, Howard S.
Naval Supply Center
Oakland, Calif.

MILES, Louis W., Jr.
Marchant Calc. Mach. Co., Inc.
Oakland, Calif.

MILLAR, Alexander B.
Dalmo Victor Co.
Belmont, Calif.

MISTERMAN, W.
S. F. Naval Shipyard
San Francisco, Calif.

MITCHELL, J. F.
Shields-Harper Co.
Oakland, Calif.

MIXON, R.
S. F. Naval Shipyard
San Francisco, Calif.

MONK, Tom W.
Owens-Illinois Pacific Coast Div.
San Jose, Calif.

MOORE, Gale D.
Naval Air Station
Alameda, Calif.

MOORE, L. D.
Mare Island Naval Shipyard
Vallejo, Calif.

MORAN, David H.
U. C. Radiation Laboratory
Livermore, Calif.

MORAN, Frank W.
Hexcel Prod. Inc.
Oakland, Calif.

MORSE, Edgar L.
U.S.A.F.B
Fair Oaks, Calif.

MULLER, Wm., Jr.
American Pipe & Const. Co.
Hayward, Calif.

MURPHY, Harold B.
Moore Business Forms, Inc.
Emeryville, Calif.

NACHBAUR, Louis J.
Mare Island Naval Shipyard
Vallejo, Calif.

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

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

ORTON, W. W.
Cutter Laboratories
Berkeley, Calif.

OSBORNE, J. H.
Mare Island Naval Shipyard
Vallejo, Calif.

PADDOCK, Norman
Lenkurt Electric Co.
San Carlos, Calif.

PAIST, T. S.
C & C Trailer & Body Co.
Oakland, Calif.

PALMER, Fred R.
Naval Supply Center
Oakland, Calif.

PARKER, Wendell
Cutter Laboratories
Berkeley, Calif.

PARKS, E. R.
Ernst & Ernst
San Francisco, Calif.

PAVLIN, John
Jacuzzi Bros., Inc.
Richmond, Calif.

PECKHAM, Harry
The Dromedary Co., Div. of
National Biscuit Co.
Richmond, Calif.

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

PHILLIPS, R.
Western Waxed Paper Div.
Crown Zellerbach Corp.
San Leandro, Calif.

PINKERT, F. J.
Mare Island Naval Shipyard
Vallejo, Calif.

POLESE, A.
U.S.N., S.F. Naval Shipyard
San Francisco, Calif.

PRAVITZ, Kenneth L.
Fibreboard Paper Prod. Corp.
Antioch, Calif.

PRAY, R. F., Jr.
Western Machinery Co.
San Francisco, Calif.

PYTEL, L.
S. F. Naval Shipyard
San Francisco, Calif.

RACINE, Gordon
Columbia & Geneva
Concord, Calif.

RAYMER, Robert L.
S.F. Naval Shipyard
San Francisco, Calif.

RAMSEY, Leslie
Friden Calculating Machine Co. Inc.
San Leandro, Calif.

REARWIN, Heath
Friden Calculating Machine Co., Inc.
San Leandro, Calif.

RANSIER, W. W.
Monsanto Chemical Co.
Santa Clara, Calif.

REED, Charles
Magna Power Tool Corp.
Menlo Park, Calif.

REED, Edward W., Jr.
National Seal Div., F.M.B.B., Inc.
Redwood City, Calif.

RICH, J. C.
Western Waxed Paper Div.
Crown Zellerbach Corp.
San Leandro, Calif.

ROCHE, Maurice F.
California Farm Supply Co.
Berkeley, Calif.

RICHARDSON, Melvin
Naval Supply Center
Oakland, Calif.

ROBERTS, F. J.
Naval Supply Center
Oakland, Calif.

ROBINSON, Margaret
Owens-Illinois
Oakland, Calif.

ROBINSON, Ross
Naval Air Station
Alameda, Calif.

ROOT, L. L.
Western Waxed Paper Div.
Crown Zellerbach Corp.
San Leandro, Calif.

ROUNDS, Gerald
Naval Air Station
Alameda, Calif.

RUFF, G.
United Air Lines Maintenance Base
San Francisco, Calif.

SAMPSON, David W.
Campbell Soup Co.
Sacramento, Calif.

SANDERS, Colvin B.
U.S.A.F.B.
Sacramento, Calif.

SANDSTROM, Henry P.
The Diamond Match Co.
Chico, Calif.

SCHAEFER, Wm. J.
Schmidt Lithograph Co.
San Francisco, Calif.

SCHALLEN, Dean F.
Fibreboard Paper Prod. Corp.
Stockton, Calif.

SCHIMKE, R. S.
Cons. Western Steel Div.
U. S. Steel Corp.
South San Francisco, Calif.

SCHULTZ, Lawrence F.
Naval Air Station
Alameda, Calif.

SEARS, Herbert
Diamond Match Co.
Chico, Calif.

SEASHORE, R. P.
United Air Lines Maintenance Base
San Francisco, Calif.

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

SEHRING, J. R.
Cutter Laboratories
Berkeley, Calif.

SHALVARJIAN, Haig J.
Sylvania Electric Prod., Inc.
Mountain View, Calif.

SIECK, Herb
Owens-Illinois
Oakland, Calif.

SIMONS, Milton R.
Naval Air Station
Alameda, Calif.

SINGLER, H.
S. F. Naval Shipyard
San Francisco, Calif.

SISCO, Robert C.
East Bay Munic. Util. Dist.
Oakland, Calif.

SMITH, Donovan E.
University of California
Berkeley, Calif.

SMITH, Keith V.
U. S. Steel Corp.
Pittsburg, Calif.

SMURTHWAITE, R. C.
Colgate Palmolive Co.
Berkeley, Calif.

SNEED, Robert C. Jr.
Federal Pacific Elec. Co.
San Francisco, Calif.

SOLBERG, R. W.
Calif. & Hawaiian Sugar
Refining Corp.
Crockett, Calif.

SOMMER, I. M.
Universal Cranehoist & Monorail Co.
San Francisco, Calif.

*SPARKS, Rance L.
Boeing Airplane Co.
Seattle, Wash.

STANTON, Edwin C.
Friden Calculating Machine Co.,
San Leandro, Calif.

STEVENS, W.
Department of Navy
Washington, D.C.

STUART, Jack S.
Wilsey & Ham, Engineers
Millbrae, Calif.

STUBBLEFIELD, Geo. W.
Naval Air Station
Alameda, Calif.

SUGAR, Carl
Consulting Engineer
Stockton, Calif.

SULLIVAN, W. J.
Matson Navigation Co.
San Francisco, Calif.

SWEITZER, L. M.
Mare Island Naval Shipyard
Vallejo, Calif.

SZPAK, Jake
C & H Sugar Refining Corp.
Crockett, Calif.

TATSCH, K. R.
United Air Lines Maintenance Base
San Francisco, Calif.

TALLIA, R. John P.
U. S. Steel Corp.
Pittsburg, Calif.

TEAGHER, H. M.
Mare Island Naval Shipyard
Vallejo, Calif.

TEAGHER, S. M. (Mrs.)
Mare Island Naval Shipyard
Vallejo, Calif.

THOMAS, Douglas
Prescolite Mfg. Corp.
Berkeley, Calif.

THOMPSON, Allan D.
Fibreboard Paper Prod. Corp.
San Francisco, Calif.

THOMPSON, E. J.
Schmidt Lithograph Co.
San Francisco, Calif.

THOMPSON, W. B.
Ford Motor Co.
San Jose, Calif.

THOR, Allen F.
Naval Air Station
Alameda, Calif.

TILLEY, E. S.
Mare Island Naval Shipyard
Vallejo, Calif.

TOLOSKI, Carl H.
Bethlehem Pacific Coast Steel
Millbrae, Calif.

*Attended Los Angeles session

TRUEBLOOD, Lt. D. R.
Naval Supply Center
Oakland, Calif.

TRYON, Walter W.
U. S. Steel Corp.
Pittsburg, Calif.

TYE, R. P.
Mare Island Naval Shipyard
Vallejo, Calif.

UGLEM, Norman
California Packing Corp.
San Francisco, Calif.

UNGER, D. J.
United Air Lines Maintenance Base
San Francisco, Calif.

VAN WINKLE, David
Friden Calculating Machine Co., Inc.
San Leandro, Calif.

VOREYER, Wm. B.
Electrical Communications
San Francisco, Calif.

WALKER, J. G.
Columbia Geneva Steel Div.
U. S. Steel Corp.
San Francisco, Calif.

WALKER, R. W.
Schmidt Lithograph Co.
San Francisco, Calif.

WARD, L.
United Air Lines Maintenance Base
San Francisco, Calif.

WARNER, Hugh F.
Westinghouse Electric Corp.
Sunnyvale, Calif.

WAYNE, Earl A.
Gen'l. Services Admin. U.S. Gov
San Francisco, Calif.

WEISS, Louis C.
Sylvania Electric Corp.
Mountain View, Calif.

WENTZ, Robert B.
U. S. Steel Corp.
Pittsburg, Calif.

WHITCHURCH, Gale M.
Mare Island Naval Shipyard
Vallejo, Calif.

WHITE, Earl
Owens-Illinois
Oakland, Calif.

WHITE, W. G.
United Air Lines Maintenance Base
San Francisco, Calif.

WHITEHEAD, E.
Rockwell Mfg. Co.
Oakland, Calif.

WIESENFELD, Warren W.
Coast Mfg. & Supply Co.
Livermore, Calif.

WILCOX, W. W.
United Air Lines
International Airport
San Francisco, Calif.

WILLIAMS, Frank H.
Fluor Products Co.
Santa Rosa, Calif.

WILLIAMSON, S. R.
Mare Island Naval Shipyard
Vallejo, Calif.

WILSON, Earl
Cutter Laboratories
Berkeley, Calif.

WINEGARDEN, Howard
Owens-Illinois
Oakland, Calif.

WINKLER, Allen J.
National Cont. Corp. of Calif.
Oakland, Calif.

WINSLOW, F.
S. F. Naval Shipyard
San Francisco, Calif.

WOLFE, Robert
Lenkurt Electric Co.
San Carlos, Calif.

WOOLLEY, Ellis H.
Naval Supply Center
Oakland, Calif.

WOOLSEY, H.
S. F. Naval Shipyard
San Francisco, Calif.

WORTMAN, Calvin B.
Mare Island Naval Shipyard
Vallejo, Calif.

WUEBEL, Paul A.
12th Naval Dist. HQ.
San Francisco, Calif.

YOUNG, Robert K.
McClellan A.F.B
Sacramento, Calif.

ZIMMERMAN, Ralph W.
National Seal Div.
Redwood City, Calif.

ZOLLARS, A. M.
Department of Navy
Washington, D.C.

ROSTER OF ATTENDANCE

LOS ANGELES

ABSEY, Donald
General Water Heater
Sherman Oaks, Calif.

AHERN, John F.
Nutrilite Products, Inc.
Buena Park, Calif.

AKERS, Rogers M.
Kaiser Steel Corp.
Covina, Calif.

ALEXANDER, W.
Pacific Rock and Gravel Company
Arcadia, Calif.

ALLEN, Albert H., Jr.
Rheem Manufacturing Co.
South Gate, Calif.

ALLEN, B.
Aluminum Company of America
Los Angeles, Calif.

AMO, J.
Aluminum Company of America
Los Angeles, Calif.

ANDERSON, A. G.
Propulsion Research Corp.
Santa Monica, Calif.

ANDERSON, Fred
Naval Ordnance Test Station
Arcadia, Calif.

ANDERSON, Ralph H.
U.S. Air Force, Norton A.F.B.
San Bernardino, Calif.

ANDRICOS, Peter C.
Tinker Air Force Base
Oaklahoma City, Oklahoma

ARNOLD, W. D.
Paper Mate Manufacturing Co.
Culver City, Calif.

ASHMEAD, Richard R.
Rocketdyne
Canoga Park, Calif.

ASTHE, Robert
McCulloch Motors
Los Angeles, Calif.

AUGUST, Peter
Western Brass Works
Los Angeles, Calif.

BAKER, J. G.
Temco Aircraft Corp.
Dallas, Texas

BANKERD, K. L.
North American Aviation
Whittier, Calif.

BARNETT, William
Collins Radio Company
Burbank, Calif.

BECKER, Martha
United Engravers
Los Angeles, Calif.

BEDALE, Fred
Kennecott Copper Corp.
Ray, Arizona

BENTZ, Fred A.
Sandia Corp.
Albuquerque, N. M.

BISBEY, E. J.
Firestone Tire and Rubber Co.
Los Angeles, Calif.

BLACK, D. M.
Hughes Aircraft Company
Culver City, Calif.

BROWN, Tom
Cannon Electric Company
Los Angeles, Calif.

BOUTON, George
Byron Jackson Div. of Borg Warner
Los Angeles, Calif.

BRENNAN, W. M.
Firestone Tire and Rubber Co.
Los Angeles, Calif.

BURCHARD, Joseph
Arthur Young and Company
Los Angeles, Calif.

BURKE, E. T.
Johns - Manville Products Corp.
Lompoc, Calif.

BUTLER, A. G.
American Pipe and Const. Co.
Downey, Calif.

CAIN, Victor
McCulloch Motors
Los Angeles, Calif.

CAMBON, G. M.
Columbia Geneva Steel Div.
United States Steel Corp.
Torrance, Calif.

CARTER, W.
Hughes Products of Hughes Aircraft
Culver City, Calif.

CARTOTTO, Edward
Rocketdyne
Canoga Park, Calif.

CAVE, M. W.
Johns - Manville Products Corp.
Lompoc, Calif.

CESAR, Richard
McCulloch Motors
Los Angeles, Calif.

CHANDLER, Lt. Col. Urey E.
Holloman Air Force Base
New Mexico

CHARLES, Frank
U. S. Air Force
Pomona, Calif.

CHARTRAND, Gene
Kwikset Locks Inc.
Anaheim, Calif.

CHILMAN, A. L.
Columbia Geneva Steel Div.
United States Steel Corp.
Torrance, Calif.

CHONG, Choy N.
Stillman Rubber Company
Culver City, Calif.

CHURCH, John L.
Booz, Allen and Hamilton
Los Angeles, Calif.

CIRNI, Frank F.
Hughes Tool Co. - Aircraft Div.
Culver City, Calif.

CLEMENTS, Robert
Linde Air Products Company
Lakewood, Calif.

CLOSE, G.
Aluminum Company of America
Los Angeles, Calif.

COATS, Roy R.
Smith Oil Tool Company
Compton, Calif.

COLE, Gilbert R.
Kaiser Steel Corp.
Claremont, Calif.

CONNORS, John B.
Collins Radio Company
Burbank, Calif.

COPPLE, Frank
Librascope Inc.
Glendale, Calif.

COSTA, Emil
Bojanower Machinery Service Co.
Los Angeles, Calif.

COSTANTINO, John
Packard-Bell Electronics Corp.
Los Angeles, Calif.

COTTINGHAM, Jack E.
Tubing Seal Cap, Inc.
San Gabriel, Calif.

COX, Vernon
Army Ordnance
Los Angeles, Calif.

CRAMEO, M.
Cannon Electric Company
Los Angeles, Calif.

CRANE, R. H.
Long Beach, Calif.

DALY, John M.
Raytheon Manufacturing Co.
Camarillo, Calif.

DANIEL, Charles
Atomics International
Canoga Park, Calif.

DAVIS, Frank W.
Alden Equipment Company
Gardena, Calif.

DAVIS, John L.
U. S. Air Force, Norton A.F.B.
San Bernardino, Calif.

DAVISON, James W.
U. S. Naval Ordnance Lab.
Corona, Calif.

DAVY, Phillip
Clary Corp.
San Gabriel, Calif.

DEAN, I. W.
Solar Aircraft Company
San Diego, Calif.

DEL MAR, R. A.
Firestone Tire and Rubber Co.
Los Angeles, Calif.

DEMAIN, Norman
Hughes Aircraft
El Segundo, Calif.

DEMANGATE, Donald
General Water Heater Corp.
Granada Hills, Calif.

DEMETER, Geza
Tectron, Inc.
Los Angeles, Calif.

DENNIS, Joseph A.
A. R. Maas Chemical Company
South Gate, Calif.

DeSANTIS, Richard
Marquardt Aircraft Company
Van Nuys, Calif.

DIETZ, E. G.
Carbide and Carbon Chemicals Co.
Torrance, Calif.

DiMILLE, A. P.
Douglas Aircraft Co., Inc.
Santa Monica, Calif.

DINUBILA, Armand A.
U. S. Air Force, Norton A.F.B.
San Bernardino, Calif.

DODEY, Dale H.
Ducommun Metals and Supply Co.
Los Angeles, Calif.

DOERING, William A.
Ador Corp.
Fullerton, Calif.

DOLL, Howard
Alden Equipment Co.
Gardena, Calif.

DONANT, John B.
U. S. Air Force, Norton A.F.B.
San Bernardino, Calif.

DORNBLASER, F.
Aluminum Company of America
Los Angeles, Calif.

DRAPER, C.
Oklahoma A and M College
Stillwater, Oklahoma

DUNLAP, Henry B.
Children's Hospital Society of L.A.
Los Angeles, Calif.

DYER, A. C.
Baker Oil Tools, Inc.
Los Angeles, Calif.

DYNES, Ruth E.
Benj. Borchardt and Assoc.
Los Angeles, Calif.

EATON, W. M.
Hughes Tool Co. - Aircraft Div.
Culver City, Calif.

ELLIOTT, P.
Aluminum Company of America
Los Angeles, Calif.

ELLIS, E. K.
Northrop Aircraft, Inc.
Hawthorne, Calif.

ERICKSON, Roy
Johns - Manville Products Corp.
Long Beach, Calif.

ESTABROOK, Sheldon
Standard Oil Company of California
Taft, Calif.

EVARTS, E.
Aluminum Company of America
Los Angeles, Calif.

FANCY, Glenn
Pacific Telephone and Telegraph Co.
Los Angeles, Calif.

FARRELL, Walter
Self Employed
Coronado, Calif.

FERGUSON, D.
North American Aviation, Inc.
Los Angeles, Calif.

FERGUSON, W. F., Jr.
Firestone Tire and Rubber Co.
Los Angeles, Calif.

FIELD, James
Bethlehem Pacific Coast Steel
Lakewood, Calif.

FIELDER, William
McCulloch Motors
Los Angeles, Calif.

FINEMAN, Abraham
General Water Heater Company
Van Nuys, Calif.

FISHMAN, W.
North American Aviation, Inc.
Los Angeles, Calif.

FOREMAN, Robert
Atomics International
Canoga Park, Calif.

FOREMAN, W.
Aluminum Company of America
Los Angeles, Calif.

FOSSACECA, Samual A.
U. S. Air Force, Norton A.F.B.
San Bernardino, Calif.

FREDERICK, H. E.
Columbia Geneva Steel
Torrance, Calif.

FREEBURG, D.
North American Aviation, Inc.
Los Angeles, Calif.

FRIEDMAN, Joe
Tectron, Inc.
Los Angeles, Calif.

FRIEDMAN, Thomas B.
The Ramo-Wooldridge Corp.
Los Angeles, Calif.

FRY, John G.
Valley National Bank
Phoenix, Arizona

GAINES, C. B.
Firestone Tire and Rubber Co.
Los Angeles, Calif.

GARABEDIAN, Ronald
General Water Heater Corp.
Los Angeles, Calif.

GAYTON, Donald V.
Fischer and Porter Company
Los Angeles, Calif.

GERTZ, Joseph L.
Collins Radio Company
Los Angeles, Calif.

GIBSON, Strauss
County Court House
Santa Ana, Calif.

GIENAPP, Melvin M.
Bank of America
Los Angeles, Calif.

GILBERT, Lloyd E.
Virtue Bros. Manufacturing Co.
Hawthorne, Calif.

GILBERT, Raymond
General Electric
Richland, Wash.

GINGRICH, Gilbert
Armstrong Cork Co.
South Gate, Calif.

GLASER, Frank
Collins Radio Company
Los Angeles, Calif.

GODGES, H.
Aluminum Company of America
Los Angeles, Calif.

GOETZ, Dick
H. C. Smith Oil Tool
Compton, Calif.

GOODELL, Bob
Hughes Aircraft
El Segundo, Calif.

GOODERHAM, B.
Aluminum Company of America
Los Angeles, Calif.

GORDON, JOHN S.
Hughes Aircraft Company
Sherman Oaks, Calif.

GOWER, James W.
Lockheed Aircraft Corp.
Burbank, Calif.

GRACIE, John
Atomics International
Canoga Park, Calif.

GRANQUIST, R. H.
Baker Oil Tools, Inc.
Los Angeles, Calif.

GREENBECKER, W. R.
General Metals Corp.
Los Angeles, Calif.

GUDGEIL, Franic
Fibreboard Paper Products Corp.
Arcadia, Calif.

GULARDO, R. E.
Northrop Aircraft Company
Inglewood, Calif.

GUTHRIE, William A.
Aerojet-General Corp.
Azusa, Calif.

HAAS, W. E.
Northrop Aircraft, Inc.
Anaheim, Calif.

HAGELIS, James G.
Pomona Tile Manufacturing Co.
Pasadena, Calif.

HAINDL, Alfred Frederick
U.S. Air Force, Norton AFB
San Bernardino, Calif.

HALL, C. A.
Hughes Aircraft Company
Culver City, Calif.

HANSON, John W.
Hughes Aircraft Company
Culver City, Calif.

HARDIE, Paul F.
Rome Cable Corp.
Torrance, Calif.

HART, Lewis D.
Hoffman Laboratories, Inc.
Los Angeles, Calif.

HARTMAN, Jack
Roberts Manufacturing Co.
Los Angeles, Calif.

HARTMAN, Kenneth
Psychological Services, Inc.
Los Angeles, Calif.

HARTZLER, Earnest D.
Leach Corp. Relay Div.
Los Angeles, Calif.

HATFIELD, George
The National Supply Company
Torrance, Calif.

HAWKIN, Scott F.
Northrop Aircraft Corp.
Los Angeles, Calif.

HEATH, Col. John R.
Los Angeles Ordinance District
Pasadena, Calif.

HECHT, Richard L.
Hoffman Laboratories, Inc.
Los Angeles, Calif.

HENNESSY, R. L.
Southern California Gas
Los Angeles, Calif.

HENRY, Edward H.
Aerojet-General Corp.
Azusa, Calif.

HEUSTIS, Lester G.
Hunter Douglas Aluminum Corp.
Riverside, Calif.

HILLER, J. C.
Columbia-Geneva Steel Division
United States Steel Corp.
Torrance, Calif.

HOLLIER, David R.
Carbide and Carbon Chemicals Co.
Torrance, Calif.

HOPKINS, George C.
Old Colony Paint and Chemical Co.
Los Angeles, Calif.

HOPKINS, R. S.
Applied Research Laboratories
Glendale, Calif.

HORNBAKER, Warren J.
U.S. Air Force, Norton AFB
San Bernardino, Calif.

HOUSER, E. K.
Rohr Aircraft Company
Chula Vista, Calif.

HOUSTON, R. G.
Proctor & Gamble Mfg. Co.
Long Beach, Calif.

HOWARD, G. W.
Baker Oil Tools, Inc.
Los Angeles, Calif.

HUGHES, Kathleen
Arthur Young and Company
Los Angeles, Calif.

HUTTON, Richard T.
U. S. Air Force, Norton AFB
San Bernardino, Calif.

JAMES, Howard D.
U. S. Air Force, Norton AFB
San Bernardino, Calif.

JAMES, William F.
U. S. Air Force, Norton AFB
San Bernardino, Calif.

JEFFREY, Edward H.
Hoffman Laboratories
Los Angeles, Calif.

JENKINS, Emmett W.
Bank of America
San Francisco, Calif.

JENSEN, W. S.
Preco Inc.
Los Angeles, Calif.

JOHNS, Dick
Clary Corp.
San Gabriel, Calif.

JOEDES, E. W.
Firestone Tire and Rubber Co.
Los Angeles, Calif.

JUBINA, William
Ducommun Metals and Supply Co.
Los Angeles, Calif.

JUNE, Robert L.
Mattel Inc.
Los Angeles, Calif.

KADAU, R. L.
Johns-Manville Products Corp.
Los Angeles, Calif.

KALENBORN, Fred M.
Standard Oil Company of California
Taft, Calif.

KEANE, Terrance O.
U. S. Air Force, Norton AFB
San Bernardino, Calif.

KEEFER, A.
Hughes Products of Hughes Aircraft
Culver City, Calif.

KENDALL, Jerrold
Leach Corp.
Maywood, Calif.

KIMBERLY, B.
Aluminum Company of America
Los Angeles, Calif.

KING, Lew
Beckman Ind. Company
Fullerton, Calif.

KIRK, J.
Aluminum Company of America
Los Angeles, Calif.

KITTLE, R. B.
Firestone Tire and Rubber Co.
Los Angeles, Calif.

KNIGHT, W. E. H.
Stauffer Chemical Company
Compton, Calif.

KNOBLOCH, Robert
Kennecott Copper Corp.
Hayden, Arizona

KROPACEK, Frank
Taylor Forge and Pipe Works
Fontana, Calif.

LANCASTER, Chester
North American Aviation
Los Angeles, Calif.

LANE, J. Alden
Alden Equipment Company
Gardena, Calif.

LANG, C. A.
Evaporated Production Division
Carnation Milk Company
Los Angeles, Calif.

LANG, Don
Hughes Aircraft
El Segundo, Calif.

LAPUTZ, John
Bendix-Pacific Division
Canoga Park, Calif.

LARSON, Gene B.
Boeing Airplane Company
Seattle, Wash.

LAUZON, R. J.
Fibreboard Paper Products Corp.
South Gate, Calif.

LAWRENCE, George
Pacific Telephone and Telegraph Co.
Los Angeles, Calif.

LEE, Joshua
Waialua Agricultural Company LMD
Waialua, Hawaii

LENHART, J.
Hughes Products, Hughes Aircraft Co.
Culver City, Calif.

LEWI, J. B.
Packard-Bell Electronics
Los Angeles, Calif.

LEWIS, James A.
Wayne Manufacturing Company
Pomona, Calif.

LEYDA, Arthur E.
Todd Co., Inc.
Los Angeles, Calif.

LITTLEFIELD, B.
Aluminum Company of America
Los Angeles, Calif.

LOGAN, George H.
North American Aviation Inc.
Los Angeles, Calif.

LOMBARD, Charles
Lockheed Missles
Van Nuys, Calif.

LORIMORE, Reg.
United Engravers
Los Angeles, Calif.

LOW, Mike
Albers Production Division
Carnation Company
Los Angeles, Calif.

LUMMUS, Clinton
Gladding McBean and Company
Los Angeles, Calif.

LUND, R.
Aluminum Company of America
Los Angeles, Calif.

LUNDBERG, Carl W.
U. S. Air Force, Norton AFB
San Bernardino, Calif.

LYONS, F. M.
Hoffman Laboratories, Inc.
Los Angeles, Calif.

McBREEN, Wesley L.
Servomechanisms, Inc.
Hawthorne, Calif.

McCARROLL, George
Hughes Aircraft Co.
Canoga Park, Calif.

McCLURE, Guy V.
Tinker Air Force Base
Oklahoma City, Oklahoma

McCOOK, Anson
Rheem Manufacturing Company
Downey, Calif.

McCUTCHAN, Melvin
Sandia Corp.
Albuquerque, New Mexico

McDANIEL, D.
Aluminum Company of America
Los Angeles, Calif.

McDONALD, C. A.
Baker Oil Tools, Inc.
Los Angeles, Calif.

McDONALD, E. Ray
Bendix Aviation Corp.
Van Nuys, Calif.

McDONELL, William C.
Southern California Gas Company
Los Angeles, Calif.

McGRATH, E. J.
Northrop Aircraft Inc.
Inglewood, Calif.

McLAUGHLIN, Curtis
Paper Mate Manufacturing Co.
Culver City, Calif.

MACARTNEY, E.
Standard Oil Company of California
El Segundo, Calif.

MacCOON, G. K.
Grant and Grant
Los Angeles, Calif.

MacCOON, L. P.
Grant and Grant
Los Angeles, Calif.

MACKENZIE, Gerald W.
Schlitz Brewing Co.
Van Nuys, Calif.

MACKINZIE, Frank Lee
U. S. Air Force, Norton AFB
San Bernardino, Calif.

MACKLEM, D. J.
Hughes Aircraft Company
Culver City, Calif.

MacLEOD, D. E.
Preco Inc.
Los Angeles, Calif.

MADIGAN, Joseph
Kwikset Locks, Inc.
Anaheim, Calif.

MALOIT, A.
Aluminum Company of America
Los Angeles, Calif.

MANGAN, W. E.
Carbide and Carbon Chemicals Co.
Torrance, Calif.

MANGOLD, Fred, Jr.
Pacific Telephone & Telegraph Co.
Whittier, Calif.

MANNING, Charles D.
Lockheed Aircraft Corp.
Burbank, Calif.

MANUS, Stan
Propulsion Research Corp.
Santa Monica, Calif.

MARGOLIN, Jack
Central D Corp.
Culver City, Calif.

MARGOLIS, S.
Arthur Young and Company, C.P.A.
Los Angeles, Calif.

MARTIN, Harold,
Aerojet General Corp.
Glendora, Calif.

MARTIN, Robert
Servomechanisms, Inc.
Hawthorne, Calif.

MATHEWSON, D. C.
Aluminum Company of America
Los Angeles, Calif.

MATOSOFF, Henry
Kwikset Locks, Inc.
Los Angeles, Calif.

MAZON, Meyer I.
American Machine & Fdry. Co.
Pacoima, Calif.

MEADE, D.
Aluminum Company of America
Los Angeles, Calif.

MELCHER, E. L.
Firestone Tire & Rubber Co.
Los Angeles, Calif.

MENDENHALL, Earl
Atomics International
Canoga Park, Calif.

MERRILL, R. E.
Carbide & Carbon Chemical Co.
Torrance, Calif.

MEYER, Karl L.
The Ramo-Wooldridge Corp.
Los Angeles, Calif.

MICHEL, Howard
Michel Bros. Egg Co.
Santa Monica, Calif.

MILEY, Don W.
U. S. Air Force, Norton AFB
San Bernardino, Calif.

MILLAR, M. B.
Columbia Geneva Steel Div.
United States Steel Corp.
Torrance, Calif.

MILLER, Robert S.
Servomechanisms, Inc.
Hawthorne, Calif.

MILLER, Troy S.
Collins Radio Company
Los Angeles, Calif.

MINIUM, Edward M.
Technicolor Corp.
Hollywood, Calif.

MINTZ, Bill
Packard-Bell Electronics
Los Angeles, Calif.

MOLER, Marvin H.
Bendix Aviation Corp. Pac. Div.
Reseda, Calif.

MOORE, Carter F.
Ducommum Metals & Supply Co.
Los Angeles, Calif.

MOORE, Robert L.
Rocketdyne
Canoga Park, Calif.

MORRIS, John
Western Gear Corp.
Downey, Calif.

MORRIS, Ralph
Rome Cable Corp.
Torrance, Calif.

MOTT, Clinton P.
Kennecott Copper Corp.
Salt Lake City, Utah

MUDD, Warren C.
Rome Cable Company
Torrance, Calif.

MUELLER, T. O.
Firestone Tire & Rubber Co.
Los Angeles, Calif.

MURRAY, Robert R.
Preco, Inc.
Los Angeles, Calif.

MUSTAD, Maurice
Hughes Aircraft
El Segundo, Calif.

MYERS, E. Paul
Rheem Manufacturing Company
Downey, Calif.

NEWTON, W. G.
Beckman Instruments, Inc.
Fullerton, Calif.

NOEL, William
Franchise Tax Board
San Diego, Calif.

NORRIS, David B.
Aerojet-General Corp.
Azusa, Calif.

NUGENT, Bob
Fitzsimmons Stores, Ltd.
Los Angeles, Calif.

OBERG, Albert
Convair
Chula Vista, Calif.

O'CONNOR, M. A.
Douglas Aircraft
Santa Monica, Calif.

OLINGER, Paul
Robertshaw-Fulton Controls
Long Beach, Calif.

OLSEN, P. E.
Fibreboard Paper Products Corp.
Vernon, Calif.

OLSEN, R. L.
Atomics International
Canoga Park, Calif.

PAHLOW, John L.
Jos. Schlitz Brewing Co.
Van Nuys, Calif.

PARSONS, Cecil
Bill Jack Scientific Instrument
Solana Beach, Calif.

PATTON, Ken
Virtue Brothers
Los Angeles, Calif.

PAULL, Alvord
Pacific Telephone & Telegraph Co.
Los Angeles, Calif.

PELL, K. W.
Firestone Tire & Rubber Co.
Los Angeles, Calif.

PETERS, I. J.
Baker Oil Tools, Inc.
Los Angeles, Calif.

PETERS, R. C.
Servomechanisms, Inc.
Hawthorne, Calif.

PETERSEN, Wm H.
Meletron Corp.
Los Angeles, Calif.

PETRAITIS, Albert
Hughes Aircraft
Culver City, Calif.

PHILLIPS, Robert V.
Pomona Tire Mfg. Co.
Pomona, Calif.

PIEKAAR, Richard
Eastman Kodak
Hollywood, Calif.

PISCHEL, Carl
Federal Mogul Bower Bearings, Inc.
Downey, Calif.

POMEROY, R. D.
Southern California Gas Company
Los Angeles, Calif.

POWERS, Patrick J.
U. S. Air Force, Norton AFB
San Bernardino, Calif.

PRATT, L.
Ryan Aeronautical Company
San Diego, Calif.

PROTHERO, Mr.
Aluminum Company of America
Los Angeles, Calif.

PRUCE, Peter
Barry and Company
Beverly Hills, Calif.

QUILLIN, G. E.
Hughes Aircraft Company
Tucson, Arizona

RAINWATER, Julius, Jr.
LA Co. Civil Service Comm.
Los Angeles, Calif.

RANDOLPH, J. H.
Firestone Tire & Rubber Co.
Los Angeles, Calif.

RANSOM, R. J.
Firestone Tire & Rubber Co.
Los Angeles, Calif.

RASHMIR, Lewis I.
U. S. Air Force, Norton AFB
San Bernardino, Calif.

RAY, Charles
Atomics International
Canoga Park, Calif.

REARDON, Don
Hughes Aircraft
El Segundo, Calif.

REASMAN, James G.
U. S. Air Force, Norton AFB
San Bernardino, Calif.

RESECK, L. F.
Firestone Tire and Rubber Co.
Los Angeles, Calif.

RICE, Leonard
Marman Products Company, Inc.
Los Angeles, Calif.

RIELAND, J. J.
Northrop Aircraft Inc.
Anaheim, Calif.

RIGGS, Harold
Pacific Telephone & Telegraph Co.
Anaheim, Calif.

ROBISON, Stuart W.
American Potash and Chemical Corp.
Trona, Calif.

ROCKMAN, R. C.
Hughes Aircraft Company
Culver City, Calif.

ROGERS, Lewis
Michel Brothers Egg Company
Santa Monica, Calif.

ROSEN, Carl
Hoffman Laboratories, Inc.
Los Angeles, Calif.

ROSER, Noel W.
Taylor Forge and Pipe Works
Fontana, Calif.

ROSSO, Ruben
U. S. Air Force, Norton AFB
San Bernardino, Calif.

ROTRAMEL, J.
Aluminum Company of America
Los Angeles, Calif.

ROWLAND, Robert
McCulloch Motors
Los Angeles, Calif.

RUBEN, Ted
Central D Corp.
Culver City, Calif.

RULE, William
Robertshaw-Fulton Controls Co.
Anaheim, Calif.

SALTER, John L.
Bendix Aviation
California

SANCHEZ, R. Jr.
Convair - Astronautics
San Diego, Calif.

SANDBERG, Stanley
Arthur Young and Company
Los Angeles, Calif.

SANT, Walter
Robertshaw-Fulton Controls Co.
Long Beach, Calif.

SATTEN, M.
Rohr Aircraft Company
Chula Vista, Calif.

SATTERLEE, Robert L.
U. C. L. A.
Los Angeles, Calif.

SAVAGE, Chester
Bojanower Machinery Service
Los Angeles, Calif.

SCHEIR, Asher
U. S. Air Force, Norton AFB
San Bernardino, Calif.

SCHINDLER, J. D.
Firestone Tire & Rubber Co.
Los Angeles, Calif.

SCHNEIDER, Kurt O.
Hughes Products, Ind. Sys. & Control
Los Angeles, Calif.

SCHROEDER, Charles R.
Zoological Society of San Diego
San Diego, Calif.

SCHUERCH, Hans, Ph.D.
Aerophysics Development Corp.
Santa Barbara, Calif.

SCHWAB, Melvin L.
Northrop Aircraft, Inc.
Hawthorne, Calif.

SCHWARTZ, L.
Northrop Aircraft, Inc.
Hawthorne, Calif.

SCHWEIEKERT, Karl R.
Hoffman Laboratories, Inc.
Los Angeles, Calif.

SCOTT, W. W., Jr.
Scott Company of Southern Calif.
North Hollywood, Calif.

SEAMANS, Bernard R.
U. S. Air Force, Norton AFB
San Bernardino, Calif.

SECKETA, Stephen
North American Aviation
Monrovia, Calif.

SEMERE, Francis G.
Ramo-Wooldridge Corp.
Los Angeles, Calif.

SENIOR, Howard R.
Sylvania Electric Corp.
Mountain View, Calif.

SEYMOUR, D. M.
Hughes Aircraft Company
Culver City, Calif.

SHUPPER, Samuel
Zephyr Metal Products Co., Inc.
North Hollywood, Calif.

SIMON, Aluin
Heinley Master Craft Products
Santa Monica, Calif.

SIMPSON, D. B.
Rheem Manufacturing Company
Long Beach, Calif.

SIMPSON, Sherwood L.
Hughes Aircraft
Culver City, Calif.

SIMS, B.
Aluminum Company of America
Los Angeles, Calif.

SMITH, B. B.
Kennecott Copper Corp.
McGill, Nevada

SMITH, C. L., Jr.
Firestone Tire & Rubber Co.
Los Angeles, Calif.

SMITH, G.
Aluminum Company of America
Los Angeles, Calif.

SMITH, Herman
Logistics Research, Inc.
Los Angeles, Calif.

SMITH, K.
Aluminum Company of America
Los Angeles, Calif.

SMITH, R. E.
Hughes Aircraft Company
Culver City, Calif.

SMITH, Raymond L.
National Screw & Mfg. Co.
Los Angeles, Calif.

SMOKER, Walter
Ramo-Wooldridge Corp.
Hawthorne, Calif.

SOMERS, Jack
Heinley Mastercraft Products
Santa Monica, Calif.

SOWELL, Walter E.
U. S. Air Force, Norton AFB
San Bernardino, Calif.

STACKHOUSE, J. W.
Pachmayr Corp.
Los Angeles, Calif.

STAIB, Donald
United States Steel Products Div.
Vernon, Calif.

STEIN, Arthur
Gladding McBean and Company
Los Angeles, Calif.

STEURER, George
Bendix Computer Division
Los Angeles, Calif.

STEVENS, Calvin E.
U. S. Air Force, Norton AFB
San Bernardino, Calif.

STONE, Orville C.
Collins Radio Company
Los Angeles, Calif.

STOSSKOPF, George
Lockheed Aircraft Corp.
Studio City, Calif.

STOVALL, B. L.
National Steel & Shipbuilding Corp.
San Diego, Calif.

SUBT, A. G.
Douglas Aircraft Company
Long Beach, Calif.

SUHR, P. B.
Atomics International
Canoga Park, Calif.

SULLIVAN, J. Bryan, Jr.
Lockheed Aircraft Corp.
Van Nuys, Calif.

SUTHERLAND, Charles J.
Servomechanisms, Inc.
Hawthorne, Calif.

SUTTON, L. Bruce
U.S. Air Force, Norton AFB
San Bernardino, Calif.

TALIAFERRO, George
Carnation Co.
Los Angeles, Calif.

TALLEY, Bill
Clary Corp.
San Gabriel, Calif.

TAYLOR, K. M.
Firestone Tire & Rubber Co.
Los Angeles, Calif.

THACKER, W. A.
Atomics International
Canoga Park, Calif.

THOMPSON, William M.
Bendix Aviation Corp.
North Hollywood, Calif.

THOMPSON, R. L.
Douglas Aircraft Company, Inc.
El Segundo, Calif.

THORTON, D. J.
Solar Aircraft Company
Los Angeles, Calif.

TIESO, Joseph
Gladding McBean and Company
Los Angeles, Calif.

TINT, Lester
Amercon Corp.
Los Angeles, Calif.

TOTH, John M.
Rheem Manufacturing Co.
South Gate, Calif.

TROEGER, E. Alan
Kaiser Steel Corp.
Ontario, Calif.

TRUESDELL, T. H.
D. B. Milliken Company
Arcadia, Calif.

TUCKER, Walden
McCulloch Motors
Los Angeles, Calif.

TULLOSS, W. Brice
Aerojet-General Corp.
Azusa, Calif.

VAIS, James A.
National Automotive
Los Angeles, Calif.

VAN HORN, Max
Byron Jackson Division of Borg-Warner Corp.
Los Angeles, Calif.

VASQUEZ, Anthony B.
U. S. Air Force, Norton AFB
San Bernardino, Calif.

WALLACE, R. V.
Stauffer Chemical Company
Los Angeles, Calif.

WATKINS, Dodd
Corps of Engineers, U. S. Army
Los Angeles, Calif.

WETTER, Charles
Robertshaw-Fulton Controls Co.
Anaheim, Calif.

WHEELER, Donald
Robertshaw-Fulton Controls Co.
Long Beach, Calif.

WHITE, Donald B.
U. S. Air Force, Norton AFB
San Bernardino, Calif.

WILLIAMS, H. B.
National Steel and Shipbuilding Corp.
San Diego, Calif.

WILLIAMS, John
Robertshaw-Fulton Controls Co.
Long Beach, Calif.

WILLIAMS, Lloyd
Genvair
Lemon Grove, Calif.

WILSON, W. A.
Web Wilson Oil Tools, Inc.
Los Angeles, Calif.

WINKLER, Joseph William
Pacific Tile and Porcelain Co.
Long Beach, Calif.

WINSLOW, James C.
Winslow Product Engineering Corp.
Arcadia, Calif.

WITTE, Lee
McCulloch Motors
Los Angeles, Calif.

WOOD, Loren E.
Ramo-Woolridge Corp.
Lancaster, Calif.

WOOD, Clayton
Johns - Manville Prod. Corp.
Long Beach, Calif.

WYLIE, Malcolm R.
Bendix Aviation Corp. K.C. Div.
Mission, Kansas

YEAMAN, R. D.
Propulsion Research Corp.
Santa Monica, Calif.

YENCER, Ralph A.
American Potash & Chemical Corp.
Henderson, Nevada

ZIELLO, A.
Hughes Aircraft
Culver City, Calif.

ZIRGES, C. C.
Firestone Tire & Rubber Co.
Los Angeles, Calif.

ZUBAR, Jack
Hughes Aircraft
El Segundo, Calif.