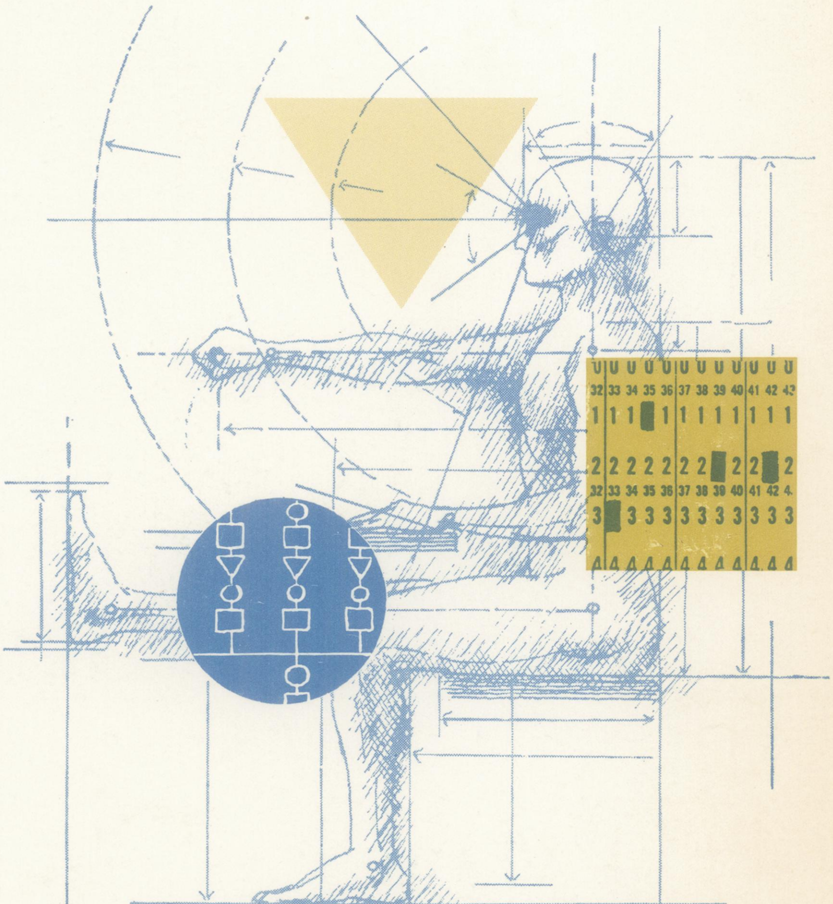
PROCEEDINGS

SIXTEENTH ANNUAL INDUSTRIAL ENGINEERING INSTITUTE



UNIVERSITY OF CALIFORNIA EXTENSION

BERKELEY and LOS ANGELES February 7 and 8, 1964

PROCEEDINGS

SIXTEENTH ANNUAL

INDUSTRIAL ENGINEERING INSTITUTE

Presented by

UNIVERSITY OF CALIFORNIA

The Colleges of Engineering
The Schools of Business Administration
The Institutes of Industrial Relations
University Extension

At Berkeley and Los Angeles
February 7 and 8, 1964

In Cooperation with

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

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FOREWORD

Sam M. Houston
General Chairman
Sixteenth Annual Industrial Engineering Institute

The Proceedings of the Sixteenth Annual Industrial Engineering Institute contain the papers of the ten speakers who appeared on both campuses, as well as the welcoming remarks by Dean Maslach at Berkeley. This year's group of speakers were especially outstanding, as may be verified by those who attended the Institute or by reviewing their presentations reproduced in these proceedings. A great deal of appreciation is extended to these men, in particular those who experienced some difficulty in order to appear at the scheduled times in Berkeley and Los Angeles.

An effort was made to improve some of the organizational and operational aspects of the Institute this year. Only individuals who were considered to be of equal interest to both campuses and therefore might appear in both Berkeley and Los Angeles were extended invitations to participate, thus limiting the total number of speakers to ten.

The subject of the papers presented this year, as in the past, was largely determined from the summarization of the interest questionnaires completed by those who attended the Fifteenth Industrial Engineering Institute. Once the general subjects were identified, the most capable individuals in each area were located.

Any credit for the success of this Institute must be shared with many individuals from both the Berkeley and Los Angeles areas. Personnel from University Extension in particular made the task of General Chairman enjoyable by continuing to provide excellent support from the initial planning stages through to the actual publication and mailing of these Proceedings.

Sam M. Houston

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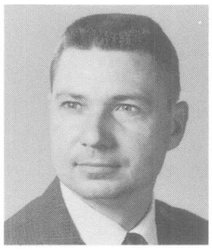

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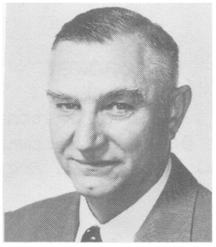

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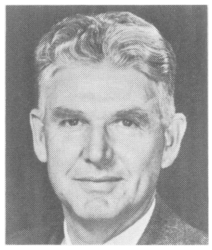

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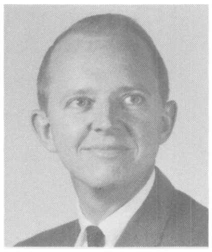

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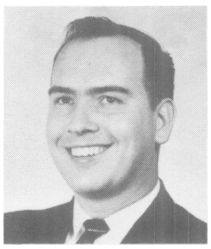

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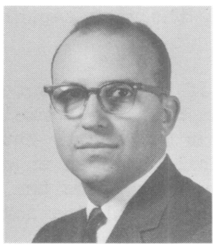

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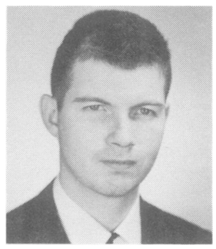

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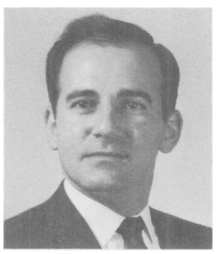

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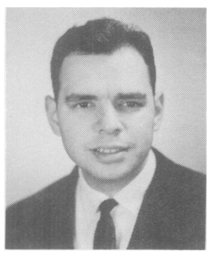

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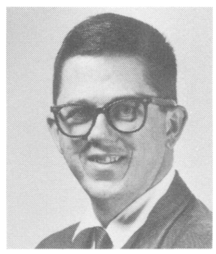

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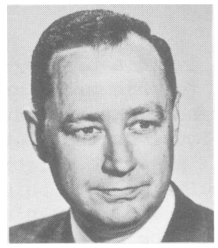

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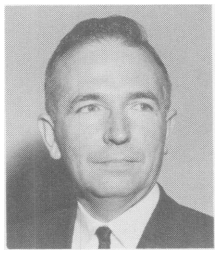

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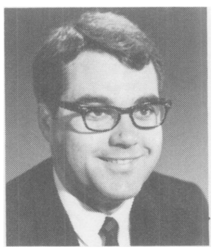

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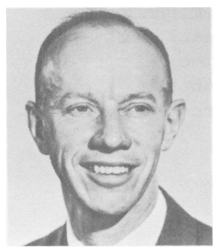

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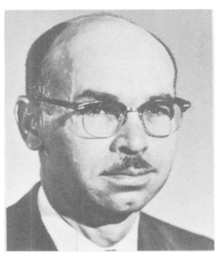

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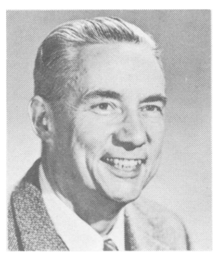

E. C. Keachie

WELCOMING REMARKS

George J. Maslach
Dean, College of Engineering
University of California
Berkeley, California

It is a pleasure for me to act as the host to this group and to welcome you to the Sixteenth Annual Industrial Engineering Institute here at Berkeley. In a sense, you and I are both celebrating an anniversary of association with this University. Nineteen hundred and forty-nine was a good vintage year. You chose to return to the University to start this program of yearly meetings; I also chose to return that year to start a new career. Therefore, in preparing my remarks, I felt it was appropriate to reach back in time to quote a phrase from the Dean of Engineering in 1949, Morrough P. O'Brien, a phrase I have always remembered and have often used. He said at that time, "Research in a University should produce two major results, namely, the research contributions themselves and the competent young men who assisted in the work." Implicit in that statement is the responsibility of the University not only to contribute research results directly, but to store, to correlate, and to disseminate these results. The University has, in fact, been called our most effective information storage and retrieval system; this may well be true. You have found over the years that the University can aid in a very pleasant fashion in the process of disseminating this information. Certainly there can be no method of passing on knowledge more enjoyably than by direct personal contact, such as you are participating in here today and tomorrow.

In this process of exchange, the University gains as well. I refer not just to the one-half inch of material which must be cataloged and stored for years to come. Rather, I refer to the feedback of information from the profession to the College, the professors, and the students. Professional schools are unique in their need to maintain strong ties with the practicing members of their profession. To avoid preoccupation with only one of the responsibilities of a professional school, that of translating new scientific knowledge into useful technology, we in a University environment must always maintain contact with the practitioners who are currently applying the latest technology, our source of examples of application using the best of methodology.

In a way, we at this Conference are all involved in a process of continuing education. For the next two days, therefore, while you are our welcome guests, consider yourselves as "professors pro tem." Your contribution to our education will not be stored for long. It will be used immediately in the classroom and in the laboratory. In years to come you may recognize your personal contribution when you hire one of our "competent young men who assisted in this work."

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CHOOSING WORK-MEASUREMENT METHODS FOR THE OFFICE

Colby Tibbetts
Manager, Management Services
Metropolitan Life Insurance Company
New York, New York

An effective clerical work-measurement program requires sound planning of a number of factors. These include:

1) Program Administration

   Establishing the objectives, policies, and practices that will govern operation of the program.

2) Organization

   Assigning responsibilities and authorities for implementation of the program.

3) Design of Performance Reporting and Analysis Systems

   Forming the basis for sound control.

4) Selection of Time-Study Techniques

5) Obtaining Management Understanding and Support

6) Selection and Training of Personnel

7) Making Provision for Maintenance of Standards

8) Program Evaluation

All these factors play an important role in determining the effectiveness of a clerical work-measurement program. However, this paper will deal with only one of the factors--selection of time-study techniques.

Before beginning an examination of technique selection, perhaps it would be helpful as a reference framework to describe my company's clerical work-measurement program. The Metropolitan Life Insurance Company is the largest life insurance company in the world. It has about 63,000 employees, of whom about one-half are sales personnel; the remaining 31,000 are clerical and administrative. Eight thousand of this latter group are located outside New York in our 1,000 local district offices; 20,000 are in our New York home office; 3,000 others are in our two head offices. Thus, when we are talking about work measurement at the Metropolitan, we are dealing with about 31,000 potentially measurable employees. Almost all the work done by these people is office paper work; 60 per cent of it is repetitive to a degree, the balance is diverse.

Work measurement at the Metropolitan has a long history dating back over 20 years. Its purpose in the beginning was largely for cost allocation. However, as time went by it became apparent that it had another important use as a labor cost control device. Throughout its history, the program has been on a voluntary basis. That is to say, the various divisions and departments of our company are free to use it or not. Responsibility for promoting the program rests with our Management Services Division. It is this unit's job to make new work-measurement installations, to maintain existing standards, and to assist in training management in the effective use of work measurement.

We have two different work-measurement programs at the Metropolitan, each designed to fit a particular set of circumstances. One is our District Office Work Measurement Program covering the 8,000 clerical people located in our 1,000 district offices. In some respects, the problem of measurement is relatively simple as regards this program. Because the procedures in each of the district offices are highly standardized, it is not necessary to time-study more than a sample of the work in order to set reliable standards. On the other hand, the problem of measurement is made difficult because of the many diverse operations performed in each district. Also, a relatively small inaccuracy in setting standards can have broad staffing implications.

Our other work-measurement program at the Metropolitan covers our home office clerical personnel numbering some 20,000. Of the 20,000, approximately 11,000 are now covered by work standards. Perhaps another 2,500 could be measured by one of the techniques now available.

Our Home Office Work-Measurement Program presents different problems than our District Office Program. We have about 300 organizational units in our home office, each doing a different job. There are very few situations where substantial numbers of people are doing exactly the same job. Thus, it is not possible to apply the same techniques that are employed in our District Office Program. Each work measurement installation in the home office has been individually tailored to a unit and to the work characteristics of that unit. Also, the problem of keeping standards current is more difficult in the home office program than in the district office program because of frequent changes in operation, each requiring separate restudy.

At the Metropolitan, work measurement is used for budgeting, forecasting staffing needs, rating of personnel, methods improvement, cost analysis, production scheduling, and cost allocation. Primarily, however, it is used as a working tool for management, aimed at keeping a reasonable balance between the staff on hand and the staff required to do a particular volume of work at a high level of efficiency.

One final characteristic of our programs at the Metropolitan is that they are not used as the basis for wage incentive systems because only one small unit is covered by wage incentives at this time.

So much for background about the Metropolitan. Let's now turn to the major question before us. How does one choose the right technique for office work measurement? As an answer to this question, I am going to suggest that there is no one best technique. Instead, I believe that many different techniques can be profitably applied to office work. This does not mean that any technique will do, but rather that each technique has its advantages and limitations. The key to selecting the best technique for a given situation involves (1) making a careful analysis of the requirements of the situation to be measured, (2) gaining a thorough understanding of the advantages and limitations of work-measurement techniques, and (3) matching the two to produce the best blend of techniques and results. Thus, the problem of selecting office work-measurement techniques is much like the problem faced by a golfer as he approaches his next shot. His decision about the right club to use is not based on finding the best club in his bag but rather on finding the club that is best for the shot at hand. Before choosing, he analyzes the job to be done in terms of distance, lie, and wind conditions and then considers which of his clubs is best designed to meet the requirements.

There are two major aspects of technique selection that I would like to cover: (1) a description of the factors that should be analyzed and defined prior to selection of a work measurement technique, and (2) the major office work-measurement techniques, their advantages and limitations.

What are the factors that should be analyzed and defined before selecting a measurement technique? I believe they fall into three general categories:

1) The Program Objective

   By this I mean that the end results you seek should have a definite influence on the techniques you use.

2) The Characteristics of the Work

   A careful analysis of the work to be measured must precede selection of techniques if sound results are to be achieved.

3) Cost-Value Considerations

   By this I mean those considerations that are involved in deciding which technique will give you the best payoff per dollar spent.

A closer examination of these three factors will show how each plays its part in determining the best method of measurement to use.

1) The Program Objective

   There are many different end results a company may seek to achieve through a clerical work-measurement program. It is not my purpose to tell you what these should be. However, I would like to suggest that it is quite important to have them clearly defined and to consider them carefully before selecting a measurement technique. For example, if your major objective is to use work measurement as a basis for direct wage incentives, you should be careful to select the technique that will give you very precise measurement. To do otherwise is to invite failure. If, on the other hand, you are interested only in establishing productivity trends within your company, a less precise and less costly technique may be adequate. A more general technique may also be adequate if the main objective of your program is to develop general staffing guides. However, if you are interested in raising productivity by increasing the pace at which people work, you should choose a technique that will enable the setting of reasonable performance goals at the individual worker level.

   There are many other objectives you may have established for your particular program. A review of each is not necessary. The relationship between purpose and technique is clear. As in all things, preciseness costs money. When selecting a work-measurement technique, don't buy accuracy beyond need. On the other hand, if your objective requires precision, don't expect to get it from a general technique.

2) The Characteristics of the Work

   The second factor to be examined before selecting a measurement technique is the work itself. There are a number of considerations involved in the characteristics of work which should exert a direct influence on technique used.

   For example, is the work highly repetitive and short cycle? Predetermined times may be the best technique for use if this is the case. This is a precise technique designed to measure highly repetitive situations. Is the operation to be studied long and involved with many steps that occur at a frequency of less than 100 per cent? If this be the case, direct observation or work sampling may prove to be the most suitable technique. Wide variations in this kind of work make the use of more precise methods, such as predetermined times, questionable. Does the work have a significant amount of thinking involved? If so, work sampling should be considered. Does the job involve tabulating equipment? A combination of techniques may prove useful to set workable standards in a man-machine situation. Is the job to be measured such that customer service is more important than precise staffing? In these situations, one of the more general methods of study may fill the bill. Does the work require that the person doing it travel throughout the building extensively, as, for example, an interoffice messenger? Perhaps a log sheet completed by the worker will suffice in these situations.

Many other examples can be cited to demonstrate the relationship between characteristics of the work and technique. The point to be stressed is that there is a relationship, and that one should proceed from the characteristics of the work to selection of technique, not vice versa.

3) Cost-Value Considerations

The third factor to be given consideration before selecting a technique is its cost in relation to the possible results to be obtained. For example, as an extreme illustration, one should not use an involved, precise measurement technique to measure an operation that is going to be radically changed in the near future. Keeping cost-value relationships in focus extends to other less obvious situations. Generally, one will find that a small proportion of the clerical operations performed in a unit are responsible for a major portion of the time expended. Precise techniques such as predetermined times can be used to measure these, and more general techniques can be used to pick up the more numerous but far less significant operations. In fact, estimates can often be used to establish time values for relatively insignificant operations.

Another consideration closely related to cost-value involves the size of your program and the speed at which you wish to complete it. If your program is just getting under way and you wish to extend coverage rapidly, work sampling or another general technique may be your best answer. If, on the other hand, your program is well established and is in a stage of refinement, a more precise method such as predetermined times may pay off for you.

In the preceding illustrations I have tried to cover some of the factors that influence the selection of office work-measurement techniques. Obviously, I have not covered them all. However, I hope that I have mentioned enough to indicate the kinds of questions you should ask yourself before choosing a method or methods. In a sense, the three factors discussed represent a definition of the job to be done and the requirements of the situation. Like the golfer selecting a club, distance, lie, and wind direction have been determined. Now, let's turn to the selection of the club, or, in this case, the technique with the characteristics that will fit the needs of the situation.

The variety of available office work-measurement techniques is extensive. The exact number available is probably indeterminable because much of this involves how you define the word technique. Rather than getting involved in the problem of semantics, I am going to discuss five categories of techniques that have reasonably common characteristics. Within each category, I will describe the major characteristics of the technique, its inherent advantages, its inherent limitations, and some of the situations in which it can be profitably employed.

The first category for consideration is the historical data method. This method involves development of time values based on past records of the unit or operation under study. A relationship is established between the volume of work completed in a previous period and the man-hours required for its completion. This relationship can then be used to calculate production performance in succeeding periods.

The historical approach is the most general technique available. Its shortcomings are many. At best, it can only present a picture of what has been, not what ought to be. Of necessity, it builds into the performance-reporting system all of the inefficiencies present during the period the data is drawn from. Also, use of this method may cause difficulty if operating management becomes accustomed to it and then a decision is made to install more precise methods of measurement.

On the credit side, the historical method has several things to be said for it. It is easily installed at a very low cost and without the use of highly trained personnel. In addition, it can form the basis for determining the trend of production performance.

When should the historical technique be used? Generally speaking, it should be considered only when there is a real need to get information about the trends of productivity quickly and, for one reason or another, it is not practical to use other techniques. If it is used, caution should be taken to see that all involved understand the limitations of the method and the fact that it contains no concept of standard.

The second technique I would like to describe briefly is the time-log method. Under this method the persons being studied keep a record of the various kinds of operations they work on, the number of minutes spent on each kind of work, and the units of work produced. Generally, this is done under carefully supervised conditions and nonstandard performers such as trainees, etc., are excluded from the study. The information derived from this type of study is summarized and, through use of statistical techniques, a relatively creditable standard can be developed.

The major advantages of the time-log method are several. It insures that all operations and all time expenditures are accounted for. It provides a basis for picking up information about the frequency of internal steps without the need for supplementary study. In addition, it captures the influences that are present under actual operating conditions.

The time-log system has several disadvantages. Even though carefully supervised, it is difficult to identify all nonproductive or personal time with any degree of accuracy. In addition, selecting a standard time from the array of data involves a great deal of subjectivity. Finally, a considerable amount of clerical time is involved in summarization of data, which adds to the cost of the method.

In spite of its limitations, the time-log approach can be usefully employed for a number of situations: for example, in a situation where a job has a wide variety of different operations, or where there are a number of positions with relatively few incumbents.

The third technique I am going to describe is what, at the Metropolitan, we call the direct observation method. This technique involves having a time-study analyst observe the work under study. A record is kept of the number of units produced in a specific period of time. As in the case of the time log, only people who are considered standard performers are chosen for study.

The direct observation method, when properly employed, has the major advantage of being the least costly technique. In addition, it gives the time-study analyst the opportunity to become intimately familiar with the work being studied. This provides a solid basis for establishment of sound, reasonable standards.

The limitations of this method include the fact that a degree of subjectivity is involved in the initial selection of people to achieve a standard time value. Furthermore, extreme care must be exercised to see that all operations are covered. The method is not applicable to long-cycle operations.

As I have indicated, we make extensive use of the direct observation method at the Metropolitan, finding it most useful in situations where the work cycle is short and where the frequency of steps within an operation varies considerably.

A fourth measurement technique available for use in office work is predetermined times, sometimes referred to as standard time data. A wide variety of these is available, but all have the same general characteristics. Generally speaking, they consist of standard unit times covering various small segments of clerical actions. For example, standard times exist for such operations as typing, posting, writing, keypunching, etc. To use them, an analyst determines the various elements of the job under study and applies these predetermined times to build up a time for the total operation. Predetermined times are usually developed from engineered stopwatch time studies or micromotion studies.

The big advantage of predetermined times lies in the fact that they are consistent and take the element of subjectivity out of time study. Thus, two different analysts timing the same job and using the predetermined times should come up with almost precisely the same standard for the operation. This is not true in other techniques where some judgment has to be exercised to select a standard time from an array of data or observations.

We have made considerable use of predetermined times at the Metropolitan. In fact, we developed our own book of time values in 1949. The major limitation we find is that this method is costly for most clerical situations. The reason for this is that most of our operations are not highly repetitive and contain a variable work content. Thus, the problem of determining the frequency at which something happens can be as important to the final standard as the time value itself. Another limitation of the predetermined-time method is that extreme care must be taken to see that all operations in a procedure are accounted for and accurately described.

However, we have found that the predetermined-time method can be combined effectively with other techniques to produce economical results. For example, we use predetermined times to check the validity of standards set by other methods. This is done by preparing predetermined-time standards for several of the larger operations performed in a unit being studied. The results are then compared with the standards set by other methods.

The fifth and final technique I would like to describe briefly is work sampling. This technique is based on statistical theories of sampling. A number of random observations are made of the work under study. On each observation, the analyst records the kind of operation being performed. These observations are later summarized by machine process and a unit time for various kinds of work is established. This is done by relating the percentage of time spent on any one kind of work to the number of units produced during the period of study.

Work sampling has the major advantage that it can be used to cover nonrepetitive situations. It insures that all elements of the work are included, and that actual operating conditions are reflected in the study results. It is also very effective in identifying nonproductive time and eliminating it from the standards established. As compared with other methods, it is somewhat less costly to use.

The limitations of work sampling include an inability to apply it to situations where a wide variety of operations exist and where a time value is desired for each. The sample size required to produce validity under such conditions usually makes the method uneconomical. Sampling is also limited in that the matter of pace is generally built into the results it produces. Some control over this latter defect can be obtained by excluding from the study personnel who are considered less than standard performers.

In the preceding discussion I have tried to present some of the principles involved in selecting office work-measurement methods. By this time you have undoubtedly wondered how these principles work in practice. Do they produce sound results? In answer to this question, I can only give you one company's experience, that of the Metropolitan. We have been using these principles to select appropriate techniques for a number of years. During this period, we have kept accurate records covering various aspects of our work-measurement program. I would like to give you some facts drawn from these records, which I believe indicate that application of these principles does pay off in terms of program economy and results achieved.

1) Two work-measurement programs covering over 18,000 people are being maintained and gradually extended for an expenditure of about 10 analysts' time.

2) On the average, it costs us only $56.00 per person measured to set new work standards.

3) Our program consistently produces first-year economies which are several times the total yearly cost of the program.

4) The program has a wide degree of acceptance by our management and extensive use of it is being made by them.

AUTORATE - COMPUTER AID IN INDUSTRIAL ENGINEERING

Martin T. Mobach
Director, Engineering & Management Services
The Service Bureau Corporation
New York, New York

INTRODUCTION

Autorate

Automatic Rate Setting, a computerized procedure for setting standards directly from a methods analysis.

Despite the tremendous accomplishments of industrial engineering in methods improvement and cost reduction, the potential effectiveness in this area has, up to now, been limited due to time-consuming procedures and techniques.

One of the most time-consuming activities is methods engineering coupled with work measurement. For years, this has been done manually. The amount of effort related to recording, computing, and reproduction of work standards has been sheer "dog"work, tedious and often dangerously error-prone. In several cases, as much as 80 per cent of the I.E.'s work has been spent in the area of "writing-up" and calculating his standards, with the result that the actual methods improvement required to achieve optimum cost levels has often been neglected.

Creeping methods changes have adversely affected even the best administered work-measurement program. The cost of keeping abreast of these changes is so prohibitive that a slow deterioration process begins as a new manual work measurement program is being implemented. The compounded annual effect of creeping methods changes over a period of ten years has amounted to as much as 20-25 per cent looseness in work standards. As a result, very costly revamping programs are needed every 10-15 years.

In this age of vast and rapid technological changes, many companies are spending large sums of money to reflect these changes in existing work standards. Quite frequently, this effort requires the pooling of manpower to satisfy a peak load created in the updating of work standards. Other tasks are neglected during this period. Often a substantial number of errors is introduced because of insufficient familiarity with the operations on the part of analysts who have been assigned to this updating task on a temporary basis.

Engineering changes are another source of continuous frustration to the I. E. Having barely developed a new work standard, one or more engineering or manufacturing changes makes it necessary to practically redo the tedious job of establishing the correct method and standard time. When a new product is introduced, a heavy influx of engineering changes often impedes a quick attainment of full standard coverage of the new operations.

Other factors, such as changing from temporary to permanent tooling, redistribution of elements in work standards to obtain a better balanced work load between the men in the shop, searching for inactive standards to produce spare parts for discontinued products, merely add to an almost insurmountable task of administering a sound work-measurement plan.

Autorate changes all this. It brings the benefits of automation to the engineer's own work through the use of mechanized data processing. It relates the engineered methods to appropriate time values stored in a computer. Through a series of programmed instructions covering the complexity of data manipulations, the computer develops work standards, print-out methods instructions, process changes of various kinds, and update work standards and routings. Only a minimum input effort is required of the engineer. Basically, the engineer concerns himself with developing the proper method--Autorate does the rest.

The benefits of Autorate can be accrued in a broad variety of shop operations (direct labor) --clerical, maintenance, warehousing, and other direct and indirect expense operations. Thus, Autorate can provide management with a powerful and economical tool for cost control; the people being measured can enjoy faster, more reliable and consistent benchmarks for a fair evaluation of their effort; and the industrial engineer can devote more time to develop improved methods.

DATA CONCEPT AND GUIDING PRINCIPLES

Various standard data systems can be used with Autorate. However, many of those in existence lack the characteristics necessary to derive full benefits through computerization. Here are five principles which must be followed for an effective processing of standard data:

1) Combine motions into patterns common to a broad range of work;

2) combine motions into motion patterns of different levels of magnitude (building block levels);

3) provide a predetermined time value for each "building block";

4) develop standardized phrasing for all elements;

5) use a practical coding system whereby motion patterns (building blocks) can be easily identified by the engineer.

Principle No. 1

Combine motions into motion patterns which are common to a broad range of work.

For an effective standard-data usage, the motion patterns must be "stripped" of their "manufacturing" or situational identification. The emphasis is placed on the motion pattern required to perform a segment of work.

Example:

"Get a screwdriver" may require the same motions as "get a pen" or "get a part," etc. By using broader terminology such as "get object," the motion pattern can be applied to more operations as a common denominator. This generalization shifts the emphasis from a specific part to the motions used to perform an operation. The engineer decides on the applicability of these motions from their structure or pattern, rather than by their specific identification.

This principle implies a "horizontal" or general application of the standard data. As a foundation for developing less general application of greater magnitude, the principle provides for consistency in standard data development and its applications.

From the standpoint of the computer, the most time-consuming task is sorting and correlating this data. Without a base of central source of data--horizontal data--the expense of this correlation would increase.

In contrast, if this principle were not applied, the volume (or volumes) of standard data would become cumbersome. In a multiplant company, each special product, in the extreme, would require a specialized set of standard data and each set would require a detailed and time consuming development. Correlating this data would also be a tremendous undertaking. The possibilities of misapplication or misinterpretation would increase. Accompanying the misapplication, the same job methods could be described in different ways and with different time values at different plant locations. Development of new standard data would often be less time consuming than the search for already established and appropriate data. Hence, an ever growing file of data.

Principle No. 2

Combine motions into motion patterns of different levels of magnitude--"building-block" levels.

Standard data is developed to reduce the repetition of searching for and rewriting minute details in rate setting. By cataloging the variables that affect the time for performing an element of work, the time required to set a standard can be reduced.

By developing different levels or sizes of elements, less time is required to analyze an operation. Highly repetitive elements of a multitude of operations can be analyzed more quickly. When larger elements are used the engineer can develop the work standard with much less effort. Yet, the building-block principle enables the engineer to refer back to any required amount of detail, as necessary.

Example:

A plant department may be solely organized to rivet parts together. Limits may have been set on the size of the parts to be connected and on the size of the rivets used. For each class of rivet machine and workplace method, tables or charts--long elements--or formulae can be built. Thereafter, the engineer can evaluate and list these variables on an analysis sheet and "sight check" the method used to assure adherence to the "best method" that was derived from the initial analysis. Accuracy of the standards and reproduceability of the methods are extremely important. In general, the shorter the operational cycle, the more important a detailed analysis becomes.

"Standard conditions" under which an employee can exercise his judgment and skill impose limits on both the size and the characteristics of the work elements (standard data). An experienced electrician may plan the method he uses in performing a task while an assembler at a work-place may exercise little or no control on his work method. Standard-element precision must reflect these differences.

Principle No. 3

Provide a predetermined time value for each building block.

Since the method by which a job is performed controls the time required to perform it, this principle provides for continued consistency in establishing standards.

It virtually eliminates the need for continuous or repetitious stop watch measurement. An over-all time or "cycle check," if desired, is all that is required to assure that all the required motions have been included.

Connecting time values with unique motion patterns means that the information can be "filed" in the computer. Thereafter, the engineer need only specify the motion pattern. Autorate will "call out from the file" the times for the selected elements and proceed to calculate the standard.

Without predetermined time values, each motion analysis would require time-study before a standard could be developed, thereby adding to the expense of standards or rate setting. In addition, the routines connected with calculating standards, done automatically in Autorate, could not be performed.

Principle No. 4

Develop standardized phrasing for all elements.

This principle provides for a standard or universal language to describe motion patterns. This dictionary or methods description provides for a wider and more consistent application of the standard data than was heretofore possible. An engineer in San Francisco can easily interpret the methods instructions developed by an engineer in New York and vice versa.

Example:

"Get," "Obtain," "Secure," can be considered as synonomous terms relating to describing work being done. By agreement, one of these verbs could be used to describe the operation of "moving the hand to an object and to get control of it." Selecting one of these verbs simplifies the methods-language describing the motion. Additionally, the meaning of this verb is understood in both writing and interpreting methods instructions. Standard phrasing, then, becomes the motion-pattern dictionary for the engineer.

From the standpoint of computer application, this principle allows this verbal description (or phrase) to be stored on tape in a manner similar to storing the time value. An element description does not have to be written by the engineer when he observes the motion pattern being performed. He need only identify it by its code name. Standard-data work sheets containing only that portion of data applicable to a given shop area make it unnecessary for the applicator to develop a encyclopedical memory.

Principle No. 5

Use a practical coding system whereby motion patterns (building blocks) can be easily identified by the engineer.

The development of abbreviations further reduces the engineer's time to describe a motion pattern.

Two types of coding are predominantly used today: serial coding and functional coding. In functional coding, each letter or number has some meaning, whereas in serial coding the number serves only to distinguish one item from another.

Convenience in application from the standpoint of the engineer is the basis of Autorate coding. The element abbreviation bears a relationship to the element description so the coding becomes a memory-jogger for the engineer and thereby facilitates the memorization of elemental codes.

The techniques of mnemonics are also utilized in Autorate coding. By grouping the items to be remembered in classes, the engineer need only memorize the mnemonic structure to be able to read and interpret the element codes.

Example:

The level or scope of application of an element is one aspect of the code. (This will be treated in more detail later.) By simply glancing at the coded description for an element, the engineer is immediately aware of its extent of application.

From the standpoint of the computer either an alphabetic or numeric code can be handled more easily than a complete phrase because the processing time for sorting and matching is considerably reduced.

The actual design of the code (within limits) is of secondary importance, but, for the computerization, total requirements of the code must be firmly established and adhered to.

Example:

The Autorate code field is designed to accommodate eight items. Initially, these may be either numbers, letters or combinations of both. Once a design is chosen it cannot be altered without a major change.

THE PRINCIPLES OF CODING

To code elements for use in an Autorate system, a novel innovation of engineering shorthand is introduced. This "shorthand" is accomplished through the media of alpha-mnemonic codes. The alpha-mnemonic code is a memory-jogger device whereby a given specific work element keys off a symbolic code for quick reference. This is accomplished by symbolic association of the first letter of key words which describe the given work element. Its purpose is to simplify the use of all data by the industrial engineer and at the same time maintain consistency in data application.

The criterion for the alpha-mnemonic code "Engineering Shorthand" is quite simple in itself --it must:

1) Be concise;

2) describe an element of work or group of elements;

3) depict any variables affecting the element or elements described;

4) be easily memorized or logically understood.

Such a code will then serve as a convenient form of "shorthand" which is invaluable for economic recording of elemental patterns as they relate to specific methods. In turn, the code becomes the media for filing and recording of the standard data element; e.g., BTST means Basic Tool use Screwdriver, Tighten or loosen. A typical code structure is illustrated in figure 1.

	N	N	L	L	L	L	N	N	N - Number
Position No.	1	2	3	4	5	6	7	8	L - Letters

Position		
1 & 2	Numeric	Control, Source of Data, or Use or Application.
3	Alpha	Level of Data.
4	Alpha	Action Verb.
5	Alpha	Noun, General.
6	Alpha	Adverb, Adjective, etc.
7 & 8	Numeric	Classification of Variables, Sequential or Representative.

Figure 1 Code Structure

SYSTEMS CONCEPT

Autorate consists of a series of complex computer programs incorporating two master files --the Code File and the Rate (Standard) File--in which information for future processing is stored. The methods analyst submits the appropriately coded input data to the system. This input data is carefully checked and processed by Autorate, which makes extensive use of the data stored in the two master files. In a matter of minutes, Autorate gives a printed output document that would take hours or days by conventional means, dependent upon the total cycle time of the operation.

Flow of Information (figure 2)

To implement Autorate the engineer must first generate the code file. He prepares the input document (exhibit 1--see the end of this paper for all exhibits) containing coded standard data representing elementary manual motion patterns. In addition to the codes themselves, it contains a descriptive phrase and an associated time value for each code. In the event that a particular code is made up of other more basic code elements contained in the file, the synthesis information would also be stored. The information on the input document is subsequently key punched, verified and processed into the computer which, in turn, prints out the Standard Data Output Documents (exhibit 2). Together these documents make up the Standard Data Manual.

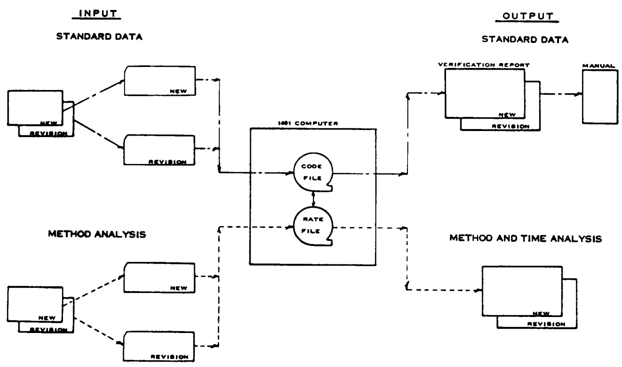


Figure 2 Autorate Flow of Information

To generate standards the engineer prepares a methods-analysis input document (exhibit 3) denoting the elements of an operation in required sequence and frequency of occurrence and other data of significance. This information is then key punched and verified, and fed into the computer. Using the code file, the Autorate programs will select the appropriate standard data, calculate times, and produce a Method and Time Analysis document as output (exhibit 4). The time standards, in turn, will be stored in the second Master File, the Rate File.

The data system could, for example, consist of a base of fundamental data. Higher levels of data are, in turn, derived from lower complexity levels (figure 3). Such a well designed pyramid of coded data will enable the methods analyst to describe the most complex operations with a minimum of descriptive information.

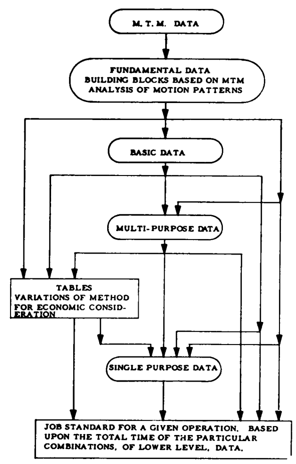


Figure 3 Flow Diagram

To update either standard data and/or work standards, the engineer merely processes the required changes, additions, deletions, and modifications. Autorate will then apply these changes to the applicable stored information, recompose and recompute the standard data and/or work standards as the end result. If standard data are changed, all affected information will automatically be updated through specific Autorate instruction programs (exhibits 5 and 6). To do this manually would be prohibitive in cost and, therefore, constitutes the main reason for the slow but sure deterioration of otherwise well administered work-measurement programs.

An essential and integral part of the Autorate system is its Input Editor Program with the primary function to insure that any input errors to the system are immediately detected. The Editor Program reviews all the input data prior to processing and either revises or rejects the data containing errors or inconsistencies. A comprehensive error report is then automatically generated for the analyst so that corrective action can be taken.

Since all pertinent information has been stored in the computer files specific information can be easily retrieved to make up meaningful control reports for management. A prime example is the engineering activity report analyzing the effectiveness of industrial engineering hours spent to develop and update standards--the company activity responsible for such changes--the net effect on the standard hours in the shop (exhibit 7).

For the setting and maintaining of production work standards and other rates, Autorate contains the following component parts:

1) A series of more than 48 programs for maintaining the standard time data file, the rate file, error controls, and control reports;

2) a time-measuring system to provide a time value for each standard data element;

3) a unique coding system facilitating both application and computer handling (Integrated Standard Data).

To make such a feat possible, the industrial engineer, the computer, and the Autorate system must, in effect, speak the same language. Coding is the connecting link or common language. Effective coding allows the engineer to "talk to the computer," and vice versa.

MECHANIZATION BENEFITS

Autorate combines the following two technical developments which logically should be tied together:

1) The computer, originally developed as a scientific tool, which has proved to be highly versatile, expedient and very effective in a broad range of manufacturing functions; and

2) Horizontal Standard Data, designed with ultimate mechanization in mind, has not only proved its value but surpassed the initial expectations for manual use in many work-measurement programs.

When these two concepts have been combined much of the routine work in rate setting has been eliminated and complete information will be available for future recall. To set a rate or standard the engineer need only study the job, develop the method, then assign coded data elements and frequencies in their order of occurrence. Autorate will do the rest--prepare a Method Analysis, with instruction statements in sequence, and a Time Analysis with the calculated standard times.

How is this easier for the engineer? What effort is eliminated? Both are logical questions which deserve an answer. First, the amount of descriptive writing is minimized because there are phrases stored in the computer for each element of standard data. Second, the extension of element times and frequency of occurrence is done by Autorate. Third, machine cycle times are calculated by Autorate based on established formulae with the variables and constants to be identified by the engineer. Fourth, the elemental time values are summarized by Autorate. Fifth, the total "raw standard" is extended by a specified allowance. Sixth, the total standard time is then computed by Autorate. Seventh, a detailed Method Analysis and Time Analysis are pointed out completely by the system.

Other clerical and typing work has also been eliminated. Where previously a typed methods instruction sheet has been given to the production departments, now a detailed computer output document is provided.

Once implemented, Autorate can become the basis for an Integrated Management Control System. This may become even more significant than the work measurement aspects of Autorate. The long-range payoff presents tremendous potential when we consider the strides made by American industry in recent years and recognize the comprehensive planning for the future. Manufacturing management is better and more quickly informed than at any other time in our history and the future is even brighter with further improvements and additions to Integrated Management Control Systems.

Some of the possible extensions to an Autorate system are:

- performance and efficiency reports
- incentive wage-payment system
- operational routing or process sheets
- tool and raw-material requisitions

- trip tickets and labor-claim cards
- process and inventory controls
- shop-scheduling reports
- product-production forecasts
- manning and machine-load reports
- product-pricing evaluations
- budgetary controls
- cost estimating
- manufacturing simulations

It is not intended here to imply that Autorate will do all these things now. Rather we are pointing out that the basic source information can be withdrawn from the systems files. When other programs are designed, the data stored in Autorate could be used to satisfy the new systems specifications and requirements. Some companies have already elected to have SBC design programs to their particular specification. Your company may choose to do this also or may elect to do work with your own systems people. The important consideration is that Autorate can be extended in the future.

There are certain benefits or advantages to be considered as a result of Autorate itself. The list that follows is not complete by any means. However, we feel that the most important benefits are:

1) Increased work-measurement "coverage" without need to increase the industrial engineering staff--also allowing for coverage of operations which previously could not be measured economically. Greater coverage usually means an increase in labor performance and productivity.

2) Reduced time to develop and update work standards (i.e., rates).

3) Effective means to keep abreast of creeping methods changes and/or heavy engineering change activities affecting methods used.

4) Consistency in company-wide standards. It enables universal application between unrelated areas.

5) Introduction of a universal engineering language.

6) Fewer errors.

7) Rapid product-transfer between departments and divisions.

8) Expediting of coverage on new products which bear some degree of similarity to existing products.

9) Establishment of uniform methods and "best-method" concepts throughout the divisions and departments of a company.

10) Effective control system through which management can evaluate the history of cost-improvement efforts and, hence, develop more effective future plans.

11) Analyses of how the industrial engineer is spending his time and effort both qualitatively and quantitatively.

12) Legible operational instructions at any required level of detail, thus eliminating the guesswork and substantially reducing "learning time."

13) Computation of machine feeds and speeds.

C

CODE C-N SDSRL01

STANDARD DATA INPUT
(CODE FILE DATA)

AUTORATE

PAGE 1 OF 1

T M U	DEPT. ANAL	AUDIT	MO DAY YR	CARD COUNT	NEW CODE
A	ISD	TGF	12 31 62	12	

ELEMENT TITLE

B RAISE AND LOWER SPINDLE
C ONE OR FIRST SPINDLE

ELEMENT SCOPE

D	STARTS	GET SPINDLE LEVER
E	INCLUDES	ALL MOTIONS NECESSARY TO GET LEVER, LOWER TO WORK,
F		AND RETURN LEVER TO REST POSITION
G	ENDS	SPINDLE RAISED AT REST POSITION
H	LIMIT	
I		
J	NOTE	NO PROCESS TIME INCLUDED

ELEMENT SYNTHESIS

	SEQ	SYNTH CODE	FREQUENCY	COMMENTS
1	1.0	FGEO 24	1.0	GET LEVER
2	2.0	FPOL 18	1.0	LOWER SPINDLE TO WORK
3	3.0		.	USE -- MACHINE CYCLE TIME
4	4.0	FPOA 18	1.0	RETURN SPINDLE TO REST POSITION
5			.	
6			.	
7			.	
8			.	
9			.	
10			.	
11			.	
12			.	
13			.	
14			.	
15			.	
16			.	
17			.	
18			.	
19			.	
20			.	

C-1 10/17/62

Exhibit 1.

VERIFICATION REPORT

NEW CODE ELEMENT

DATE 01-27-63
PAGE 01

CODE SDSRL01 — RAISE AND LOWER SPINDLE
ONE OR FIRST SPINDLE

SERVICE BUREAU
DATE 12-31-62

DEPT.
ANALYST ISD
APPROVAL TGF

SCOPE OF APPLICATION

STARTS GET SPINDLE LEVER
INCLUDES ALL MOTIONS NECESSARY TO GET LEVER, LOWER TO WORK,
AND RETURN LEVER TO REST POSITION
ENDS SPINDLE RAISED AT REST POSITION
NOTE NO PROCESS TIME INCLUDED

SYNTHESIS

SEQ.	CODE	TMU	FREQ.	TOTAL	DESCRIPTION
1.0	FGEO 24	26	1.00	26	GET OBJECT GET LEVER
2.0	FPOL 18	26	1.00	26	PLACE OBJECT LOWER SPINDLE TO WORK
3.0			.		USE -- MACHINE CYCLE TIME
4.0	FPOA 24	21	1.00	21	PLACE OBJECT RETURN SPINDLE TO REST POSITION
				73	

END

Exhibit 2.

M

AUTORATE

METHOD AND TIME ANALYSIS INPUT DATA

PAGE 1 OF 1

T	PART NO.	OPER.	SUB	O REV.
MN	987654	15		P

REV. ALL. CAT.	S	U	E.C. NO.	DEPT.	ENGR.	APP.	D	R	DATE	CARD COUNT	OLD OPERATION IDENTIFICATION PART NO.	OPER.	SUB	O REV.	PL
A	15	H	69696	333	9	13			05 17 62	16					

	E	MACH. GROUP	ALT. MACH GROUP 1	ALT. MACH GROUP 2	ALT. MACH GROUP 3	N	SERIAL NO.	DEV. TIME
B	R	1974	1972					

OPERATION DESCRIPTION

C MILL .250 DIM. TO PRINT
D
E

REMARKS

F	INSP. CHARACTERISTICS	CK	FREQ	PL	INSP. GAGE
G	CK 13/16 DIM	1	1/10	WH	SCALE
H	CK .250 DIM	2	1/10	WH	MICS.
Z					

SEQ.	R	CODE	FREQUENCY	M	P	S	C	DESCRIPTION	
10		MGLC 01	1.0					(F/TL NO. 24242A)	1
20		MFCS	1.0						2
30		MFNW 05	1.0						3
40		MALM 01	1.0			S		START MACHINE	4
50		MGUC 01	1.0						5
60		MCAS 01	1.0					OF FIXTURE	6
70		11MIGS01	0.1	C				13/16	7
80		11MIGM01	0.2					.250	8
90		FORM0001	1974					A/1.450, B/.250, C/1.350, D/135, E/5	9
90		FORM0001					1	F/.008, G/26, H/8, I/.17	10
									11
									12
									13
									14

M-1

Exhibit 3.

SERVICE BUREAU

DATE 05-17-62
PAGE 1

TEMPORARY

METHOD ANALYSIS

PART NO. 987654 MILL .250 DIM. TO PRINT
OPER NO. 15- -P
DEPT. NO. 333
MACH. GRP. 1974 ALT MACH GRP 1972

E.C. NO. 69696
ANALYST 9
APPROVAL 13
SHOP DATE
REV. NO.

MACHINE SETTINGS AND DATA

9.0	CUTTER DIAMETER	-	5
	NO. TEETH IN CUTTER	-	26
	TRAVEL	-	3.050
	AVAIL. R.P.M.	-	95
	AVAIL. FEED IN/MIN.	-	7.0

FIXTURES

TL. NO. 24242A

REMARKS

INSP. CHARACTERISTICS	CK	FEED	PL	INSP. GAGE
CK 13/16 DIM.	1	1/10	WH	SCALE
CK. .250 DIM.	2	1/10	WH	MICS

SEQUENCE OF OPERATIONS

SEQ.	DESCRIPTION	CLAIM
1.0	PLACE PART IN JIG T/TL. NO. 24242A	
2.0	FASTEN AND UNFASTEN SWING TYPE CLAMP	
3.0	FASTEN NUT WITH OPEN END OR BOX WRENCH	
4.0	START MACHINE	
5.0	UNLOAD JIG	
6.0	BLOW OFF SURFACE	
7.0	CHECK DIM. WITH SCALE 13/16 DIM.	

SERVICE BUREAU

DATE 05-17-62
PAGE 1

TEMPORARY

TIME ANALYSIS

PART NO. 987654
OPER NO. 15- -P
DEPT. NO. 333
MACH. GRP. 1974

E.C. NO. 69696
ANALYST 9
APPROVAL 13
SHOP DATE

SEQUENCE OF OPERATIONS

SEQ.	CODE	TMU	FREQ.	HRS/100	CUM.TOTAL
1.0	MGLC 01	64	1.0000	.0640	.0640
2.0	MFCS	30	1.0000	.0300	.0940
3.0	MFNW 05	210	1.0000	.2100	.3040
4.0	MALM 01	26	1.0000	.0260	.3300
5.0	MGUC 01	42	1.0000	.0420	.3720
6.0	MCAS 01	71	1.0000	.0710	.4430
7.0	11MIGS01	187	.1000	.0187	.4430

Exhibit 4.

```
SERVICE BUREAU                                              DATE 05-17-62
                                                            PAGE        2

CONTINUED                  TEMPORARY
                           ---------
                        METHOD ANALYSIS
                        ------ --------

PART NO.     987654  MILL .250 DIM. TO PRINT               E.C. NO.   69696
OPER NO.    15-  -P                                        ANALYST        9
DEPT. NO.       333                                        APPROVAL      13
MACH. GRP.    1974   ALT MACH GRP  1972                    SHOP DATE

                    SEQUENCE OF OPERATIONS
                    -------- -- ----------

  SEQ.                       DESCRIPTION                          CLAIM
  -----    ---------------------------------------------------    -----
   8.0     CHECK DIM. WITH MICROMETER
           .250 DIM.

   9.0     A/APP, B/CLR, C/LOC, D/SFM, E/CD,
           F/CLT, G/NT, H/ADV, I/TF
                A/1.450, B/.250, C/1.350, D/135, E/5,
                F/.003, G/26, H/8, I/.17

END
```

```
SERVICE BUREAU                                 DATE 05-17-62
                                               PAGE        2

CONTINUED              TEMPORARY
                       ---------
                     TIME ANALYSIS
                     ---- --------

PART NO.     987654                            E.C. NO.   69696
OPER NO.    15-  -P                            ANALYST        9
DEPT. NO.       333                            APPROVAL      13
MACH. GRP.    1974                             SHOP DATE

                 SEQUENCE OF OPERATIONS
                 -------- -- ----------

 SEQ.   CODE       TMU     FREQ.    HRS/100   CUM.TOTAL
 ----- -------- ------ --------- ---------  ---------
  8.0 11MIGM01    173     .1000     .0173      .4430

  9.0 FORM0001    MACHINE TIME     1.7848     2.2278
                TOOL ALLOWANCE      .1235     2.3513

                  PFD -  15 (       .3527     2.7040

                  ***** STD TIME-HRS/100      2.704

END
```

Exhibit 4.

```
                                 CODE IMPACT REPORT                     DATE 06-30-63
                                 ---- ------ ------                     PAGE       01
                                REVISED CODE ELEMENT
                                ------- ---- -------

CODE 12ETGW26          WRAP 26 YELLOW WIRES W/AIR GUN AND POSITION WIRES
                                                                         DEPT.     321
SERVICE BUREAU                                                           ANALYST   231
DATE 05-09-63                                                            APPROVAL  148

                                 SCOPE OF APPLICATION
                                 ----- -- -----------
                STARTS    WITH GET WIRE
                INCLUDES  THE PLACING AND ROUTING OF WIRE, THE OBTAINING OF GUN AND
                          WRAPPING OF WIRE
                ENDS      AT THE COMPLETION OF 26 WRAPS
                LIMIT     L-SHAPE WIRE, DOES NOT INCLUDE READING OF WIRE INSPECTION
                          LIST OR LOCATION OF PINS

NEW TMU        11156
OLD TMU         9413
PCT. CHANGE     18.5

                                      SYNTHESIS
                                      ---------
 SEQ.      CODE        TMU     FREQ.     TOTAL                   DESCRIPTION
 -----   --------    -----    -------    -----   ---------------------------------------------------
   1.0   MTGW 01       362       1.00      362   TOOL GUN WIRE WRAP-CONGESTED Y WIRE
                                                     WRAP 1 Y-WIRE
   2.0   MTGW 06       266      25.00     6650   TOOL GUN WIRE WRAP-2 LEAD CAP.
                                                     WRAP 25 2 LEAD CAP.
   3.0   12ERYW06       84      19.00     1596   ROUTE YELLOW WIRE, L-SHAPE 4-6 IN.
*  4.0   12ERYW07      364       7.00     2548   ROUTE YELLOW WIRE, L-SHAPE 6-14 IN.
                                         -----
                                         11156

END
```

Exhibit 5.

SERVICE BUREAU

DATE 09-30-62
PAGE 01

SUMMARY

ENGINEERING ACTIVITY ANALYSIS

FROM 09-01-62
THROUGH 09-30-62

CATEGORY	DESCRIPTION	QUANTITY	DEV. TIME-HR	TIME CHANGED-HR/100	
01	NEW ESTIMATE	253	723.2	12523.9	
02	MANUFACTURING CHANGE	179	420.7	236.8	
03	ENGINEERING CHANGE	67	160.3		29.9-
04	METHODS CHANGE BY LINE MANAGERS AND/OR LINE PERSONNEL	87	156.2		344.7-
05	CALCULATION ERROR	71	52.0	38.1	
06	METHODS CHANGE BY MANUFACTURING ENGINEERING FUNCTION	32	77.3		66.6-
07	QUALITY CONTROL CHANGE	19	48.4	1.9	
08	CHANGE IN STANDARD DATA	3	1.7	7.3	
09	DEPARTMENT CHANGE AND/OR MACHINE GROUP CHANGE	3	3.8	3.5	
		714	1643.6	12811.5	441.2-

END

Exhibit 7.

SERVICE BUREAU

DATE 02-28-63
PAGE 01

RATES AFFECTED
BY
CORRECTIONS TO CODE MASTER FILE
01-16-63

PART NO.	OPER. NO.	DATE SUB.	STANDARD TIME-HR/100 OLD	NEW	PCT. CHANGE
02124501	0012-00-P	11-05-61	35.637	34.176	4.0-
02124501	0015-02-P	11-05-61	48.101	48.181	0.2
02124501	0036-00-P	10-27-61	27.254	27.900	2.4
02124501	0041-00-P	10-18-61	103.468	107.505	3.9
02124501	0050-01-P	11-07-61	290.123	288.421	0.6-
02124537	0039-01-P	09-17-61	90.721	93.702	3.3
02124537	0040-00-P	01-30-62	25.088	24.091	4.0-
02124537	0045-00-T	08-05-62	8.069	8.400	4.1
02124628	0024-02-P	04-30-62	7.207	7.009	2.8-
02124628	0035-00-P	05-12-62	19.124	18.919	1.0-
02124628	0043-21-P	05-12-62	68.706	69.200	0.7
02124635	0012-00-P	05-31-62	43.521	45.530	4.6
02124635	0020-00-P	05-31-62	35.398	37.403	5.7 *****
02124635	0030-01-P	12-21-61	31.027	32.020	3.2
02124635	0033-00-P	04-21-62	22.212	21.618	2.7-
02124703	0049-01-P	06-26-62	37.989	36.860	3.0-
02125735	0070-01-P	06-28-62	52.666	51.928	1.4-

END

Exhibit 6.

INDIRECT LABOR-COST CONTROL THROUGH WORK MEASUREMENT

Robert F. Durkee
Supervisor, AIM Engineering
Autonetics
Anaheim, California

INTRODUCTION

Autonetics, North American Aviation's electronics and electromechanical division, is very much aware of the need to stay competitive. The division employs approximately 25,000 men and women. Annual payroll is nearly $200 million. Sales for the Anaheim, California, division were $601 million in 1963. While occupying 3.5 million square feet of floor space, Autonetics further occupies a position among the nation's top 10 electronics manufacturers. Today's presentation on indirect labor-cost control through work measurement will describe the approach taken at Autonetics in a major move to stay on top.

Much has been written in recent years about increases in administrative costs attendant upon changes in products and customer demands. With more and more of today's government contracts being placed on a fixed-price or incentive basis, labor controls in the aerospace industry have become essential. A company must be able to demonstrate that it can do an effective job of controlling costs, as well as meet the customer's technical capability requirements.

We all recognize that the white collar workers are increasing in number at a faster rate than the remainder of the labor force. Since the clerical and technical fields are highly representative of this industry, measurement of the factors that affect the cost of these support functions becomes the most important element of cost control. In this environment, the inevitable question an alert management will ask is: "How can we control these indirect labor costs and stay competitive?"

Frederick W. Taylor, the father of scientific management, stated, "You can only control that which you can measure." This concept was stressed in proposing a detailed work-measurement program to Autonetics' management. As you can well imagine, selling a cost-conscious management on such a program, to cover over 10,000 burden or indirect personnel, presented a challenge. Thanks to sound preparation on the part of the engineers doing the selling, and to the existence of an enlightened executive committee, the proposal was accepted.

With the full support of Autonetics' management, the decision was made to use individual quantitative performance measurement rather than the more usual "activity indicator" or "broad brush" systems. This we felt would give us maximum economic control of indirect labor costs. Such an approach is in keeping with the time-honored axiom that "the amount of control you get depends on the quality of the measurement."

It was fully recognized from the start that specialized consulting services would be desirable in order to (1) insure a uniform engineering approach in establishing work-measurement controls on such a broad scale, and (2) to minimize the need for the internal development of universal standard data. Upon investigating the technical capabilities of various management consulting firms, the firm of Bruce Payne & Associates was selected to provide this service.

The consultant not only provided a nucleus of methods-time measurement based on Standard Data Manuals that contained basic time data covering universal elements of work; but in addition was responsible for the training and certification of each engineer in the fundamentals and application of MTM. Thus, as the program became firmly established, the consulting services were phased out.

OBJECTIVES

In line with the alphabetical game being played today, the program was titled AIM, meaning, Analyze, Improve, and Measure for control. The AIM Program was established by Autonetics' management in December, 1961, as an integral part of the total Cost Improvement Program with the objective of reducing and controlling the labor costs of support functions. The over-all program has been designed to enable functional management to utilize manpower more effectively and to provide for the installation of improved and standardized methods.

This is accomplished through: Analysis of the activities performed within departmental organizations; Improvement and standardization of methods required for task accomplishment; Measurement of each assigned activity to establish standard times per labor-task element; and implementation of a reporting system to provide functional supervision, prompt visibility of employee performance, manpower utilization, and resulting labor cost trends.

ORGANIZATION

AIM Program coordination, guidance, and assessment of effort is vested in an AIM Program Manager, reporting to the Director of Cost Improvement. The AIM organization provides additional engineering capability for all of Autonetics. Within Autonetics there are four AIM Engineering groups representing the various divisions. An AIM Steering Committee, consisting of the supervisors of each of the AIM Engineering groups, and a Chairman (the AIM Manager) constitute the governing and policy-making body for the program. To insure consistency of work-measurement application throughout Autonetics, the AIM Steering Committee is responsible for:

1) implementing policy established by the Executive Office,

2) developing policies, procedures, measurement techniques, and reporting systems necessary to establish a uniform work-measurement standards program,

3) issuing Autonetics' Standard Data Manuals and the AIM Standard Practice Manual,

4) coordinating methods-improvement recommendations resulting from labor-task analysis to assure maximum benefits throughout Autonetics,

5) planning program schedules to avoid duplication of effort and to provide maximum standards coverage,

6) planning and scheduling training courses for supervision of affected departments, and certification courses for AIM engineers, and

7) coordinating labor-cost-reduction reporting with cost-improvement administrators.

THE HUMAN FACTOR

Those of us associated with the AIM Program have continually stressed the fact that, beyond the technical aspects of the program, the human factor must be given primary consideration. Successful installation of labor controls is always attended by clear understanding and effective motivation on the part of company personnel. Further, we recognize the differences in motivation and method of approach required of organizations engaged in government contracting as opposed to those in commercial enterprises.

During the formation of our program we heard it stated that, because certain personnel are oriented to the sciences, their concepts are nonbusiness or antibusiness and that profit motives and the ability to meet competition are outside of their interests. Our experience in the last two years has been a denial of this cliché.

The scientific organization is accustomed to dealing with facts and logic. Where we have demonstrated an understanding of their way of thinking, we have shown that we can speak a common language. After establishing this kind of rapport, the facts and logic supporting such a program as AIM, have elicited the positive leadership such a program requires.

HOW IS AIM APPLIED?

1) Indoctrination meetings

Prior to the installation of the program in any department, all managers, supervisors, and lead personnel of the department being measured are briefed in the steps for implementing the AIM Program in their respective departments. At this time, the responsibilities in the program are clearly defined. Employees to be measured are also briefed, preferably by their immediate supervisors, with AIM Engineering members assisting. The importance of this communication cannot be overstressed. Success in the introduction of work measurement into new areas is largely dependent upon obtaining the understanding of everyone concerned of the objectives, approaches, and techniques to be used.

2) Organizational and functional analysis

The AIM Engineer's next effort after briefing is to review departmental procedures and operating instructions. Group-level organization charts are also prepared. Full participation on the part of supervision and lead personnel in providing rosters, charts, "little black books," present control methods, etc., is vital. The "roles and missions" of the section to be measured must be defined at the outset. The engineer has a prime responsibility to define the productive tasks required to perform those "roles and missions" and to isolate those activities that do not add value to the end product.

3) Work-distribution analysis

In an attempt to use engineering time more effectively, an analysis is made of the significance of the employee's assigned tasks. Use of information gained through discussions, on-the-job observations, duty questionaires, work-distribution logs, historical records, etc., assists in this analysis. Thus, engineering time will be expended to develop standards for only those duties considered primary to the department's function.

4) <u>Flow process and operation summaries</u>

Those tasks deemed primary and economically measurable, within the department being analyzed, are observed by the engineer. Elements required in the performance of the task are documented on an "Operation Summary" sheet, later used for standards development.

5) <u>Methods improvements</u>

Using the documented information contained on the "Operation Summary," the AIM Engineer notes opportunities for methods improvement and, where practical, these improvements are made at once. These can occur in: layout, both departmental and work-station; elimination and combination of operations; standardization of work methods; or procedural and organizational changes as applicable. Methods changes, other than those in standardization, are generally limited to those that can be immediately approved and implemented by line supervision. Recommendations concerning major changes, and involving detailed investigation, are referred to appropriate industrial engineering groups. Primary emphasis is placed on coverage of burden-personnel with standards and AIM controls.

6) <u>Standards Development</u>

With methods documentation complete, the engineer begins standards development. He uses not only his past work-measurement experience, but also the knowledge and techniques obtained during his attendance at a four-week MTM and standard-data-training course given by the consultants. Full certification is mandatory prior to assignment to the program.

With the MTM Association's certification, it would naturally be expected that the standards developed by the AIM Engineer would be MTM oriented. While this is the case, considerable latitude is given the engineer in the employment of other methods of measurement such as clerical standard and multipurpose data, statistical evaluation, time study, etc. (within the limits prescribed by the AIM Steering Committee). It must be remembered, however, that every standard used in the AIM Program is fully documented as to derivation. Experience indicates this to be one of the greatest selling points of the program. Resistance of the skeptical manager is more quickly reduced when he sees that the standards used are engineered and supported with adequate back-up data.

Upon completion of standards development for the entire department, the AIM Engineer is responsible for the preparation of a manual showing the development of all standards, methods utilized, etc. Distribution of the manual includes the other three AIM groups, as well as the AIM Manager. In this manner, all AIM groups are provided data which may be useful in areas under their jurisdiction, and the AIM Manager's staff is also provided with material for the development of multipurpose data.

We have found that approximately 70 per cent of the information contained is readily usable in like operations in other divisions, and this secondary effort reduces the total number of AIM Engineering man-months required. This practice further assists in standardization of methods and cross-polination of work-simplification ideas. In utilizing data developed by other groups, consultants, etc., extreme care is taken to assure that it is applicable. Methods and conditions must be compatible.

7) <u>Reporting</u>

The reporting system used for functional supervision, such as prompt visibility of employee performance, manpower utilization, and resulting labor-cost trends, includes the following: (1) an Employee Activity Log, which requires listing of units of production, nonproductive activities, and distribution of hours; and (2) a Group Activity Report and Cost and Performance Analysis, which include individual and group time distribution and performance, supervisory labor-utilization rating, standards coverage ratio, and labor-cost evaluation (cost of doing business). Details of these reports will be given later in this paper.

8) <u>Maintenance of standards and audit</u>

Standards, once established and authorized, must not be allowed to become obsolete, although changing methods and conditions will require modification of the standards. The AIM Program specifically provides this needed flexibility. We consider AIM as an Autonetics' asset, such as a building which will depreciate rapidly in value unless required maintenance is performed. To expect supervision to use the AIM visibility for reduction of costs, performance-reporting must reflect a true evaluation.

To maintain integrity of the total AIM system, two audit procedures, using check lists, have been formulated. The first, the AIM Internal Audit, represents an evaluation of engineering compliance with technical requirements of standards development. It is initiated prior to standards installation.

Specifically, the Internal Audit is designed (1) to insure the selection of groups whose size, and preponderance of measurable activities, warrant AIM Engineering effort; (2) to stimulate the exchange of data and know-how between AIM Engineers in order to broaden application proficiency; (3) to provide line supervision with documented back-up assuring them that the standards they are to work under have been validly conceived; (4) to create a body of standard data applicable across all Autonetics' divisions; (5) to verify compliance with the AIM Standard Practice Manual; (6) to generate common usage and interpretation of standard data for improved consistency and continuity of application; and (7) to evaluate the accuracy and integrity of reported claims.

The second procedure, the Maintenance Audit, represents an evaluation of engineering effectiveness. It is initiated periodically and is specifically designed (1) to determine the causes for poor or continually fluctuating performances; (2) to substantiate the existence of a reproducible method; (3) to evaluate the effects of creeping method changes; (4) to determine the extent and effect of changing work load, product-mix, and frequencies; (5) to verify the continuing compliance with the AIM Standard Practice Manual; (6) to assure disclosure of all pertinent information to line supervision; and (7) to insure AIM participation in the development and follow-through of budget determination and goal setting.

PROGRAM KEY

Success in a program such as AIM is based primarily on having top management support, and the active participation of line supervision. The measurements, standards, activity levels, hour-distribution visibility, etc., are vital elements of a program culminating in control of indirect labor through budgets. They are, of themselves, of limited value if they are not employed by first-line supervision to effectively control costs. Controls in themselves do not save money; it is the corrective action taken as a result of this visibility that saves costs.

APPLICATIONS OF AIM

Figure 1 illustrates ten functions and sample organizational groups now using AIM. An inspection of these areas under measurement reveals activities ranging from janitorial functions to contracts administration.

TEN FUNCTIONS & EXAMPLE ORGANIZATIONAL GROUPS NOW UTILIZING AIM

1-Administration	2-Engineering	3-Financial
Blueprint Control	Config/Accounting Verification	Accounts Payable
Correspondence Services	Engineering Checking Unit	Key punch
Engineering Document Release	Engineering Order Release	Payroll
Reproduction Services		Property Accounting
		Timekeeping

4-Logistics	5-Manufacturing	6-Material
Engineering - Change Documentation	Planning - Mech Cont Kardex	Purchasing - Equipment & Hardware Procurement
Engineering - Configuration Records	Planning - Order Control	Purchasing - Material Control
Supply Support - Data & Services	Planning - Project groups	Purchasing - Purchase Order Processing
Supply Support - Documentation	Project Administration - Prod Control Serv	Traffic - Chauffeurs
Supply Support - Project Administration	Project Administration - Project group	Traffic - Dock activity
Supply Support - Support Equipment	Shipping - Box Shop	Traffic - External trucking
Supply Support - Support Services	Shipping - M&R group	Traffic - Office
Supply Support - Tech Data & Catalog	Shipping - Office	Warehousing - Receiving dock
	Shipping - Packaging	Warehousing - Receiving office
		Warehousing - Stockroom

7-Marketing	8-Personnel	10-QRS & Quality Control
(Contracts & Pricing)	Personnel Records	Environmental Laboratory
C & P - Contracts & Proposals	**9-Plant Engineering**	IID - Data Control
C & P - Data Submittal	Maintenance - Janitorial	IID - Item Identification
C & P - General Pricing	Maintenance - Moving & Rearranging	Procurement QC - Receiving Inspection
C & P - Services	Plant Property	Purchase Material Test
C & P - Spares Pricing		

Figure 1

Similarly, figure 2 presents the wide range of occupations presently covered by AIM controls within the salary, hourly, and weekly payroll.

EXAMPLES OF OCCUPATIONS COVERED BY AIM

Salary & ATP Payrolls
Associate Technical Publications
Buyer
Contract Administrator
Contract Analyst
Estimator
Item Description Coordinator
Publication Analyst
Supply Analyst
Supply Coordinator

Hourly Payroll
Expeditor
Carton Packer
Chauffeurs
Janitor
Material Stock Clerk
Packaging Machine Operator
Receiving Dockman
Truck Driver
Wrapper Preserver

Weekly Payroll
Accountant
Accounting Clerk
Blueprint Trimmer
Blueprinter
Clerk (Typist;File,Gen)
Coder Field Data
Key Punch Operator
Mail Room Clerk
Machine Operator (All types)
Material Clerk
Material Expediter
Material Investigator
Messenger
Parts Lister
Production Control Clerk
Programatic Typist
Spares Analyst
Statistician
Stenographer
Stenographer-Secretary
Technical Writer
Timekeeper

Figure 2

CONTROL REPORTS

1) Employee Activity Log (figure 3 front; figure 4 back)
   Individual employees report their daily activities to their supervisor by means of weekly activity logs or claiming documents. This report gives the supervisor a regular indication of the individual's daily production of units and use of time in other than productive activity. This report also provides the input for the Weekly Activity Report.

2) Weekly Activity Report (figure 5)

   The Weekly Activity Report is, in effect, a group manpower utilization summary and a summation of units produced times the standard. The supervisor uses this report to determine employee output with a view toward necessary corrective action. The report also serves to relate the distribution of gross hours for each employee. This includes the time expended in activities that are nonproductive. Time lost through improper scheduling, delays, poor methods, and low performances are readily brought into focus.

In essence, the supervisor is provided with timely and concise indices. As a result, he is in a position to objectively establish staffing requirements, realistic schedules, and improved performance, and he has a firm foundation for the concept of a fair day's work.

The following definitions have been formulated for the Activity Reports:

Gross hours: Total actual hours worked by the employee in the assigned department.

EMPLOYEE ACTIVITY REPORT

DIVISION: XXXX — DEPARTMENT: XXXXX — EMPLOYEE NAME A. SMITH

GROUP: XXX TECHNICAL WRITERS — APPROVED BY ______ — WEEK ENDING 2-9-63 PAGE 1 OF 1

AREA	DESCRIPTION	UNIT OF MEASURE	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	CODE	TOTAL UNITS	EARNED HOURS
RESEARCH FOR CHANGE	DISCUSS ECP WITH COORDINATOR	ECP	1					001	1	.061
	OBTAIN DRAWINGS	TRIP	3	1	2	2		002	8	.712
	COMPARE FACE OF DRAWINGS	PARTS	372	300	432	360		003	1464	1.464
	READ CHANGES IN CHANGE BLOCK	CHANGE	67	81	14	47		004	209	.627
	READ NOTES ON DRAWING	NOTE	15	20	33	26		005	94	.188
	COMPARE LISTS OF MATERIALS	PART	225	200	250	226		006	901	1.261
	READ E.O.'S ATTACHED TO DRAWINGS	E.O.	16	10	7	3		007	36	.396
	CHECK WIRES IN WIRING LISTS	WIRE	250	200	167			008	607	1.316
	CHECK WIRES IN WIRING DIAGRAM	WIRE	67	121				009	188	.188
	MAKE OUT SPARES FORM	FORM	1					010	1	.087
	NUMBER OF PARTS PER FORM	PART	22					011	22	.066
	MAKE OUT (IOL)(AVO)	IOL/AVO	1					012	1	.028
ART	DETERMINE AND OBTAIN ART	PIECE	6	5	7	7		050	25	1.750
	ORDER AND EXPLAIN TO ART	ORDER				1		052	1	.060
	CHECK IBM TYPE	TOTAL				1		053	1	.297
	EXPLANATION OF FINAL BOARDS TO ART	EXPLANATION					1	054	1	.103
WRITE DOCUMENT	PHYSICAL CHECK OF UNIT	CHECK		1				100	1	.456
	WRITE ROUGH DRAFT	STEP	21	8	7	21		101	57	2.206
	WRITE TEXT	TEXT	1					102	1	.456
	ISSUE CERTIFICATE OF MODIFICATION	CERTIFICATE	2			3		103	5	.085
	PREPARE WIRING LIST	WIRE			3			104	3	.012
ROUGH BOARDS	MAKE UP ROUGH BOARDS	BOARD	1		1		4	150	7	2.752
	REREAD AND CHECK	BOARD					11	151	11	.792
	CHECK ROUGH TYPE	DOCUMENT					1	152	1	.275
CHECKS	EDITORIAL	CHECK OR REVISION					2	200	2	.090
	TECHNICAL	CHECK OR REVISION					2	201	2	.402
	ENGINEERING	DELIVERY OR PICKUP					1	202	1	.325
	ENGINEERING REVISION	REVISION					1	203	1	.165
		HOURS WORKED	8.0	8.0	8.0	8.0	8.0	TOTALS	40.0	
		LESS MISC ACTIVITY CODES (SEE BACKSIDE)	4.5	4.6	3.7	3.1	3.6		19.5	16.5
		MEASURED HOURS	3.5	3.4	4.3	4.9	4.4		20.5	
		% PERFORMANCE ON MEASURED WORK								81

FRONT SIDE

Figure 3

MISCELLANEOUS ACTIVITY CODES

CODE	DESCRIPTION	DATE	TIME FROM	TIME TO	ELAPSED HOURS	TOTAL CODE HOURS
1. PRODUCTIVE WORK FOR WHICH NO STANDARD HAS BEEN ESTABLISHED	RESEARCH IID NO's	2/4	10.5	11.5	1.0	1.0
3. FORMAL TRAINING OFF THE JOB, PERSONAL REVIEWS, FIRST AID, OTHER TIME ALLOWED OUT OF AREA	SOLID FUEL SCHOOL	2/4	9.5	10.5	1.0	
	FIRST AID	2/5	8.0	8.5	.5	
	FIRST AID	2/6	8.0	8.5	.5	
	FIRST AID	2/7	8.0	8.5	.5	2.5
4. LEAD FUNCTION - DIRECTING GROUP ACTIVITY	LEADMAN SICK	2/4	1.0	3.0	2.0	
	LEADMAN SICK	2/5	1.0	3.0	2.0	
	LEADMAN SICK	2/6	1.0	3.0	2.0	
	LEADMAN SICK	2/7	1.0	3.0	2.0	
	LEADMAN SICK	2/8	1.0	3.0	2.0	10.0
5. UNPLANNED TASKS, SPECIAL PROJECTS, ETC NOT RELATED TO NORMAL PRODUCTIVE OUTPUT	ON JOB TRAINING WITH COORDINATOR	2/4	8.0	8.3	.3	
	READ REVISED DEP'T MANUAL	2/5	9.5	10.1	.6	
	REARRANGE GROUP FILES	2/8	9.7	10.3	.6	1.5
6. REWORK, ADDITIONAL WORK OR CORRECTION OF ERRORS CAUSED BY OWN GROUP	CORRECT WIRING LIST	2/6	3.1	3.3	.2	
	CORRECT WIRING LIST	2/7	3.5	3.8	.3	.5
7. STANDBY, WAITING FOR SUPERVISION, DIRECTIONS OR WORK	WAIT FOR MANAGER	2/5	3.0	4.5	1.5	
	WAIT FOR MANAGER	2/8	3.0	4.0	1.0	2.6
8. REWORK CAUSED BY ANOTHER GROUP OR ADDITIONAL WORK DUE TO MANAGEMENT DIRECTIVE	CORRECT MATERIAL LIST	2/4	11.3	11.5	.2	
	TRIP TO ENG - DISCUSS MISSING MOD KIT PART	2/6	9.5	10.5	1.0	
	CORRECT MATERIAL LIST	2/7	9.4	9.7	.3	1.5
					WEEKLY TOTAL	19.5

BACK SIDE

Figure 4

GROUP ______
SECTION ______
DEPT ______

ACTIVITY REPORT

DIVISION — WEEK ENDING 2-9-63 — SUPV

COLUMN NO.	1	2	3	4	5	6	7	8	9	10	11
EMPLOYEE	GROSS HOURS	NON-CHARGE CODE 3	PLANNED CODE 4	NON STD CODE 5	REWORK CODE 6	DELAY CODE 7	REWORK CODE 8	NON-MEAS CODE 1	MEAS CODE 2	STD HOURS PROD.	EMPLOYEE PERF
A. SMITH	40.0	2.5	10.0	1.5	0.5	2.5	1.5	1.0	20.5	16.5	81
X. JONES	40.0	0.5		1.5	1.0	3.5	5.5	2.0	26.0	20.0	77
G. WHITE	40.0	3.0	6.5	1.0	2.5	5.0	1.0	0.5	20.5	15.5	76
R. BLACK	40.0	1.0	1.5	5.0	1.5			4.0	27.0	19.5	72
Y. BROWN	40.0	0.5		0.5	0.5	1.5	4.0	5.5	27.5	19.5	71
Z. RED	40.0	3.5	15.5	2.0	2.0	3.5	0.5	2.5	10.5	7.0	67
N. GREEN	40.0			3.0	5.0		3.0	10.0	19.0	12.0	63
W. PINK	40.0	2.0	6.0	1.0		3.0		1.5	26.5	16.5	62
J. DITTO	40.0			2.0	4.5	6.0	2.5	3.5	21.5	13.0	61
TOTALS	360.0	13.0	39.5	17.5	17.5	25.0	18.0	30.5	199.0	139.5	70
							COLUMN 14 COVERAGE		COLUMN 13 RATING		COLUMN 12 PERF
							87		54		70

Figure 5

Nonchargeable hours (Code 3): Time paid for by the department for other than direct effort, which usually requires the employee to be absent from his department. This includes any activity for which the time is considered not applicable directly or indirectly to the furtherance of productive output, such as first aid, training (off the job), progress interviews, formal classroom training, etc.

Planned hours (Code 4): Time planned (usually budgeted) for leadmen or technical assistance.

Nonstandard hours (Code 5): Labor hours resulting from unplanned labor requirements, such as reports and assignments.

Rework--chargeable (Code 6): Labor hours spent in correcting errors caused by employees within the same claiming group.

Delay--unavoidable (Code 7): Nonproductive labor hours which are not controllable by the employee, e.g., waiting for work, direction, supervision, etc.

Rework--nonchargeable (Code 8): Labor hours spent in correcting errors originating in another department and/or additional work resulting from management directives.

Nonmeasured hours (Code 1): Productive labor hours for which a time standard has not been established.

Measured hours (Code 2): Labor hours for which a time standard has been established.

Standard hours produced: Work units completed multiplied by the time standard for that operation.

Employee performance: An individual employee's performance-to-standard while on measured work. Derived by dividing standard hours produced by hours on measured work.

Group performance: Performance of all employees. This is the sum of all standard hours produced divided by the sum of all hours on measured work.

Group rating: Reflection of the supervisor's ability to hold delay and rework hours to a minimum and keep output high. Group rating is derived by dividing the total standard hours produced by the sum of all hours spent on delay, nonstandard, chargeable rework, plus measured hours.

Group coverage: Reflection of the AIM Engineering group's ability to maintain adequate standards coverage in the group under measurement. It is derived by dividing measured hours by the sum of measured and nonmeasured hours.

3) Cost and Performance Analysis (figure 6)

A Cost and Performance Analysis, converting the Weekly Activity Report into dollars, provides management an indication of the labor cost of performing a required function, and shows how that cost was distributed by labor category.

Report visibility is enhanced through a review of excess costs. The source and extent of these costs can be isolated for remedial action. In the larger sense, increasing or decreasing cost trends may be anticipated and acted upon.

Distribution of the Cost and Performance Analyses follows a management-level reporting concept. This concept provides for the preparation and distribution of AIM reports at each succeeding level of management, in pyramid fashion, until the division or vice-presidential level is reached.

GROUP ________
SECTION ________
DEPT ________
FUNCTION ________
DIVISION ________

COST AND PERFORMANCE ANALYSIS

	PERCENTAGES				COST PER STANDARD DOLLAR											FINANCIAL RESULTS		
																	SAVINGS	
WEEK ENDING	COV	PERF	RATE	STDS PAYROLL	STD COST	PLANNED CODE 4	SUB-STD	NON-STD CODE 5	REWORK CODE 6	DELAY CODE 7	TOTAL CHARGE-ABLE	REWORK CODE 8	NON CHARGE-ABLE CODE 3	TOTAL NON CHARGE-ABLE	DEPT TOTAL	AVG HOURLY EARNINGS	CURRENT WEEK	CUM SAVINGS
BASE	81	51	34	236	1.000	0.441	0.960	0.255	0.245	0.274	3.175	0.225	0.127	0.352	3.527	2.31	—	—
12-29-62	82	54	44	305	1.000	0.303	0.881	0.182	—	0.167	2.533	0.129	0.068	0.197	2.730	2.31	196	196
1-5-63	80	57	41	282	1.000	0.336	0.796	0.189	0.189	0.197	2.707	0.164	0.082	0.246	2.953	2.31	132	328
1-12-63	83	60	40	298	1.000	0.314	0.715	0.185	0.169	0.192	2.575	0.123	0.069	0.192	2.767	2.31	179	507
1-19-63	83	63	48	356	1.000	0.260	0.636	—	0.123	0.137	2.156	0.117	0.065	0.182	2.338	2.31	362	1169
1-26-63	85	66	49	321	1.000	0.309	0.504	0.151	0.144	0.165	2.273	0.158	0.079	0.237	2.510	2.31	289	1458
2-2-63	86	68	50	332	1.000	0.287	0.532	0.133	0.147	0.189	2.288	0.133	0.084	0.217	2.505	2.31	294	1752
2-9-63	87	70	54	358	1.000	0.256	0.487	0.114	0.114	0.162	2.133	0.117	0.085	0.202	2.335	2.31	371	2123
COL 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19

Figure 6

Thus, each level of management receives an AIM report reflecting performance and cost information pertaining to all AIM measured units reporting to that level.

The following definitions have been formulated for the Cost and Performance Analysis:

Week ending: Last payroll period.

Group coverage: Reflection of the AIM Engineering group's ability to maintain adequate standards coverage in the group under measurement. Derived by dividing measured hours by the sum of measured hours and nonmeasured hours.

Group performance: Performance of all employees. This is the sum of all standard hours produced divided by the sum of all measured hours.

Group rating: Reflection of the supervisor's ability to hold delay and rework hours to a minimum and keep output high. Found by dividing the total standard hours produced by the sum of hours on measured work, nonstandard work, rework (nonchargeable), and delay (unavoidable).

Standards payroll: The straight time cost of producing all units of productive output at the standard rate; Average hourly earnings multiplied by standard hours produced. The result is added to the average hourly earnings multiplied by Code-1 hours times base-period performance to account for unmeasured productive activity.

Standard cost: The common denominator of all "Cost per Standard Dollar" is always equal to 1.000. A Standard Dollar assumes 100 per cent manpower utilization on productive work at a performance rate of 100 per cent with no inherent excess costs.

Planned hours (Code 4): The measure of planned indirect labor in relation to the total standards payroll. The standards payroll is divided into Code-4 hours multiplied by average hourly earnings.

Substandard: A measure of the excess costs resulting from performance less than 100 per cent. Standards payroll is divided into substandard hours multiplied by average hourly earnings.

Nonstandard hours (Code 5): A measure of costs from unplanned indirect labor requirements. Standards payroll is divided into Code-5 hours multiplied by average hourly earnings.

Rework--chargeable (Code 6): A measure of rework caused and corrected within the claiming group. Standards payroll is divided into Code-6 hours multiplied by average hourly earnings.

Delay--unavoidable (Code 7): A measure of the cost of delay. Standards payroll is divided into Code-7 hours multiplied by average hourly earnings.

Total chargeable: A measure of the total chargeable labor per standard dollar. It is the sum of standard cost, substandard cost, Code 4, Code 5, Code 6, and Code 7.

Rework--nonchargeable (Code 8): A measure of rework caused by errors in another department. Standards payroll is divided into Code-8 hours multiplied by average hourly earnings.

Nonchargeable hours (Code 3): A measure of cost not chargeable to output. Standards payroll is divided into Code-3 hours multiplied by average hourly earnings.

Total nonchargeable: A measure of total cost not chargeable to output. It is the sum of Code 8 and Code 3.

Department total: The sum of total chargeable and total nonchargeable.

Average hourly earnings: A measure of the average rate of pay for employees under measurement. It represents total pay less premiums and overtime divided by total hours worked.

Savings--current week: A measure of reduced (or increased) costs of operation for this week compared to the base period.

Savings--cumulative: The total of savings from date of installation of standards.

4) Cost and Manpower Analysis--Goal Setting (figure 7)

To further focus management attention on the progress of measured groups, techniques have been developed for the establishment of goals. Primary goals are set for both Cost per Standard Dollar and Headcount. This is done by conversion of the Cost and Performance Analysis into the related variance in headcount from a maximum expected cost level. With the appropriate charts, functional supervision is provided an immediate indication of desirable group manpower requirements based on workload.

For maximum visibility, the trends of total actual cost and headcount variance are plotted on a two-part graph. The weekly plot visually indicates the effect of management action in controlling variances from the established goal. To further aid management, it has been found useful to incorporate, as part of goal setting, a detailed letter indicating those

COST & MANPOWER ANALYSIS FOR FUNCTIONS MEASURED BY AIM WORK STANDARDS

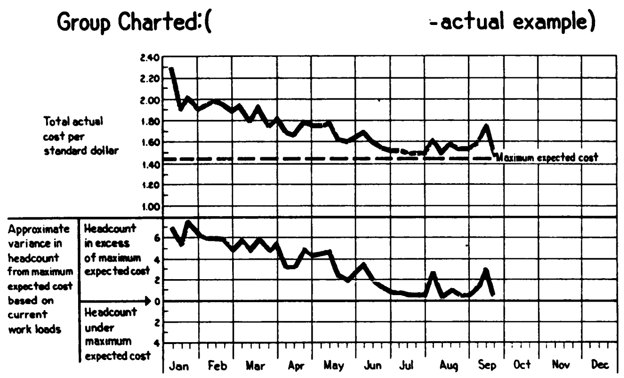


Figure 7

steps necessary to attain prescribed goals. This letter, initiated by AIM personnel, is merely a statement of existing conditions and recommended action. This procedure has proved invaluable as a starting point for management planning.

5) Mechanization of reporting (figure 8)

As the AIM Program at Autonetics expanded to encompass measurement and reporting of the work effort involving literally thousands of people, a point was soon reached where sheer volume alone, of data to be processed, presented problems with respect to timeliness, accuracy, and completeness of reporting by manual means. These growing problems are highlighted by the management-level reporting concept, discussed previously.

AIM Engineering looked to computer application as a means of internal cost reduction in report preparation. Since the complexity of the system would necessitate a separate presentation to fully explore all facets of mechanization, only broad categories will be treated in this paper:

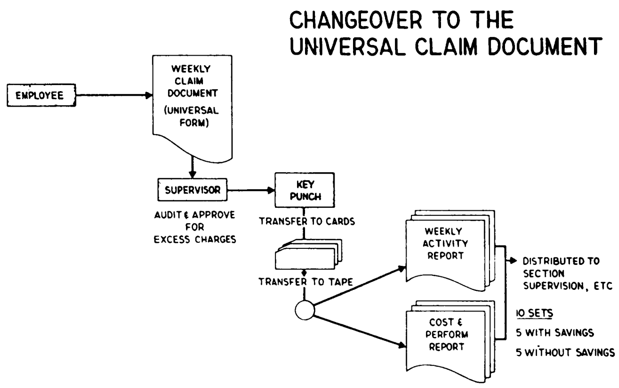


Figure 8

Input: AIM data enters the computer via punched cards which are created from the weekly Universal Transmittal sheets filled out by each person reporting under AIM measurement. Earlier we referred to these as Employee Activity Logs.

Processing: The actual processing of data by the computer to create the two AIM reports has been programmed according to the AIM procedure described earlier in this paper. Control of processing to generate successive management-level reports is achieved by an organization identification number. This number in varying combinations can key specific input to specific levels of management throughout Autonetics.

Reports printout: The Activity Report, showing only the current week's activity, is processed and printed first. Summary tapes from the activity report are then used as input to produce the Cost and Performance Analysis. At this point a "history" tape is interjected to print the ten-week history necessary to provide trend visibility. Also, the departmental goal, as discussed earlier, is printed to provide supervision an immediate reference to "out of control" areas.

Standards development: The next major step in the AIM mechanization program entails the extension of computer application to the actual development of AIM standards. The plan to be pursued this year is to establish master files of universal standard data, multipurpose data, singlepurpose data, and basic MTM motions, coded into an integrated system for retrieval and printout by computer at the AIM Engineer's command. The objective is to further reduce engineering hours required for standards development and accelerate AIM coverage through Autonetics.

One might ask, "Why not use the computer for establishing standards at the beginning of the program?" The answer is that such a system cannot be implemented overnight. You must have a complete data package and coding system, as well as confidence in the basic work-element levels making up the package.

ACCOMPLISHMENTS

In originally proposing the AIM program it was felt that an indirect labor-cost reduction of 20 per cent in the first year could be expected. This has proved to be a conservative estimate. Actual labor savings generated as a result of productivity improvement from base period, in measured areas, has far exceeded original estimates. Including operations that have been on AIM control for periods of less than one year, the current average improvement is closer to 30 per cent.

After having attained a break-even point (program costs versus savings) 13 months from inception, savings now exceed $2.7 million. These are real savings in that they represent an over-all reduction in manpower requirements resulting from actual productivity improvement. The decrease in labor costs were the direct result of reduction of personnel and overtime, and increased output per employee.

The total number of employees covered by AIM controls since program approval now exceeds 3,000.

SUMMARY

We are compelled to stress again that success in the introduction of work measurement into new areas is largely dependent upon obtaining the understanding of everyone concerned of the objectives, approaches, and techniques of work measurement. We again emphasize the necessity of the selling approach to work measurement. The AIM Program, for control of indirect or supporting labor, has been sold from top to bottom. Autonetics' top management is sold and has demonstrated it with support. Without it, the program would have died long ago.

Selling all levels of supervision, as well as the actual employee to be measured, on the basic fairness of the program, the necessity of it, and the soundness of the controlling techniques to be used, is of prime importance. With participation based on understanding, the odds are good that the program will continue to be successful, and that lasting benefits to the company will result.

Toward this end, the following lists of responsibilities are provided:

Management Responsibilities:

1) To promote and motivate participation in all cost-improvement programs.

2) To establish performance and labor-cost goals for supervision.

3) To devote time in regular staff meetings to the review of Cost and Performance reports and to establish plans for corrective action.

Responsibilities of Supervision:

1) To provide information necessary for the AIM Engineer to analyze thoroughly the work content of the department.

2) To instruct and train employees in selected methods.

3) To install individual reporting documents, to guide the employees in their use, and to assure the integrity of the reports.

4) To establish expected performance levels for individuals and groups.

5) To create a cost-conscious atmosphere and motivate participation.

6) To use Activity and Cost and Performance reports as administrative tools for controlling labor hours and costs.

7) To use standards to budget labor hours, measure backlogs, schedule work, evaluate performance, and reduce costs.

AIM Engineering Responsibilities:

1) To inform management and supervision of AIM concepts, purpose, scope, techniques, and benefits.

2) To analyze the work content involved in the units of production of individuals or groups.

3) To establish, with supervision, the best method for performing operations and to assist supervision in the installation of the agreed-upon method.

4) To develop an attainable standard for productive units of work.

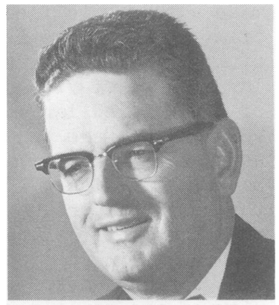
5) To design employee-reporting forms.

6) To maintain standards coverage and accuracy of standards to assure a true evaluation of individual and departmental performance.

7) To assist supervision in learning the most effective use of the Cost and Performance reports and to suggest corrective actions that will improve the use of labor hours.

After two years, what controls has the AIM Program provided? To enumerate a few: we have seen a strengthening of supervisory ability to manage through cost and performance visibility a reduction of overtime and backlogs, a more accurate basis for computing labor costs in a competitive bidding, a means of forecasting manpower and budget requirements based on work load, an application of work simplification and methods improvement leading to standardized work methods, and an increased capability of man-paced equipment.

There are proponents of many systems less complex than AIM who feel strongly that the inexpensive "broad-brush" approach to manpower control will suffice. We don't challenge their theories or say that "activity indicators" are not beneficial. Autonetics chose to put into the hands of its supervision a tool for effectively managing and controlling all aspects of the labor dollar. The tangible results of the use of individual quantitative performance measurement, at Autonetics, has more than justified the AIM approach.



WHAT MANAGEMENT EXPECTS OF INDUSTRIAL ENGINEERING

Walter B. Scott
Vice President, Motorola, Inc.
Chicago, Illinois

When I accepted the invitation to speak before this group on the subject of what management expects of industrial engineering, I realized that much has been said on this particular subject by men representing managements that have done outstanding work with qualified industrial engineering departments. I accepted the opportunity to speak because I felt that although much had been said on this subject there are certain points that bear repeating. Also, there is new emphasis in the field of industrial engineering that is becoming of great importance to management.

One of the big areas of concern today is the worldwide competition that companies face with respect to their product sales. Since we have managed to teach most of the world the techniques of modern production at low cost to them by furnishing them the most advanced machines, tools, and equipment, plus the techniques of using this equipment, we now find them most impressive competitors at the market place. This, of course, stresses new areas of importance on the part of all management. However, before we talk about what management expects of industrial engineering, I think we should talk briefly on the word "management."

We often hear this term used as if we were referring to an unknown third party. It is also used many times as a way of passing the buck, or doing nothing about current problems. Foremen in the shop may refer to management as the superintendent, or plant manager. The plant managers may, in turn, refer to management as the works manager, or vice president of production, or some other executive. The works managers and vice president of manufacturing sometimes refer to "management's prerogative," and are hinting that this is directed from the president's office.

I am sure if you were to question the president of an aggressive organization that believes in good communications, both up and down the line, he would give you a very broad definition of the term. The smart chief executive is constantly pushing the thought down the line that management consists of many echelons within the corporation, not the least in importance being the shop foreman. I believe we should all keep pushing the term down the line and spread the understanding that management involves a large number of people who today might not know they are considered as management. After all, it isn't only the lonely soul in the corner office of mahogany row, sitting behind a big desk, who bears the title of President, who is "management."

Now, when I discuss the term "Industrial Engineer," I am referring to him as an individual who is equipped professionally with the proper education, both from a technical and a practical experience-exposure viewpoint. He has experience in working with people and he understands the fundamentals of the basic economics that make up a profit and loss statement. Before I speak on the subject I should like to indicate several observations I have made regarding the industrial engineer and the atmosphere in which he should function.

First, I have yet to see a good, topnotch, efficient plant that did not have a topnotch industrial engineering department as the keystone of its success.

Second, I have yet to see a topnotch, efficient plant that did not create the position of the industrial engineering function as one of respect within the company, and high rapport with it.

These things seem to go hand in hand, for industrial engineering is a basic production function. It is a tool for manufacturing and production management, and, as such, must have its proper amount of limelight to conduct its function in a proper and nonrestricted fashion. To illustrate: When you hire a tradesman to do some work in your home you expect him to report with the proper equipment to carry out the duties for which you have hired him. In like fashion, a vice president of manufacturing or production, a works manager, or a plant manager, as the case may be, should be allowed the tools of his trade. One of these tools is a well-run industrial engineering department. Now, we would not think of taking the bookkeeper away from the accountant, or the design engineer away from the chief development engineer, but I am sometimes puzzled at the corporate attitude having to do with the industrial engineering department. Sometimes these shocking reactions come from intelligent top executives of highly reputable companies.

What are the general attributes that are expected of industrial engineering? I have a list of items that I feel are important, but, in like fashion, I believe everyone in the audience has his own list of items that he feels are of equal importance. Instead of relating to you the opinions that might be merely my own, I have made a search to find out some of the thinking of my counterparts in industry. After learning of my assignment I wrote a personal letter to a large group of vice presidents of manufacturing of the hundred largest companies in our country. These names were taken from the list of the hundred largest companies which was published by Fortune magazine. I asked these gentlemen what the really important items were that they wanted most from their industrial engineers. After receiving their replies I listed all of their ideas on a spread sheet. In this way I had a birds-eye view of the various weights they gave to certain industrial engineering functions within their companies. It also gave me the opportunity to detect any trends that might be occurring in the field of industrial engineering, as seen by a substantial number of top executives. So, my remarks from here on contain not only my personal beliefs, but also reflect the results of the survey made in order to obtain a truer answer to the question at hand.

1) There was an almost complete void in the results of the survey having to do with such basics as time study and methods. I think it is proper to assume from this that this is an area of responsibility where, generally, a good job has been done. During the past 20 years much has been done to update these techniques to a point where at present they are assumed to have developed into a specific science that, generally, is being handled quite well in industry. I don't think this could have been said with the same firmness 20 to 25 years ago. This speaks well of the development of the science during this period of time. Management, however, is looking for new breakthroughs. They are looking for help in combatting the very complex problems with which they are faced today. It is only recently that industry has been faced with the severe foreign competition we witness today and the industrial engineer and the industrial engineering function have a keen responsibility to come through with the aggressiveness necessary to combat this.

2) One of the things that has been pointed out in my search is that there is a growing interest in making the industrial engineering function responsible not only for the measurement of direct labor efforts, but for all indirect labor as well. This places on the industrial engineer and the industrial engineering department a tremendous amount of new responsibility. It also places on management a new responsibility of being highly resourceful in aiding and selling this technique within the corporation. This is not something that can be passed on lightly. It isn't something that can be assigned to the head of the department by way of edict or letter. It will be successful only if the chief executive of a company not only plants the seed within his organization, but also spends some time cultivating it and helping it to grow in an atmosphere that is well oriented to this new objective of measurement. After all, we are dealing with people who have not been measured before and it requires a tremendous amount of selling to have it done properly. I think the intelligent measurement of everything that can be measured in a company is a good objective. It certainly will go a long way toward aiding our ability to compete in world-wide competition. After all, we have concentrated on the direct labor for many years and through this concentration we have managed to make this a moderately absolute science. The same opportunity exists today in the entire field of indirect measurement. My friends who are in the consulting business tell me that their requests for help in the indirect field are nine to one over their requests for help in the direct field. This is an indication of a changing trend in industry. The industrial engineers must equip themselves for this.

3) If I were to pick one item of difference between a good plant manager and a mediocre plant manager I would have to say that the best plant manager has developed a certain technique that his counterpart has not discovered. I think the same holds true of an outstanding industrial engineer versus one who is just getting by. I refer to the use of a little common horse sense in applying the power of observation. Many people look at things but don't really observe them. When I walk through a plant with a plant manager on an inspection trip I often raise a series of questions as to specific conditions that I observe in his plant. The fellow who is really on the ball can say unhesitantly, "I know about the condition and this is what we are doing about it." The other fellow says, "I was not familiar with it, but I will make it a point to go out and check it." This is what I refer to as the power of observation. Things are continuously happening all around us. Some people have the power of observing changing conditions and others have to be hit over the head with the proverbial brickbat. I rate the power of observation very highly. One of my counterparts in the survey indicated that the one area he feels is of extreme importance is the industrial engineer's power of observation of the whole package and not the bits and pieces of a problem, and after he observes the entire package to know and

sense the urgency of getting something done about it.

4) The ability to maintain corporate standards in a multiplant corporation is of great importance. It is one thing to maintain standards within a facility, but it is another to maintain corporate standards within a multiplant complex. Setting up standards so the time to perform the same task within the corporation is identical, regardless of where it is performed, is not easy, but it is certainly worth working for. One of the ways this can be done is by having the chief industrial engineer in a multiplant organization aggressively sell management on the importance of holding industrial engineering department conferences so as to establish a corporate program, and to stimulate the exchange of ideas and techniques for maintaining good policies that are important to good industrial engineering results. You will be amazed at how much talent you have within a multiplant organization when you get your key people together to discuss common problems. The proof comes when techniques and suggestions are offered in a "for the good of the order"type of atmosphere.

5) Have you given thought to the establishment of a manufacturing research group as an operating arm of your industrial engineering department? This is a group of well-qualified men who have the ability to think creatively toward the standardization and redesign of components, or assemblies, of the end product so that they can be fed through your factory operations with the least possible cost. One of the measures of the success of this function is its ability to standardize so that the product can be automated in a most efficient fashion. But, let's face it, all design engineers have their own ideas of how they would build a product. We need a clearing house through which all this information goes so that it can be standardized. Many of the companies answering my request indicated that they have set up a manufacturing research function, or are contemplating this function, in order to give them improved costs. Not too many have done it, but those who have done it well would not operate today without it.

6) A common term now used is that of corporate goals and objectives. This sometimes ties into much of the work being done nowadays in corporate planning. For many years we have listed on January 1 of each fiscal calendar year those objectives and goals that we expect to work on for the next twelve months. In many cases we have listed a goal or objective of something we only hoped to accomplish. I remember the year we indicated that we wanted to start measuring indirect labor. At the time we said, frankly, that we did not know how to do it, but the fact that we put it in writing kept prompting us. Today in one of our largest plants 90 per cent of our indirect people are on some form of measurement. Unless we had originally had the desire and expressed it as a corporate goal and objective I doubt that we would have made the same progress that we have.

Each year the industrial engineers should set up their own goals and objectives. If you have an objective to get more direct labor coverage, say it in writing and also say what percent of improvement you wish to see. This is a form of communication as it orients other people to what is intended. It goes without saying that goals and objectives are no good if they are left in the filing cabinet. These should be sent to all your key people so that everyone knows what the goals for the next twelve months are.

We have even found it a good thing to outline, by plant, the amount of money we expect to save for that year through our methods improvement program, and we measure each plant against this objective monthly. I suggest you try it for a year and I am sure you will find it very thought provoking.

7) We should have a real desire to break with tradition. When I make this statement I sometimes shock people. I think we should all look very quizzically at things that have become tradition. I realize there are things in every corporation that we do traditionally which have intrinsic value. However, most of those things that we do each day because they are traditional I look at askance, because many times tradition falls short of good results.

I will give you a good illustration of where we broke with tradition. For a year we had an objective to impress our people with the importance of the cost of the operations they directed. Many foremen in the company have several hundred people working for them. In many cases this is more than entire companies have, including the president. The foremen tended to think of their operations in numbers of people, such as 150, 175, etc. We had never given them an insight as to how much money is handled by their direction, including all costs making up the head count. This year we broke with tradition by issuing a personalized check book to each foreman, department head, plant manager, and even the works manager and vice president. On the first day of each month everybody receives a check from his immediate superior, made out in full for all of the money allowed in his budget, including direct labor, indirect labor, fringe benefits, and expenses, for the following month. This is signed by his superior. This amount is entered as a starting balance in his department head's checkbook. In turn, each week the department head draws a check covering his actual expenses, including all fringe benefits, and deducts it from his deposited amount. He is encouraged not to overdraw his account. I know of no other company that has done this exact thing. I know it was quite a shock when recently some of these checkbooks accidently were directed to the accounting department from the receiving department. There was quite a bit of excitement over who was drawing all the checks on the company funds. The important point I stress here is that many opportunities exist to break with tradition. This is merely an example. Needless to say, our department heads were quite surprised at the hundreds of thousands of dollars they were directing through their efforts. They just did not think of it in quite these terms. You know and I know that people take fringe benefits for granted, and you would be amazed if you saw how your costs are affected by these fringe benefits.

To illustrate again how tradition can be successfully broken, let me give you briefly another example. In each of our facilities for which I am responsible we require that at least twice a year we hold an "I-Recommend Day." On this day anybody can make any recommendation that he may wish to make. The plant manager, in turn, must post answers to all of these on a special bulletin board that is created for this purpose. I ask that he answer all of the recommendations within thirty days. This has really put our plant managers on the spot. It has given us the opportunity of breaking with tradition in many areas: For instance, we got a lot of complaints and suggestions because we did not have enough clocks to punch out on at quitting time. People were running to be first in line to punch out. Naturally, the traditional way of answering this would be to buy more time clocks.

We broke with tradition, however, and said, "Let's no longer require our employees to punch out." This, of course, was met with complete shock by our timekeeping department. We were told it was against the law; we would not have accurate records, etc., etc. After finding these assumptions erroneous, and answering each and every one, we announced on the bulletin board that from a certain Monday on none of our employees would be required to punch out in the evening unless they worked overtime, or went home before they finished eight hours; but anyone who worked one turn, or eight hours, would not be required to punch out. What were the results?

a) We have more time clocks than we need.

b) There is no more running in the plant at the end of a shift.

c) Our people are staying on the job until quitting time because they are not running to be first in line, nor, therefore, leaving their workstation early.

The first day we put this into effect I went into the shop to witness it. Some of the employees came up to me and said, "You know, I feel like an executive today." I am merely giving you an illustration of a case where we have been successful in breaking with tradition. There are many more opportunities where the industrial engineer should start looking in a quizzical fashion at things which have been done and are being done traditionally.

8) Have you considered setting up an internal audit within your company whereby you audit your own standards, chargeoff costs, and similar types of items? You will be amazed how this will get more people keyed up about getting their standards in better shape and, in addition, give a better control to the pencil pushers who tend to defeat the basic standards we work so hard to perfect. I realize that in very small companies a full-time auditor may not be possible; if not, then do it on a part-time basis. I think you will find this will aid the industrial engineering function a great deal.

9) Much has been said about using new approaches in problem solving--such as computers, PERT, and mathematical approaches. Each of these items are subjects on which complete seminars can be and are being held. The industrial engineer of the future must become acquainted with these more sophisticated and scientific approaches to problem solving. The companies with which I have been in contact have indicated that as our systems become more sophisticated we, in turn, must be able to better manage the data that is required to put into these more advanced techniques.

10) The big challenge to industrial engineers is one that I think we too often take for granted and, as a result, many times a not-too-efficient job has been done with respect to it. This is the challenge to our ability to motivate people, including our associates. When I say "associates" I mean both subordinates and superiors. A big challenge in the future is to understand the techniques of getting people to act. It is the real key to the success of a good executive. The industrial engineer must play this role better in the future.

I am going to read verbatim several responses received to my inquiry. As I read these, think about the task of getting people into action on these items. Remember, top executives are telling you they want to get action in their companies on such items.

a) "Keep everybody in the company on the ball from a cost-reduction and importance viewpoint."

b) "Assume the leadership in the analysis of operations to determine and make recommendations for optimum utilization of resources and facilities."

c) "Use up-to-date standards and measurement of all phases of operations."

d) "Use applied mathematics, critical-path scheduling, or linear programming to back up approaches for low cost operating plans."

e) "Provide recognized techniques for optimum utilization of man, material, equipment, and plant."

f) "Establish long- and short-range goals for utilization of man, machines, materials, minutes, and money."

g) "Make major contributions to profits through lower costs in all phases of the business.

h) "Try to provide an increasingly quantitative basis for all corporate decisions in order to maximize current and long-range benefits in return for what is disbursed."

These comments certainly indicate that to be successful the industrial engineer must not only know his stuff technically, but must be able to sell his ideas and motivate people. This ability to motivate for results cannot be understressed as a portion of your major contribution to your future.

INTERNATIONAL PRODUCTION INTEGRATION

Richard P. Conlon
Vice President, Business International Corporation
New York, New York

International Production Integration (IPI) can be defined basically as the manufacture of components and products wherever in the world they will cost the least--considering transportation to and tariffs at points of assembly and/or sale. In short, I will be talking about rationalization of production on a global basis.

THE INTERNATIONAL CORPORATION

IPI, being a global concept, is related to, and is of necessity subordinate to, the concept of the international corporation. To minimize confusion, I should say that the international corporation is the same as the world corporation, the multinational corporation, or the transnational corporation. I am sure you have all seen increasing references to these terms.

By way of definition, these are corporations whose top executives think internationally --who think about the nations of the world as many of us now think about the states of this Union of ours. The executives of these international corporations think internationally in terms of science and technology, buying and selling, engineering and manufacturing. They are companies that by their very nature must eventually be owned internationally.

Why this emphasis on global thinking, global organization, and global production?

Briefly, the world today--both the old and the new nations--is engaged in a great race to extend the technological revolution to its ultimate limits. The opportunities provided by advancing technology must be thought of--and acted upon--in global terms because they have global implications.

For example, improvement in transportation and communications makes possible the extension of business activities over vast distances. Growing demands for scarce resources, less expensive labor, and new markets force foreign companies as well as US companies to look to foreign areas. In turn, each country has become and continues to become increasingly dependent upon the other countries for materials and markets, generating on the one hand greater economic cooperation, and, on the other, greater economic competition.

One result: the internationalization of corporate enterprise.

US BUSINESS AND THE WORLD MARKET

To better understand the sharply increasing international involvement of US corporations during the past decade, and particularly during the past four or five years, let's look backward for a moment.

For about forty years--from 1919 to sometime in the 1950's--the management of US industry was guided, consciously or subconsciously, by four basic ideas:

1) That the US market for manufactured goods was larger than the rest of the world's combined--that the US produced and consumed more electricity and steel, more motor cars and radios, more bathtubs and breakfast foods, than the rest of the world combined.

2) That the rest of the world needed and wanted our goods more than we needed or wanted theirs; that we were relatively self-sufficient.

3) That mass production and low unit cost of production was an American invention, an American monopoly.

4) That a favorable balance of payments was part of the American way of life. It was a subject one studied in school and then never heard about again.

During these forty years, all four of these points were true. They constituted a very valid basis for corporate policy-making. We did produce and consume more manufactured goods than the rest of the world; we were relatively self-sufficient; we did have a virtual monopoly in mass production and low unit costs; and we did enjoy a favorable balance in our international accounts.

We put our best brains into domestic production and domestic marketing. We focused our energies on the great and burgeoning US market--which was, but for only a few remaining years will be, the world's largest "common market."

Today we have a new generation managing our industries, and they face an entirely different world. None of the five facts about economic and political life that prevailed for about forty years is true today. We no longer produce and consume more manufactured goods than the rest of the free world combined (eliminating the Communist world from the calculations). We are no longer relatively self-sufficient. We have switched from being a net exporter to being a net importer of iron ore, petroleum, copper, and many other vital materials. We are dependent upon supplies from abroad to keep our industries operating. We no longer enjoy a monopoly of low unit costs and mass production. And we suffer a serious deficit in our international accounts.

If the guide-posts which very properly served US management for forty years are no longer valid, what new guide-posts are there? What facts about the US and international economic life can we seize upon now to guide corporate policy-making for the next four decades? I submit that there are four new truths that, barring a world war, will serve well as foundations for corporate policy-making. They are:

1) The rate of economic growth in most of the world outside the US is already significantly greater than it is within the US and will continue to be greater. For example, during the period of 1956 through 1961, the GNP at constant prices in the US grew 12 per cent. Now remember that figure--12 per cent--while I cite corresponding figures for a few other countries: France, 22 per cent; Germany, 32 per cent; Venezuela, 37 per cent; Brazil, 39 per cent; and Japan, 65 per cent.

2) With the formation of the great trading blocs--the European Economic Community, the European Free Trade Area, the Latin American Free Trade Association--there is an inexorable move, as the tariffs and other barriers to trade within the blocs are eliminated, toward regional economic integration and the resultant economies which can be achieved through mass production and mass marketing. Already, the exports of the six-nation Common Market exceed the exports of the US by more than $10 billion annually. The seven-nation EFTA group overtook the US in export trade last year.

3) The world is moving--perhaps at a slower rate, but just as inexorably--toward freer trade. Great efforts are being made, exemplified by the US Trade Expansion Act and the forthcoming Kennedy Round, to reduce tariffs between the US and the new regional trading blocs. This movement will open the US market to even greater competition from abroad, but at the same time provide us greater opportunities for exporting from the US and third countries from American-owned foreign-production bases.

4) There will be greater and greater government intervention in the affairs of business in many ways, but particularly in two: in the spreading of antitrust legislation, and in the enforcement of competition throughout the free world. Already 12 European countries have new antitrust laws, and the Rome Treaty Imposes similar restraints upon the whole of the Common Market. Also, we shall see more state intervention in corporate affairs owing to the rapid spread of government planning. France, Italy, Spain, and many other countries already have formal government organizations for economic planning.

These four certainties about the future spell both danger and opportunity: danger because the US home market will be increasingly exposed to foreign competition; opportunity because the vast overseas markets represent potentials for vast growth. It has already been demonstrated that US corporations earn significantly greater profits on their investments abroad than they do at home.

Thus, from a manufacturing standpoint, it would appear more than likely that the lower cost producer will have a distinct global advantage wherever he located. Just as we found in our huge market that automobiles can be made at lower cost in Michigan than in the South, and that most textiles can be made more economically in the South than in the North, we shall find that many products and/or components can be made abroad at less cost than they can be made in the US, owing to labor or materials advantages or both--particularly if coupled with a continuing productivity lag in this country.

This is not theory. We already have a zero tariff on typewriters, and a significant share of the typewriters that we use in America were manufactured in Europe. Most of them, please take note, by US corporations that had the good sense to protect their sales and profits in the US market by producing abroad themselves. I repeat, the US corporation which concludes that it is too risky to produce internationally is inviting an even greater risk--losing its US market position to foreign competition.

Peter Drucker, the economist and writer, puts this fact of life a bit more succinctly by saying "that if an American machine tool manufacturer can't compete in Dusseldorf and Osaka he better be prepared to lose his market in Kalamazoo."

I have dwelt at some length--perhaps a disproportionate length--on "why" corporations are internationalizing. My reason for so doing is, I hope, readily obvious to you by now. I wanted to stress and restress the vital and basic need for all in corporate management to think, plan, and act internationally.

The competitive challenge of an increasingly interdependent world cannot be met, in my opinion, by corporations which continue to think in terms of the "US and other markets"; which continue to delegate "overseas operations" to a few staff executives or even a separate line division, or which continue to set up one operation in Germany, another in France, another in Brazil, and another in Japan, etc.

The future belongs to the corporations that take a look at the entire world market and decide where and how many centers of production and assembly, and centers of marketing and distribution there should be for maximum efficiency and profitability.

EXAMPLES OF IPI

Fortunately, life, and particularly corporate life, is not all black and white. There are stages and degrees and, of course, exceptions to every generalization or rule--especially when an outsider is trying to tell you how to run your business! So, let's look briefly at a specific case of how a US firm has rationalized its multiplant operations in Europe.

A US machinery producer, which I will identify fictitiously as Process Machinery, Inc. (PM), found itself a few years ago with 15 plants in nine European countries. Of PM's 30-odd products, all but four were produced in more than one plant, and quite a few in as many as eight or nine. The complex product line required nearly 80,000 parts, about half of which were subcontracted, the rest self-produced, often in several different plants. Since they were responsible for the individual profit centers, local managers were given a good deal of autonomy in deciding whether to buy parts from a sister company, subcontract locally, or make them internally. They could even decide to assemble a machine locally if it could be done more economically than importing from another subsidiary (and provided they had the capital).

Although PM experienced a vigorous growth in Europe (sales rose by an annual average of 20 per cent after World War II), and despite the fact that a PM worker in Europe earned only 30 per cent of his US counterpart, every PM product cost more to produce in Europe than in the US. In view of this and several other factors, PM started to evaluate the merits of rationalization.

The arguments against rationalization boiled down to two external and six internal complications:

1) High tariffs and taxes on the movement of machines from one country to another, especially between EEC and non-EEC countries. Particularly worrisome in this regard was the UK, a major market for PM products.

2) The possibly adverse consequences of stopping production of some machines in certain countries, including losses of the "made locally" sales tool, prestige, and possibly government orders. Furthermore, it was feared that the generally excellent relations with local governments would be disturbed. In addition, the plant managers, who were usually local nationals, were reluctant to rationalize for patriotic reasons and for fear of losing opportunities for future expansion.

3) The enormity of the task of retooling 15 factories, transferring numerous machine tools, changing assembly lines, retraining workers, and similar headaches.

4) The partly unpredictable changes in individual plant workloads, in light of the company policy not to lay off workers if at all possible (PM employed 15,000 in Europe and thus was vulnerable).

5) Securing new sources of supply, particularly in view of some of PM's unusual specifications, and the problem of fair treatment for existing suppliers who might be hurt.

6) The difficulty in anticipating demand to prepare adequate inventories during the transition.

7) The perhaps excessive demands, in capital and skilled manpower, on plants allocated the more complex items of PM's line (costing upward of $1 million).

8) The higher operating costs, owing to freight costs, duties, taxes, etc., for plants shifting from local production to import of some products.

The proponents of rationalization, while recognizing the validity of these arguments, felt they could be overcome. Significantly, most of these proponents were manufacturing executives. They held that:

1) Production would be more economical through rationalization (this was the compelling argument), runs would be lengthened, duplication of tooling avoided, scheduling and quality control considerably eased, and inventories kept lower since demand would be met from only one source.

2) The introduction of new products, which are growing more complex all the time, would be speeded.

3) The centrally produced machine would be acceptable to any buyer, since PM products did not have to be designed to customer specifications.

4) Tariff barriers and import restrictions were becoming less severe as the EEC was reducing internal duties, and as the rest of Europe would probably follow suit.

5) Technical problems could be overcome, particularly if the transition were spread out over several years.

Despite the fact that the costs of either alternative could not be measured with even a fair degree of accuracy, PM proceeded with rationalization. The process took 12 to 24 months, involved tremendous cost, and, needless to say, implementation was extremely difficult. But the morale problems were easier than expected and, importantly, the change has proved profitable.

In theory, International Production Integration will normally pass through three stages:

1) A company with assembly units in several markets will find that certain components can be more economically supplied from various other sources rather than having them all shipped from the principal manufacturing site, be it in the US or abroad. Example: a pharmaceutical manufacturer shipping 10 base chemicals to a Pakistan processing operation finds it more profitable to ship one basic from India, two from the UK, and the rest from its US facilities, rather than all from the US.

2) IPI will then lead to the second stage--to the company deciding on only one supply source in the world for each component and supplying all assembly operations, US and abroad, from these units. Example: the pharmaceutical firm acquires or builds plants in India and the UK for those base chemicals best made there, cutting out the marginal US sources, and thus centralizing manufacture of each basic chemical in one place.

3) Finally, in the third stage, one plant (or a small number of regional plants) will be chosen to produce each product for the world, doing away with all assembly units, and shipping the components from their most advantageous source to that location. As many components as possible would be made at that plant. Example: the pharmaceutical firm supplies world products from the Pakistan, India, UK, and US plants.

Some companies will not find it economical to go beyond the second stage. Ford, for example, is today operating in Stage Two, but, because of the nature of its product, it is doubtful if Stage Three of IPI (i.e., one plant for each product) will ever be reached; although plans do call for concentration of tractor and heavy truck production in England to supply all of Europe and, possibly, in the years to come, the world.

The IBM World Trade Corporation has already advanced into Stage Three of IPI. Because of high import duties and currency blocks, IBM also started out by manufacturing components in a multiplicity of locations. Parts were shipped from country to country (duties were lower on parts than on finished goods), and every plant carried on assembly operations.

Like Process Machinery, Inc., the manufacture of electric typewriter parts was split among nine European countries. In each of these countries the IBM plant had an assembly line for electric typewriters. While inefficient, the system permitted market penetration. This was the Second Stage of IPI where components are made at various plants.

But as trade restrictions began to relax, IBM began to implement its "product by plant" program. Its ultimate aim is to switch from the manufacture and assembly of the same product at several locations to the manufacture of each product in only one location. Electric typewriter production is now in two plants--and eventually there will be only one.

Similarly, manufacture of sorters is being concentrated in the UK, electronic calculators in the Netherlands, large electronic systems in France. The new plant going up in India will supply unit record equipment for the whole Asia and Pacific area, and hopefully for the world as time goes on.

IBM estimated in 1960 that its IPI efforts over the next five years would enable production to continue to increase at 20 per cent a year, while the number of manufacturing employees would rise by only 5 per cent yearly, thus allowing big productivity gains. It is reported that its European IPI efforts have cut delivery costs by 50 per cent.

IBM maintains maximum IPI flexibility. While certain plants are now assigned specific products, these may be changed. What is now manufactured in the German plant may be switched to the French plant and vice versa, if profit or other factors dictate. The existing machinery in each plant is capable of making components for many products, with only minor changes. Thus, at the same time, IBM has created a situation permitting rapid, economical future shifts in production, is doing this at minimum cost of maintaining the necessary facilities in every country, and is achieving product specialization now at minimum reorganization cost to take advantage of the savings of mass production in a mass market.

Time, unfortunately, does not permit more case examples. Dealing on a daily basis with over a hundred globally-minded US and European firms, as my firm does, I can say with conviction, however, that these cases are typical rather than atypical; that smaller corporations with annual world sales of from $10 to $50 million are utilizing properly planned IPI as a tool for insuring maximum world-market penetration as effectively as--indeed, in many cases even more effectively than--the large grants of industry.

IPI's advantages, I believe, are obvious: the longest possible production runs and the concentration of capital equipment and highly specialized skills spell the lowest possible unit costs. Products or components requiring high labor content can be made in areas of low labor cost, such as Hong Kong or Taiwan, Pakistan or India, Mexico or Colombo. Production of sophisticated items can be located closer to the European and US markets while the manufacture of "obsolescing" products can be shifted, as one Los Angeles company is already doing on a planned basis, to lesser developed countries where a developing rather than a declining market exists. The declining or marginal markets continue to be served via exports from the new production location.

INTERNATIONAL OWNERSHIP

Earlier in this talk, I indicated that a true international corporation is one that is owned internationally. The notion that US citizens can retain--or these days even acquire--the total ownership of worldwide industrial empires is unrealistic, even if desirable. But joint ownership of individual subsidiaries, which is popular in many countries around the world and increasingly demanded by some governments, creates many conflicts of interests. Importantly, local participation in a local subsidiary has the effect of preventing that rationalization of production, marketing, and financial arrangements for the worldwide enterprise which, of course, is its principal reason for being. As the President of The Singer Company, Donald P. Kircher, recently remarked: "It is not difficult to visualize the impeding effect on a worldwide enterprise such as Singer, which at last count operated in about 180 foreign jurisdictions, of a general requirement that the operating unit of the company in each of these foreign jurisdictions must be partially owned by nationals of that country."

The solution which a few pioneering US corporations are finding to this problem is exchanging the minority shares held by local nationals in their foreign subsidiaries for shares in the parent US company. Others are acquiring control of foreign companies by swapping stock or by creating a new worldwide controlling company in which their former foreign partners in local subsidiaries hold shares. The effect is the same--all shareholders, regardless of nationality or residence, become partners with common goals in a total world enterprise.

In concluding, gentlemen, I would like to say that what I have been talking about concerns not only the world of tomorrow, but the world of today--your careers, your company's present and future.

SIMULATION FOR PLANNING AND CONTROL OF JOB SHOP OPERATIONS

Earl LeGrande
Operations Analyst
Hughes Aircraft Company
El Segundo, California

The organization of this paper is intended to:

1) Discuss the application of simulation to job shop operations.

2) Describe a simulation system that was developed at the El Segundo Division of Hughes Aircraft Company (using the IBM Job Shop Simulator) to process actual data from an existing mechanized production control system.

3) Describe the recent development of a day-to-day simulator for short-range visibility of fabrication shop operations at the El Segundo Division.

Much of the information given in points (1) and (2) has been published under the title of "The Development of a Factory Simulation System Using Actual Operating Data" in Management Technology, vol. 3, no. 1, May 1963.

SIMULATION IN THE JOB SHOP

Characteristics of a Job Shop

A job shop type of operation can be characterized by:

1) a variable product mix,

2) the physical arrangement of equipment,

3) the large number of possible paths through which jobs can flow, and

4) the information and decision rules required for operation.

The product mix in a job shop is highly unstable. Because of this, the work must be planned as individual orders, and equipment must be located so that a large variety of orders can be processed. Equipment is organized into functional work centers. Each work center is composed of equipment capable of performing the same operation. Due to the variable product mix and the physical arrangement of equipment, a large number of possible paths of order flow develop. Theoretically, any sequence of operations from one work center to another is possible. Information must flow in such a way that the individual orders can be planned, scheduled, and controlled. Decisions must be made pertaining to the sequence of operations on each order, where each operation should be performed, the scheduling of orders, and the assignment to a particular machine of one order out of all those waiting for the machine (i.e., dispatching).

Job Shop Problems

The basic problem of job shop operation is one of minimizing the sum of the costs of carrying in-process inventory, having idle machine or labor capacity, and meeting specified order-completion dates. To have a high degree of labor and machine utilization we would need much work waiting so that no machine or operator was ever idle. This would tend to result in higher inventory carrying costs and poor schedule performance if the orders had specified due dates. To have orders meet their completion dates we would need enough machine and labor capacity so that orders could be processed without delay. This, in turn, would result in lower machine and labor utilization.

The operating characteristics of a job shop contribute to many problems. Each order must be planned and controlled so that specified completion dates can be met. A large degree of shop interaction exists due to the high variety of orders, variable processing times, machine breakdowns, and the expediting of special orders. This interaction causes certain work centers to become critical, and waiting lines form. Orders that are held up at one point are affecting future work centers through which they must pass. Therefore, orders must be scheduled with an allowance for waiting and they must be dispatched in such a way that the schedules will tend to be met. Because of the high degree of interaction, the amount of time to allow as wait time for any one order at any one work center is practically impossible to predict. This affects the accuracy of the scheduling procedure and hence the entire job shop operation.

Definition of Simulation

Simulation can be defined as the exploration of various courses of action in a decision-making situation, and the anticipation of the consequences of each without actually trying them out in the real world. If various alternatives are tried in the real world, this then becomes a process of trial and error and not simulation.

Hence, in simulation, it is essential that alternative courses of action are explored before the decision is made.

In simulating, we need three basic elements:

1) A decision-making situation. There must exist an opportunity for decision-making with various courses of action possible.

2) A model. The model must reflect how the environment will behave under a given decision. It must be able to predict the effects that a decision will produce in the environment and how the environment will react to the decision.

3) A manipulative device. A device is needed that can manipulate decision and model information in such a way that the effects of a given decision can be computed quickly and accurately.

How Simulation Can Assist in Job Shop Management

The technique of simulation can help establish a set of conditions under which we anticipate that the various costs of operating the job shop will be optimized as much as possible. Simulation will allow management to pretest operating decisions; that is, test possible decisions in the simulator instead of in the actual shop situation. By using an electronic computer this evaluation can be done in a very short time compared to the time it takes to evaluate an actual decision in the real world. If we start with a set of given conditions and orders, we can simulate and anticipate the outcome of running the jobs under these conditions. This anticipation will undoubtedly show trouble spots (bottlenecks, overloaded areas, etc.). Next, taking these trouble spots into consideration, management can make a decision which is expected to relieve the situation (increase manpower and/or machine capacity, use overtime, subcontract, vary the order releases, reschedule orders, reroute orders, etc.). However, instead of making this decision in the actual shop and then making another decision to relieve resulting trouble areas, management can pretest several decisions in the simulator and pick the set of decisions that appears to supply "best" results. The first decision that management makes may just move the trouble spots; but through repeated trial decisions in the simulator a best set of conditions can be established through manipulation of the controllable factors.

The effective use of job shop simulation can assist management specifically in the following ways:

1) To establish more realistic scheduling wait times:

Most scheduling procedures use wait times that are some kind of gross average. Through the simulation process, an average wait time can be determined for each machine group based on current or expected orders. The wait times derived by simulation will be different for each machine group depending on the load and the average order-processing time at that machine group. By use of these simulation wait times in scheduling, a better picture of the actual order-make span can be obtained.

2) To establish more realistic order schedules:

The wait times derived from simulation as described above can be used in the scheduling procedure. Most scheduling procedures assume an unlimited shop capacity. However, through simulation we can see where trouble spots and overloads will occur and schedule accordingly, since the wait times computed in simulation will contain the effects of overloaded and underloaded areas.

3) To evaluate the effects of various dispatch rules:

Under a given set of conditions, various dispatch rules can be used in simulation to determine the effect of each on order completion, inventory costs, and other criteria. Hence, for a given set of conditions management can choose the priority rule which best meets its objectives.

4) To forecast shop load:

Since the estimated wait times will increase in accuracy, so will a shop-load analysis. We now have a more realistic estimate of when a job will arrive at a particular machine group and how long it will stay there.

5) To plan equipment layout.

The order analysis and shop-flow analysis of the El Segundo Simulation System (described in the next section) can be used in planning the layout of new equipment. If the types of future orders can be forecast, "chains" of routing will build up and the machine groups of these chains can be located in close proximity.

6) To test various sets of operating decisions.

Some of management's decisions have been mentioned in the preceding five points. However, there are other decisions that management can test by simulation. Through simulation, management can evaluate manpower and machine utilization and pinpoint areas of excess and inadequate capacity under given conditions. Upon the appearance of trouble areas, management can survey the effects of working extra shifts, adding men to or deleting them from the labor force, adding or removing equipment of specific types, subcontracting certain types of work, changing the way in which orders are released, and changing the order mix.

THE EL SEGUNDO SIMULATION SYSTEM

The El Segundo Division is one of the major manufacturing divisions of Hughes Aircraft Company, a producer of military electronic systems. Simulation was selected as a tool to assist in the management of the Fabrication Shop at El Segundo. This shop consists of five interacting sections: Machine Shop, Sheet Metal Shop, Processing (Plating, Heat Treating, etc.), Waveguide Manufacturing and Tool Manufacturing. Approximately 1,000 machines and work stations and 400-500 men are required for the fabrication operation. From 100-150 shop orders are processed per day with approximately 1,800-2,500 orders in process at any one time. For simulation purposes, the resources of the Fabrication Shop were organized into 115 machine groups and 47 labor classes.

The heart of the El Segundo Simulation System is the IBM Job Shop Simulator program. The original model was developed jointly by IBM, Data Systems Division, and General Electric Company personnel for simulation in the Large Steam Turbine Generator Department of General Electric at Schenectady, New York. This was originally an IBM 704 program which has been rewritten for the IBM 7090.

General characteristics of the Job Shop Simulator are illustrated in figure 1. The simulation section is essentially for data handling. The computer releases orders, assigns orders to available men and machines, follows orders through the shop, and keeps track of much data to be used in evaluating the anticipated results of operating the job shop under the given set of conditions. It must be stressed that the simulator illustrates the dynamics of the job shop situation. It considers the interaction of many factors. In direct contrast to a scheduling procedure, simulation does not use assumed wait times to process orders but attempts to tell us how long orders can be expected to wait at each machine group. It is this process of "playing through" the simulation period which illustrates the effects of operating a job shop under a given set of conditions over a future time period.

Figure 2 shows a general flow diagram of the El Segundo Simulation System. Order input data is taken directly from IBM disc files of the El Segundo Data Processing System, transposed to the form required for simulation, and supplied with other input data to the simulator.

Actual active or "in-process" orders are used to set up the shop in its initial condition. Actual nonreleased or "future" orders are analyzed to get their characteristics and then artificial nonreleased orders are generated for simulation. This must be done because there are not enough future orders in the disc files to carry out a simulation for as long a time span as is generally desired. If enough future orders existed, then these would be used directly.

The results of simulating can be evaluated and operating decisions revised to try alternate simulations and eventually come up with a set of operating decisions which is anticipated to best meet management's objectives.

Samples of the output reports are shown in figures 3 through 6. Figure 3 gives two samples of machine-group information. Here the performance of a particular machine group over a period of time can be seen quickly. For each machine group we can see how we would schedule the load, how we can expect to utilize the equipment, how many orders can be expected to arrive and depart, how long the waiting line should be, how much time orders should have to spend waiting, and the yearly inventory carrying cost we could expect if conditions continued for a year as they have in the simulation periods.

Part of figure 4 gives an example of machine-group information for the total shop and is simply an accumulation of the individual machine-group information. This can be used in observing expected total shop performance. The remaining part of figure 4 shows the expected total labor utilization.

Figure 5 contains information pertaining to the expected performance of labor class 3. For example, 90.4 per cent of labor class 3 was used in the first period; a total of 285 manhours, with 202 of these used in machine group 5 and 83 in machine group 6. Also included is information showing the percent of machine capacity used for each machine group. To see whether more manpower alone will help relieve a trouble area we must also look to see if machines are available or if we may have to add machine capacity also. In other words, is our capacity labor limited, are our machines limited, or both.

Figure 6 shows how we can expect orders to be completed in relation to their planned (scheduled) due date. The total orders completed are divided into those that were released to the shop "on time" and "late." Late releases are those orders that had a scheduled start date earlier than their actual release date. The time scale at the top of the report shows how early (E) or late (L) orders were completed in simulation, with the 0-line showing orders completed exactly on their planned due date. From this information, a distribution of completions about an "on time" point can be constructed.

Results of and conclusions from the development of the El Segundo Simulation System were:

1) The Simulation System is valuable as a study tool for fabrication shop management.

2) The size of the shop simulated at El Segundo taxes the memory of the 7090 computer and, depending on the number of orders passing through the shop, the 7090 may or may not be sufficient.

3) Simulation of the fabrication shop was successful when releasing approximately 130 orders per day with about 1800 orders in process. However, when the order flow is much above this the 7090 memory is not sufficient.

4) By reducing the actual order load a study of dispatch rules was conducted. The results of this study are presented in the previously cited article.

5) A need was recognized in the fabrication shop for short-range visibility of order flow. It was decided to pursue the development of a day-to-day simulator to operate from actual order data (maintaining work order identity) and to be processed on an IBM 1410-1301 installation at the El Segundo Division.

A DAY-TO-DAY SIMULATOR

This simulator program has been developed by a colleague, Harry Steinhoff, at the El Segundo Division, and as of this time has not been published. The program is operative and waiting for other changes in the mechanized production control system before being installed about January, 1964.

A need existed within the fabrication shop for operating personnel to gain short-range visibility of order flow. This is a critical problem due to the volume of engineering changes and orders being "held" for planning, tooling, engineering, etc., and the necessity of expediting "hot" orders (i.e., those orders which may move through several operations in one day). The task was to develop a simulator economical enough to operate daily to give the next few days' expected order flow. It was felt that this program should be run daily since engineering changes, etc., have a great influence on the expected status of the shop after even one day.

Within the El Segundo mechanized production-control system, fabrication order status (i.e., location and remaining operations) is updated daily after the second shift. Using this current status, the day-to-day simulator will keep track of actual orders and give output as to what orders can be expected at which machine groups, when these orders can be expected to arrive, and the relative priorities of each order. This has been done for a normal one-shift load (i.e., 100 orders being released, 1200 orders in process, and 850 moves per shift) in approximately 30 minutes of 1410-1301 time. However, the time parameter is variable and simulation can be carried out as far into the future as we have actual orders in the file. A general diagram of the day-to-day simulator is given in figure 7.

Output of the day-to-day simulator may be presented as operating statistics or shop reports. Statistics can be developed relating to shop load by machine group, machine and labor utilization, the number of orders arriving and departing at each machine group, how long orders wait, the length of queues, and the cost of carrying the work in process.

The intended shop-report output at this time is a list for each machine group, similar to figure 8, to be supplied to fabrication shop operating personnel. This has been called an Order Schedule Report and specifies the jobs that are located in the machine group at the beginning of the shift, the jobs that are expected to arrive, during the period being simulated, when these jobs are expected to arrive, where they will be coming from, and a relative priority of the present and expected jobs. The foreman or a dispatcher will use this listing to gain visibility in expediting jobs, making sure tooling is available, and so forth.

The important point in developing the day-to-day simulator is that the output was requested by operating personnel and simulation proved to be a technique whereby the desired information was attainable.

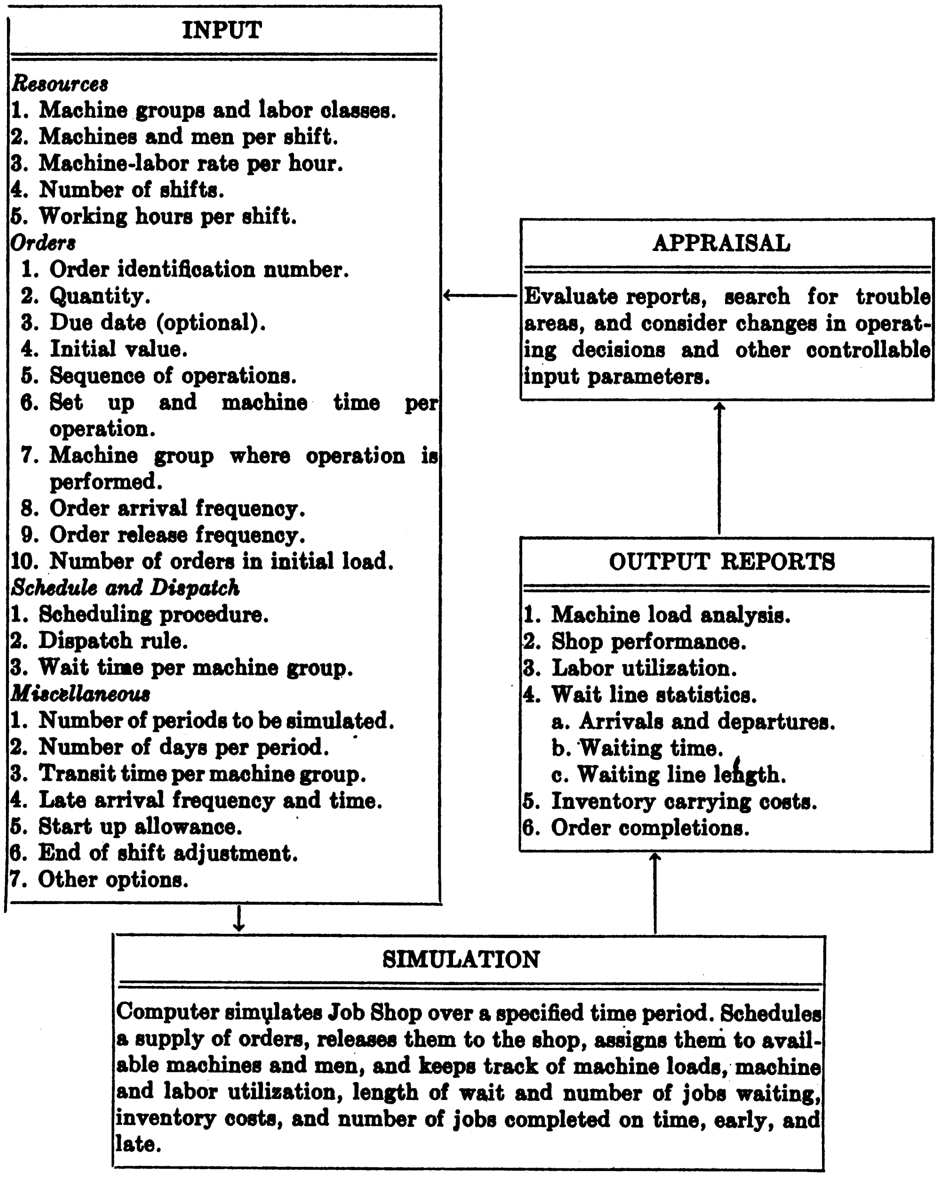


Figure 1. Characteristics of the Job Shop Simulator

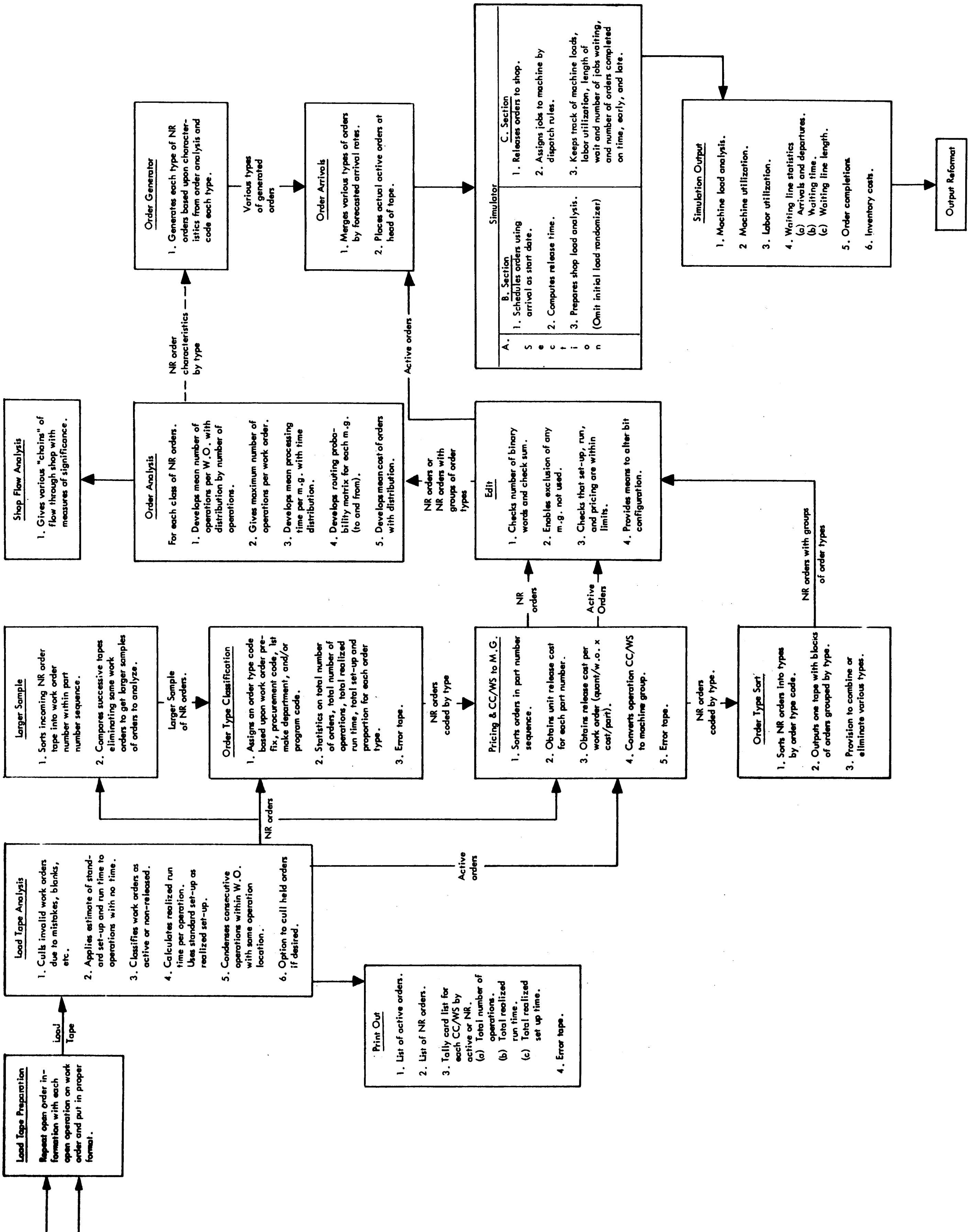


Figure 2. The El Segundo Job Shop Simulation System

SIMULATION MACHINE GROUP NO. 5   SHOP MACHINE GROUP NO. 5   DESCRIPTION – TURRET LATHES TO 1½
AVAILABLE MACHINE CAPACITY? HRS. 210   NO. OF MACHINES – 3   LABOR CLASS – 3   MEN PER SHIFT – 6, 3
INITIAL ORDERS AT THIS MACHINE GROUP – 23   INTEREST RATE FOR INVENTORY CARRYING COST – 10.0 PCT.

PERIOD	LOAD HRS.	LOAD RATIO	UTIL. HRS.	UTIL. RATIO	Q ARRIV.	Q DEPART.	Q TIME DAYS	AVER. Q	INV. CARRYING COST PER ANNUM Q TIME	MACH. TIME	RATIO
1	472	2.249	202	.963	41	20	.739	31.9	1481	181	8.172
2	251	1.196	189	.900	35	22	1.276	45.1	2097	126	16.607
3	322	1.532	189	.901	39	26	1.466	62.1	2989	206	14.500
4	362	1.725	179	.851	31	27	1.263	70.1	2903	113	25.707
5	367	1.745	165	.784	51	25	.829	87.0	3881	109	35.467
6	279	1.328	133	.634	36	16	1.052	109.4	4975	83	60.235
YTD	2053	1.629	1057	.839	256	136	1.122	67.6	3054	136	22.388

SIMULATION MACHINE GROUP NO. 6   SHOP MACHINE GROUP NO. 6   DESCRIPTION – TURRET LATHES OVER 1½
AVAILABLE MACHINE CAPACITY, HRS. – 210   NO. OF MACHINES – 3   LABOR CLASS – 3   MEN PER SHIFT – 6, 3
INITIAL ORDERS AT THIS MACHINE GROUP – 3   INTEREST RATE FOR INVENTORY CARRYING COST – 10.0 PCT.

PERIOD	LOAD HRS.	LOAD RATIO	UTIL. HRS.	UTIL. RATIO	Q ARRIV.	Q DEPART	Q TIME DAYS	AVER. Q	INV. CARRYING COST PER ANNUM Q TIME	MACH. TIME	RATIO
1	73	.347	83	.393	8	10	.343	1.2	42	33	1.267
2	83	.394	71	.337	12	9	.181	.8	29	50	.574
3	89	.425	82	.388	9	12	.284	1.0	75	67	1.116
4	160	.764	81	.386	8	7	.193	.5	21	64	.319
5	169	.804	124	.588	11	9	.200	.7	28	101	.276
6	105	.500	182	.866	7	7	.746	2.5	158	144	1.103
YTD	679	.539	621	.493	58	54	.312	1.1	59	76	.767

Figure 3. Sample Simulator Report

TOTALS FOR ALL MACHINE GROUPS   AVAILABLE MACHINE CAPACITY, HRS. – 46340   NO. OF MACH. – 662
INITIAL ORDERS IN THE SHOP – 1906   INTEREST RATE – 10.0 PCT.   MEN PER SHIFT – 464, 97

PERIOD	LOAD HRS.	LOAD RATIO	UTIL. HRS.	UTIL. RATIO	Q ARRIV.	Q DEPART.	Q TIME DAYS	AVER. Q	INV. CARRYING COST PER ANNUM Q TIME	MACH. TIME	RATIO
1	14086	.304	14329	.309	2856	3381	.392	1321.2	153382	11559	13.270
2	13986	.302	11507	.248	2413	2522	.719	1138.6	148120	9692	15.282
3	12772	.276	11071	.239	2709	2416	.519	1257.5	120348	8645	13.921
4	14859	.321	10607	.229	2290	2188	.571	1450.7	100842	8405	11.998
5	14231	.307	10981	.237	2535	2288	.392	1634.0	105628	9732	10.853
6	17793	.384	9713	.210	2009	1947	.759	1790.5	105910	8341	12.698
YTD	87727	.316	68208	.245	16718	14742	.544	1432.1	122372	9396	13.024

TOTAL FOR ALL LABOR CLASSES   AVAILABLE MAN-HOURS – 19635

PERIOD	1	2	3	4	5	6	YTD
UTILIZ. MAN-HOURS	14329	11507	11071	10607	10981	9713	68208
UTILIZ. RATIO	0.730	0.586	0.564	0.540	0.559	0.495	0.579

Figure 4. Sample Simulation Report

LABOR CLASS NO. 3 - ASSEMBLY PERSONNEL								AVAILABLE MAN-HOURS - 315
PERIOD		1	2	3	4	5	6	YTD
UTILIZ. MAN-HOURS		285	260	271	260	289	315	1679
UTILIZ. RATIO		0.904	0.826	0.860	0.825	0.916	1.000	0.888
HRS. BY MACHINE GROUP								
	5	202	189	189	179	165	133	1057
	6	83	71	82	81	124	182	621
UTILIZ. RAIO BY MACHINE GROUP								
	5	.963	.900	.901	.851	.784	.634	.839
	6	.393	.337	.386	.386	.556	.866	.493

Figure 5. Sample Simulator Report

ORDER COMPLETION REPORT

		EARLY COMPLETIONS, BY DAYS												LATE COMPLETIONS, BY DAYS										
PERIOD	RELEASE CATEGORY	OVER 30	26 TO 30	21 TO 25	16 TO 20	11 TO 15	6 TO 10	5	4	3	2	1	0	1	2	3	4	5	6 TO 10	11 TO 15	16 TO 20	21 TO 25	26 TO 30	OVER 30	TOTAL
1	ON TIME	11	8	13	19	44	97	18	13	47	25	17	3	2	1	-0	-0	-0	-0	-0	-0	-0	-0	-0	318
	LATE	29	10	9	20	39	96	21	35	38	36	46	51	62	30	74	53	34	29	-0	-0	-0	-0	-0	712
	TOTAL	40	18	22	39	83	193	39	48	85	61	63	54	64	31	74	53	34	29	-0	-0	-0	-0	-0	1030
2	ON TIME	18	7	6	17	20	52	14	5	13	13	9	6	5	4	1	6	2	1	-0	-0	-0	-0	-0	198
	LATE	22	11	11	19	22	62	14	19	15	20	28	28	29	22	26	35	19	39	9	-0	-0	-0	-0	461
	TOTAL	40	18	17	36	42	114	28	24	28	33	37	34	34	26	27	41	21	40	9	-0	-0	-0	-0	649
3	ON TIME	12	2	2	13	26	47	9	10	12	15	12	4	2	6	-0	4	-0	4	-0	-0	-0	-0	-0	180
	LATE	13	6	9	12	27	51	9	11	25	21	25	14	26	17	21	29	13	28	18	2	-0	-0	-0	377
	TOTAL	25	8	11	25	53	98	18	21	37	36	37	18	28	23	21	33	13	32	18	2	-0	-0	-0	557
4	ON TIME	6	2	4	7	17	37	6	8	7	11	2	1	3	1	1	1	-0	2	1	-0	-0	-0	-0	117
	LATE	7	4	7	13	32	32	14	15	10	12	20	29	27	9	29	19	10	17	7	6	-0	-0	-0	321
	TOTAL	13	6	11	20	49	69	20	23	17	23	22	30	20	10	30	20	10	19	8	6	-0	-0	-0	438
5	ON TIME	4	5	7	5	18	42	11	8	10	8	5	4	1	1	-0	-0	1	3	2	-0	-0	-0	-0	135
	LATE	9	4	3	15	24	38	9	13	14	12	17	18	22	16	26	32	7	12	7	6	4	-0	-0	308
	TOTAL	13	9	10	20	42	80	20	21	24	20	22	22	23	17	26	32	8	15	9	6	4	-0	-0	443
6	ON TIME	4	1	-0	9	9	32	9	6	8	5	3	2	-0	1	1	-0	1	3	2	1	2	1	-0	103
	LATE	6	2	6	7	16	37	3	7	5	15	14	23	17	10	11	22	6	10	5	9	6	7	1	245
	TOTAL	10	3	6	16	25	69	12	13	13	20	17	25	17	11	12	22	7	13	7	13	8	8	1	348
YTD	ON TIME	55	25	32	70	134	307	67	50	97	77	48	20	13	14	3	10	4	13	5	4	2	1	-0	1051
	LATE	86	37	45	86	160	316	70	100	107	116	150	163	183	104	187	191	89	135	46	25	10	7	1	2414
	TOTAL	141	62	77	156	294	623	137	150	204	193	198	183	196	118	190	201	93	148	51	29	12	8	1	3465

Figure 6. Sample Simulation Report

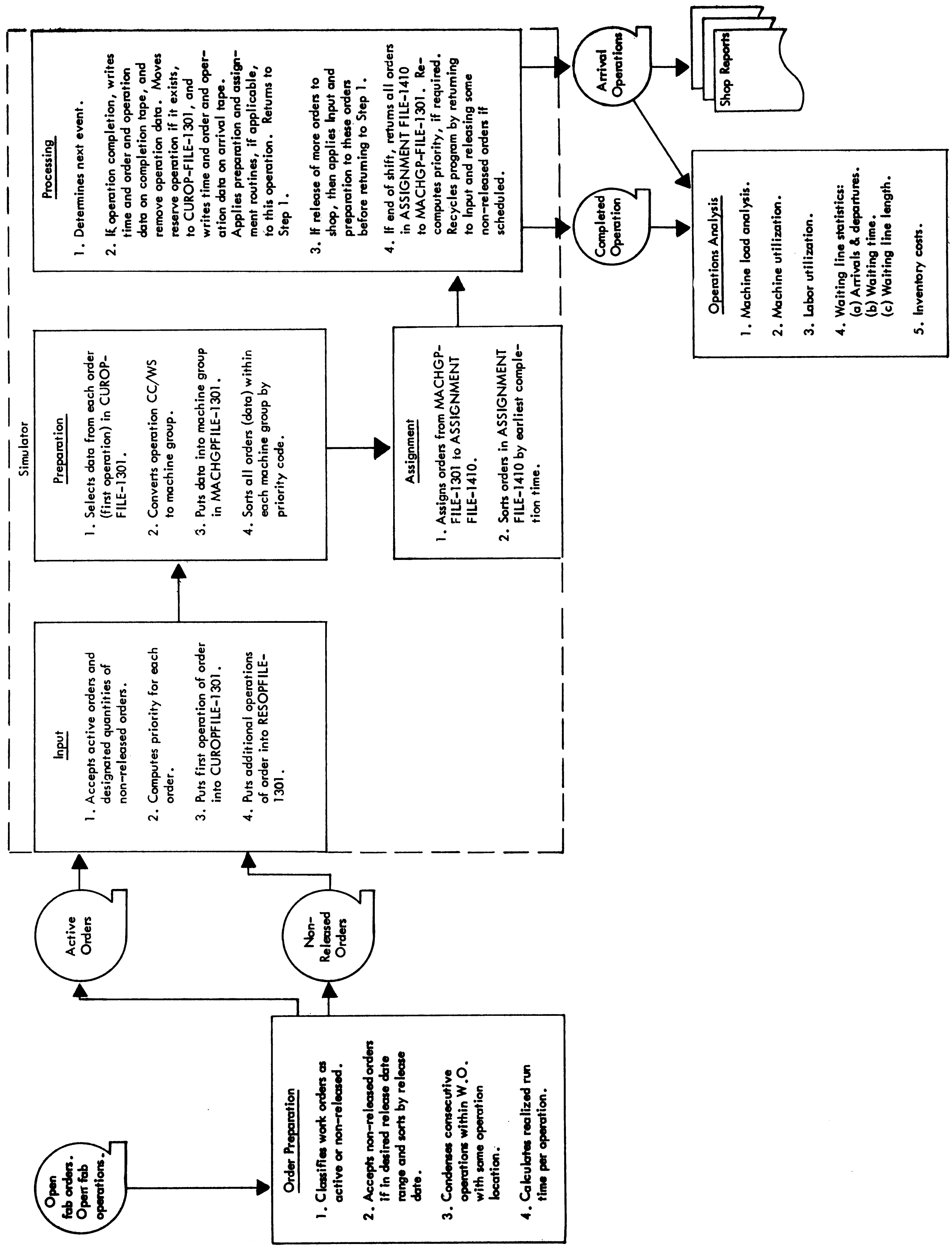


Figure 7. Day-to-Day Simulator System

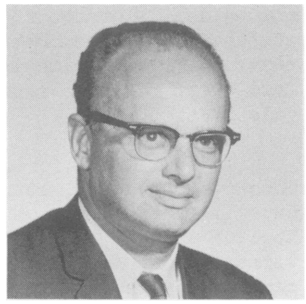
M-DAY 251 DATE Oct. 14 MACHINE GROUP 71-24

Priority Code	Part Number	Work Order Number	Previous Location	Expected Arrival	Standard Hours
ORDERS-IN-STATION					
10.0	80-446555	21-978605	79-33		18.4
2.1	2-297848-001	21-090929	71-92		1.0
4.5	435-170552	21-976600	79-51		16.9
7.9	90-439247	21-093345-01	79-51		2.0
INCOMING ORDERS					
M-Day 251		Date Oct. 14			
1.5	90-439247	21-092301	79-51	10:30	1.5
8.0	512189	26-976049	18-50	14:00	0.3
M-Day 252		Date Oct. 15			
6.0	454198	21-952400	79-51	8:00	28.1
M-Day 253		Date Oct. 16			
4.0	80-457173	21-960404	79-33	18:00	0.2
2.6	90-439256	21-953633	79-51	19:00	1.5

Figure 8. Sample Order Schedule Report, Day-to-Day Simulator System

SIMULATING WITH SIMSCRIPT*

Harry M. Markowitz
Consultant
The RAND Corporation
Santa Monica, California



Simulation is presently being used as an analysis and management tool in numerous fields such as manufacturing, logistics, economics, transportation, and military operations. Unfortunately, the development of simulation programs, using conventional programming techniques, can be extremely time consuming. The SIMSCRIPT programming system, on the other hand, is especially designed to facilitate the writing of simulation programs.

For the industrial engineer or operations research analyst, the SIMSCRIPT programming language serves as a convenient notation for formulating simulation models. For the programmer, it reduces programming time severalfold as compared to simulations written in FORTRAN and permits relatively easy program modification and expansion. If the analyst and programmer are not the same person, SIMSCRIPT greatly simplifies the problem of communication since the model and the computer program are written in a notation readily understood by both.

There are three aspects of SIMSCRIPT which enable it to reduce the programming time required for simulation. These are its world-view of the model to be simulated; its method of communicating to the computer the world to be simulated; and some features which are useful for programming in general, and thus for simulation programming in particular. In this paper, we will concentrate on the first two aspects--the SIMSCRIPT world-view, and its basic approach to simulation programming.

SIMSCRIPT'S WORLD-VIEW

SIMSCRIPT requires that the world to be simulated be structured in terms of the concepts listed in Figure 1.

STATUS	Entities
	  Temporary
	  Permanent
	Attributes
	Sets

EVENTS	Exogenous Endogenous

Figure 1. Basic Concepts in SIMSCRIPT World-View

As of any moment of time, the simulated world has a status characterized in terms of how many of which type of entities exist; what are the current values of their attributes; what sets the various entities belong to, and who are the members of the sets which they own. For the sake of programming efficiency, we make a distinction between temporary and permanent entities. Temporary entities can be created and destroyed (can appear and disappear) in the course of a simulation run. Permanent entities do not come and go, but stay with a run from start to finish.

We can illustrate the foregoing in terms of a simple job shop example. Within a shop, labor classes and machine groups might be treated as permanent entities; jobs as temporary entities. Respective attributes of these would be the number of idle machines in each machine group, the number of each kind of personnel, and the due date of each job. A set might be a collection of jobs waiting for processing by a machine from a particular machine group.

Part of the SIMSCRIPT world-view is an event--a point in time when status changes. Exogenous events are caused from outside the simulation process. To continue the job shop example, an exogenous event might be the arrival of a new job. Endogenous events are caused by prior occurrences inside the simulation, e.g., the completion of processing one stage of a job. Thus, as illustrated in Figure 2, during the course of the simulation the exogenous events (vertical arrows) occur at predetermined times, perhaps causing one or more subsequent endogenous events, which, in turn, may cause still other endogenous events.

The SIMSCRIPT supplied timing routine

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The SIMSCRIPT language[1] described in this paper was developed at The RAND Corporation to advance the "simulation art" generally, and to facilitate the writing of Air Force logistics simulators in particular.

The present paper was extracted from a RAND memorandum.[2]

automatically orders all events in time sequence so that the most imminent event occurs next. Simulated time in the model is advanced from event to event rather than at fixed intervals of time.

We will not formally define the basic concepts of entity, attribute, set, and event, but will rely mainly on their meaning in common English usage. The precise meaning of these terms, as far as SIMSCRIPT is concerned, is determined by the way they are used. Hence, we cannot understand what we call the SIMSCRIPT viewpoint until we see how a world to be simulated, conceived in these terms, is communicated to the computer.

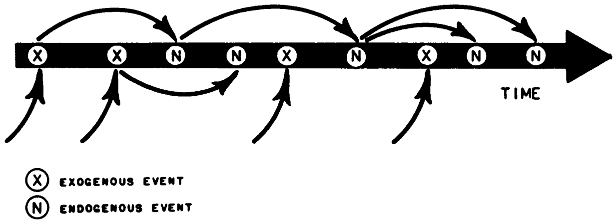


Figure 2 Schematic Representation of Exogenous and Endogenous Events through Time

Let us suppose, then, that an analyst familiar with the precise way we use our basic concepts can, in fact, conceive of a world to be simulated as containing entities of various kinds with their attributes and sets. He further conceives of this world as changing when certain types of events occur. How does he "tell it to SIMSCRIPT"?

THE SIMSCRIPT METHOD OF COMMUNICATION

In order to describe status, the analyst must fill out a Definition Form as illustrated in Figure 3. (We will get a closer look at the various panels of this form in subsequent figures.) On this form he must list, by name, each type of entity, each attribute, and each type of set distinguished in his simulated

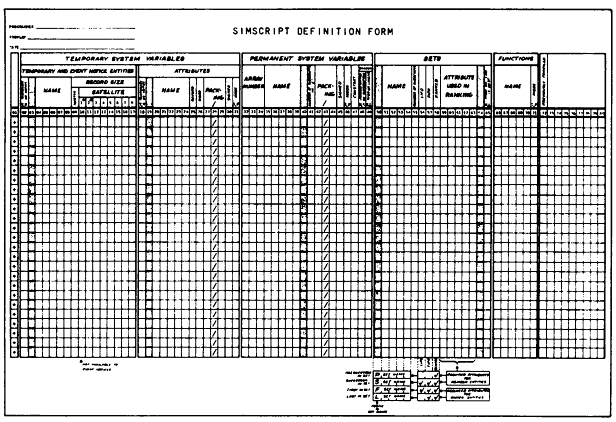


Figure 3 SIMSCRIPT Definition Form (reduced)

world. In addition, the user of SIMSCRIPT must provide a small amount of additional information such as the number of words of computer storage needed to store the values of the attributes of any temporary entity, and also where in the entity record the user would like each of the attributes to be stored.

The first panel of the definition form (Figure 4) informs SIMSCRIPT of the temporary entities and their attributes. According to the example presented in Figure 4, this particular simulation contains a type of temporary attribute called a JOB. A four-word record is used to store the current values of its attributes. Thus, if the programmer writes an event routine that says "CREATE JOB," four consecutive words of memory, not otherwise occupied, will be found and subsequently used to store the attributes of the particular job just created. The form also indicates that a temporary attribute called RECT (receipt time) is to be stored in the third word of a JOB record, in the second half of the word.

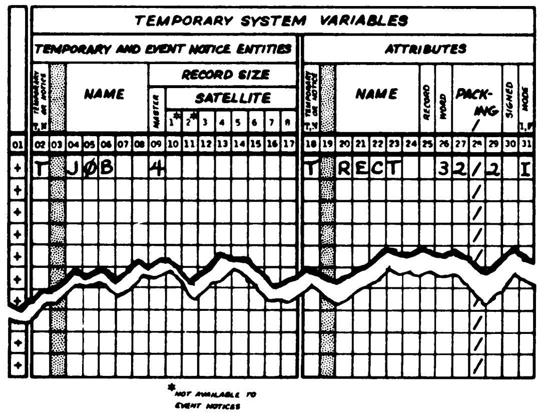


Figure 4 Example of Temporary Entities and Their Attributes Using First Panel of SIMSCRIPT Definition Form

The second panel of the definition form (Figure 5) is used to inform SIMSCRIPT about permanent entities and their attributes. Thus, according to the Figure 5 example, the system contains a permanent attribute called MG (short for machine group), there is an attribute called FREE (which represents the number of free machines in the machine group), and there is a random variable called FACTR (associated with each machine group).

Figure 6 shows the third panel, which is used for sets. The example has a set called QUE; the "X" in Column 58 indicates that it is a "ranked" set (rather than a first-in-first-out or last-in-first-out set). Columns 59 through 63 specify that the members of this set are to be ranked according to the attribute RECT. The L in Column 65 indicates that the low values of RECT are at the front end of the set.

Thus the names of the various types of entities, attributes, and sets to be distinguished

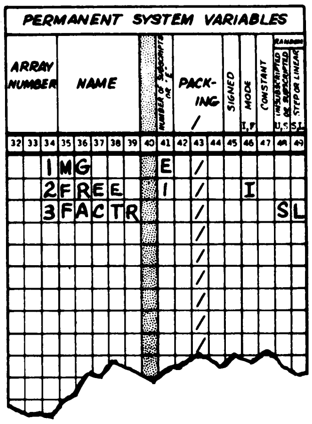


Figure 5 Example of Permanent Entities and Their Attributes Using Second Panel of SIMSCRIPT Definition Form

in the specific simulation are indicated on the definition form, together with information needed by SIMSCRIPT to process these properly.

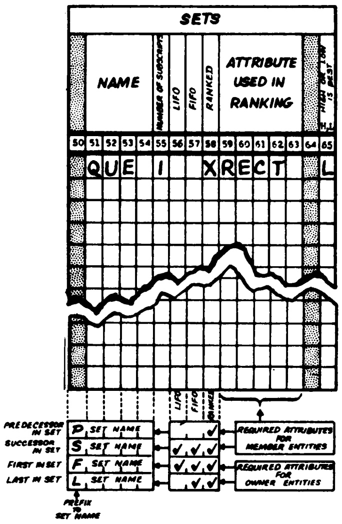


Figure 6 Example of Sets Using Third Panel of SIMSCRIPT Definition Form

The various types of events occurring in a simulated world are described to SIMSCRIPT by means of event routines written in the SIMSCRIPT source language. Figure 7 presents an example of such an event routine. This particular routine describes what occurs at an End of Process (here abbreviated EPROC) in one simple job shop simulator.

The SIMSCRIPT source program language is especially designed to allow the programmer to specify those operations which must typically be accomplished in event routines. These include the operations enumerated in Figure 8, namely, changing current status, causing (or cancelling) future events, processing decision rules, accumulating and summarizing information on how well

```
      STATEMENT
       ENDOGENOUS EVENT EPROC
       STORE ORDRP(EPROC) IN ORDER
       STORE MGPRC(EPROC) IN MG
       DESTROY EPROC
C      - DISPOSITION OF THE ORDER -
       IF ROUT(ORDER) IS EMPTY, GO TO 10
       CALL ARRVL(ORDER)
       GO TO 20
   10  LET CUMCT = CUMCT + TIME - DATE(ORDER)
       LET NORDR = NORDR + 1.0
       DESTROY ORDER
C      - DISPOSITION OF THE MACHINE -
   20  IF QUE(MG) IS EMPTY, GO TO 30
       REMOVE FIRST ORDER FROM QUE(MG)
       CALL ALLOC(MG, ORDER)
       ACCUMULATE NINQ(MG) INTO CUMQ(MG) SINCE TMQ(MG),
      X    POST NINQ(MG) - 1.0
       RETURN
   30  LET NOAVL(MG) = NOAVL(MG) + 1
       RETURN
       END
```

Figure 7 Endogenous Event Routine Describing the End Process for an Order at a Machine Group

the simulated system is doing, and displaying this information in a form intelligible to the human being. Let us consider briefly how SIMSCRIPT specifies each such action.

a) Change Status

b) Cause (or Cancel) Future Events

c) Process Decision Rules

d) Accumulate and Summarize Information

e) Display Results

Figure 8 Types of Operations Performed in Event Routines

CREATE JØB

DESTRØY JØB

LET RECT (JØB) = TIME

READ DUE (JØB)

FILE JØB IN QUE (MG)

REMØVE JØB FRØM QUE (MG)

REMØVE FIRST JØB FRØM QUE (MG)

Figure 9 Examples of Commands that Change Status

Since status consists of entities, attributes, and sets, the only ways it can change are if an entity is created or destroyed, a new value is read or computed for some attribute, or some entity gains or loses set membership. Actions of this sort are specified by the commands of CREATE, DESTROY, READ, LET, FILE, REMOVE, illustrated in Figure 9. Using these commands, the programmer tells SIMSCRIPT how status is to change when a particular kind of event occurs. Similarly, with the aid of the CAUSE and CANCEL statements, the programmer can specify how the occurrence of one event causes some subsequent event or cancels a previously scheduled event that has not yet occurred.

```
GØ TØ (10, 20, 25), X(I)

IF (A(B(I))GR(5), GØ TØ 20

DØ TØ 55, FØR EACH JØB ØF QUE(MG), WITH
(RECT(JØB)) LS (TIME-LEAD)

IF QUE (I) IS EMPTY,RETURN
```

Figure 10 Examples of the SIMSCRIPT Versions of Conventional Types of Control Commands

As we use it here, the phrase "decision rule" denotes any tests or calculations performed to determine how status will change or what events should be caused. To facilitate such decision calculations, SIMSCRIPT has a complement of arithmetic and control statements (some illustrated in Figure 10) somewhat similar to those contained in other recent programming languages. In addition, SIMSCRIPT has FIND MIN, FIND MAX, and FIND FIRST commands, illustrated in Figure 11, which are particularly suited to perform search-type operations frequently found in complex simulations. The case illustrated, for example, instructs the computer by a single FIND MIN statement to do the following:

> ... search over the set of machine groups (MG) served by a particular labor class (here SRVD is a SET duly defined on the definition form and LC is a labor class determined earlier in the routine). In this search, machine groups with no FREE machines are excluded, as are machine groups with no jobs in queue. Among all machine groups in the set with a free machine and something in queue, the one with lowest (best) priority is chosen. The variable MMG is set equal to the minimizing machine group, the variable MPRI is set equal to the minimum priority value. If, as can happen, there is no machine group that meets the conditions set forth in the FIND statement, the computer is instructed to go to Statement 50. Otherwise, it proceeds with the following command.

```
FIND MPRI = MIN ØF PRI(MG), FØR EACH MG ØF

SRVD(LC), WITH(FREE(MG))GR(0), WITH (FQUE(MG))

GR(0), WHERE MMG, IF NØNE, GØ TØ 50
```

Figure 11 Example Use of FIND MIN Command

Similarly, many fairly complex decision rules can frequently be described with a single FIND MIN, FIND MAX, or FIND FIRST command.

Accumulating information over time and summarizing it as of a particular point in simulated time is made easier by the use of ACCUMULATE and COMPUTE STATEMENTS, shown in Figure 12. The accumulate statement is used for taking an integral under a curve drawn over time; the use of the COMPUTE statement should be apparent from the example.

```
ACC FREE(MG) INTØ CFREE(MG) SINCE

   TFREE(MG), ADD 1.0

COMPUTE MX, SX = MEAN, STD-DEV ØF

   X(I), FØR I = (1)(N)
```

Figure 12 Examples of Accumulate and Compute Statements

Finally, the display of information is specified by means of the Report Generator. As illustrated in Figure 13, the programmer specifies the form, content, and row or column repetition desired on a report generator layout sheet. The left-hand side of this sheet is keypunched and then the right-hand side. From the resulting deck, SIMSCRIPT produces a report routine which can be called as required by any event routine or other subroutine of the simulation program.

In sum, the analyst must first conceive of the world to be simulated as having a STATUS consisting of ENTITIES of various types, with various attributes, set ownerships, and set memberships. Status changes when events take place. Once the world to be simulated is thus conceived, it is described to SIMSCRIPT by means of the definition form and event routines. On the definition form, the user notes the names of entities, attributes, and sets, plus a small amount of pertinent information concerning each. With the event routines, and their subroutines, the user describes the effects his various types of events have on the system. These event routines and subroutines are written in the SIMSCRIPT source language, which is particularly suited to instructing the computer to change current status, cause or cancel future events, process decision rules, and accumulate or summarize information. The report generator specifies how information should be displayed.

REFERENCES

1. SIMSCRIPT: A Simulation Programming Language, H. Markowitz, B. Hausner, H. Karr, Prentice-Hall, 1963.

2. "A Brief Review of SIMSCRIPT as a Simulating Technique," RM-3778-PR, August 1963, M. A. Geisler and H. M. Markowitz, The RAND Corporation.

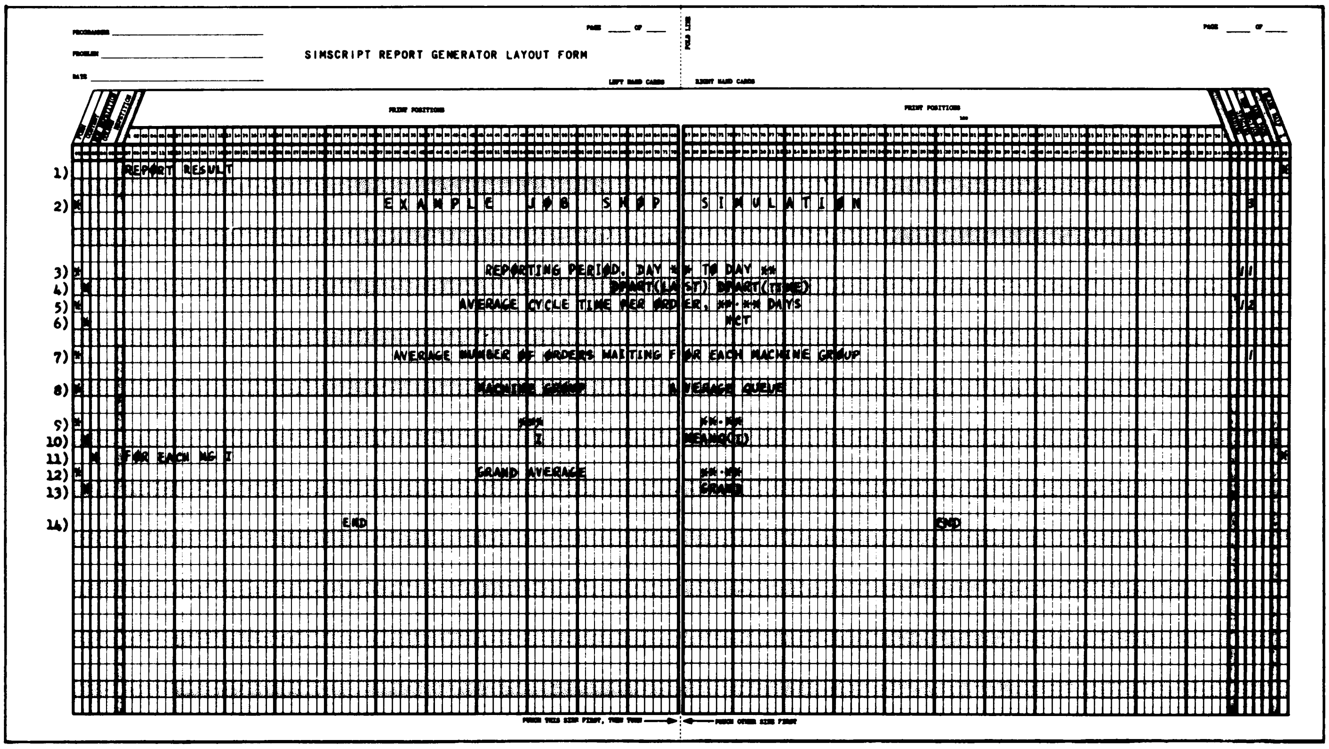


Figure 13 SIMSCRIPT Report Generator Layout Form (reduced)

CAN AMERICA COMPETE AGAINST THE WORLD?

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

There are now about three billion human beings in the world, and approximately 6.4 per cent or 190 million of them live in the United States.

Each one of the 2,810,000,000 other persons who live outside our country in 53,831,000 square miles of land are very similar to those who live in the small area of 3,675,000 square miles here in our 50 states located in North America.

We all have to cover our bodies in varying ways with clothes; have some form of shelter; raise our children; have transportation for ourselves and the goods we use or produce; have light to dispel the darkness, heat to combat the cold, and cooling to dispel excess heat.

Every one of us has to breathe air; live in a narrow temperature range of about a hundred degrees; use a certain amount of fresh water each day and eat enough food to maintain life.

People need to communicate with each other, so everyone speaks some language, and there are usually customs or laws of some sort to regulate the individual in his contacts with other individuals.

Therefore, as a person, one of us in the United States is just about the same kind of living being as we'll find in any other part of the world.

In other words, people are people and most of them--or 93.6 per cent of the whole group --live in other places.

These observations may come as a surprise to my fellow countrymen, but I can assure you they are not my opinion but merely the facts compiled by the world statisticians.

Somewhere, some distortions of viewpoint have become all too common in the minds of the average American citizen.

There seems to be a pretty general feeling that only in the United States can things be done--and with our advanced methods of communication, such as our press, the radio, television, etc., coordinated by our professionals in the publicity and advertising fields, we now have an automatic self-sustaining chain reaction that develops its own fuel to completely assure everyone in our country that his already high opinion of himself and his fellow countrymen, is, if anything, on the low side.

Living our waking moments in a deluge of so-called better filters for our cigarettes; long-lasting razor blades; new automobiles; improved household appliances; sudsier detergents; slicker hair oil; wonderful vacations; and all the other things you can buy now and pay for later. We're certainly not running out of ammunition for ourselves.

It's no wonder that today each man, woman, and child in every part of this fair land is completely convinced that we in this country are IT and everyone else is different.

Yes--they're not as capable, not as well educated, civilized, or productive in other countries as we are here at home.

This unfortunate outlook on our neighbors in the rest of the world is just not supported by conditions as they exist today in a growing number of places on this planet.

The present leaders in our country's communities probably spent some time overseas in the last war, which ended some 20 years ago.

They saw foreign lands ravaged by war, with complete shortages of all kinds; all in all, their memories of conditions in foreign countries in that formative period of their lives were not conducive to giving them a very high rating as compared to their own country.

And furthermore, upon these men's return home, their impressions were further strengthened, because the contrast was even greater at that time than they could believe while they were away on foreign soil.

The very conditions that created this image of our superiority in the early '40's were the seeds from which the improvements and growth abroad has come. And from this destruction, the Phoenix of foreign modernization has arisen.

As they cleared the rubble of destruction in the war-torn countries, they physically and mentally plowed under old things and ideas that were worn out, and rebuilt anew with the latest and best plants and equipment of the day.

In other words, they were able to start

afresh at the place where we in this country left off.

In our foreign aid programs we made available our latest, and provided the most modern know-how. We did this vigorously and spent billions upon billions of dollars--and a dollar in those days purchased almost 50 per cent more in goods and services than the same dollar buys today! Our foreign aid so far adds up to 108 billion dollars!

The facts are that now, in the foreign industrial nations, the average age of their plants and machinery is much less than that of our old plants and machinery right here at home. Ten years ago 56 per cent of our machine tools were more than 10 years old--and today 64 per cent of our machine tools are more than 10 years old--only 36 per cent of them are less than 10 years old!

They have the new modern facilities while now we have the old ones!

Their governments have had a more enlightened outlook on the operation of private business enterprise in their helpful and constructive attitude toward business, encouraging business owners in every way to build up their industry and provide jobs in the private economy.

Taxes have been less on industry. There have been more liberal depreciation allowances, and foreign governments have further helped industry in their country to do a better job by providing a more favorable business climate with fewer restrictions and regulations, and less general business harassment than we have had in this country.

In the last 15 years I personally have seen the phenomenal growth of better conditions outside our country on some 50 trips I have taken abroad in the operation of our business.

I never fail to return a more respectful person than I was when I left.

Wherever there are people, they can do things. And, believe me, today they are doing things and doing them in a most enlightened manner.

I have found that we have no monopoly on education--and in my travels I meet well-educated people. Usually people in management speak several languages fluently, and usually one of them is English. This always embarrasses me, and I ask myself, "What was wrong--after going to private schools and an excellent college, where I was subjected to Latin, French, and Spanish, why can't I speak the languages I studied?"

Fortunately for my own peace of mind, my friends who took the same courses can't speak the languages either! I was afraid Hallowell was alone, but now I am forced to the sad conclusion that abroad the method of foreign language instruction is, or at least was, superior to that in our own country.

I find that a university degree in some European countries seems to be about equivalent to a Master's Degree in our country. An Apprentice there has a better grounding in the fundamentals of his job. The intellectual discipline of a person who has been educated there, at any level, seems to be stronger than I have found here.

Yes, our foreign competitors are a well-educated and highly enlightened group. And so are their workers!

In Europe, as in this country, we are suppliers to most of the machine tool manufacturers. In one way or another, they use the products we make in our plants abroad. Therefore, it follows that away from home we are diversified users of the machines made by our customers who are users of our products in foreign countries.

We find that these machines do a most effective job for our tooling and production needs.

With the employees in our foreign plants using the facilities made in foreign countries, our output per man hour seems to compare very favorably with the same job being run in our American plants with American employees producing on American-made machine tools.

Of course there are exceptions, but there are exceptions both ways: higher in some cases and lower in others. But by and large, over-all, we find very little difference.

For years I have been visiting our foreign customers' exhibits in the European machine tool shows which are held every year. These shows are much larger than any ever held in this country, because there are many more machine tool manufacturers producing and exhibiting. I recall that in a recent show there were 140 manufacturers of lathes along with hundreds and hundreds of other different machine makers.

Several years ago at the show in Hanover, Germany, there were more than 25 miles of aisles --an absolutely overwhelming display of mechanical progress. As in any collection, there were all kinds, types, and grades of machine tools shown and running. An enormous planer was in operation--larger than any I had ever seen, so large, in fact, that on its main control console there was a television screen that could be connected with several television cameras located at the far parts of this giant machine so the operator could see the graduations on the several scales as he worked the remote controls. And this was six years ago!

From this monster, the scale of size went down to machinery making watch gears so small that one needed a magnifying glass to see the work being produced.

In this exhibition there were unique and unusual approaches to many machining problems, showing the results of an enlightened, creative, and fresh approach to many things that we have come to take for granted in this country.

In essence, it is a very uninformed person who today can feel that, in the design, building, and use of machine tools, we have any competitive advantage over the producers and users of these items in other countries.

I have the greatest respect for American machine tools whose manufacturers we supply from our American plants in this country--and in turn our American plants are equipped with American-made tools. But I also have great respect for those in use abroad, in plants that are nowadays more modern than most of those in this country!

There are those who may feel that competition is keener here in the United States than in other parts of the world. With this I would disagree--they've been doing business longer abroad, and over there have a heritage of hundreds and hundreds of years of trying to buy at the lowest price.

There are many more companies doing business and many more suppliers, because, as a rule, the size of the average business is smaller than ours in this country.

On the other hand, some foreign companies are larger than the largest we have in a comparable field in our United States. For instance:

Company	Employees
Royal Dutch/Shell (GB & Neth.)	225,000
Unilever (GB & Neth.)	292,700
Nestle (Switz.)	81,469
Imperial Chemical Ind. (GB)	93,909*
Philips Gloeilampen (Neth.)	233,000
Siemens (Ger.)	239,700
Fiat (It.)	119,838
Daimler-Benz (Ger.)	99,740
Hitachi (Jap.)	112,356
Hawker Siddeley (GB)	127,000
Tokyo Shibaura Electric (Jap.)	106,380
Tube Investments (GB)	62,000
Brown, Boveri (Switz.)	76,456
Courtaulds (GB)	60,000
Aluminium (Can.)	49,855
SKF (Swed.)	55,570

* UK only

1963 figures

In management practices abroad I find two types: Those equal to or ahead of our latest--and those very much behind.

The thirst for know-how outside of our country concerning ways to do a more effective job has provided a stimulus in management advances that, again, always leaves me wondering why today we're not more progressive in our country, even though I see great change and progress here.

The workers in foreign countries really seem very similar to those over here. The myth of the man who works harder there than here has been somewhat exaggerated. Using the equivalent machines, tools, and producing the same parts to the same specifications under the same working conditions, the output per hour is very much the same.

We find abroad,that, as in this country, workers tend to directly reflect the attitudes of their supervisors. A capable, well-trained, and enlightened leader in a production department develops a production atmosphere and team that can equal any I have seen in our country. On the other hand, incapable supervision can produce the same poor results it often does.

Living standards are rapidly rising abroad, and in a way that is a wonderful thing both for their people and ours. The taste of better things whets the appetite for more. And the people--both men and women--are, generally speaking, so very like our people, wherever one goes.

Back in the early 50's, driving through the towns in England, one could see in each block of houses one or two television antennas. The next year there were more--and so it went until today just about every home seems to have one.

In London, early on a Sunday morning in 1950, driving through the city, there would be very few cars parked along the streets outside their owners' homes. But today, what a different sight--there seem to be almost more cars than houses! Yes--people are certainly alike.

I see the same trend everywhere--the old bicycle becomes a new one; then it becomes a motorbike or scooter; those with the latest in two-wheel transportation move up to a light four-wheel vehicle, and then to a bigger and better one. This creates some appalling traffic problems, so now new highways have to be built. The pick and shovel have been replaced with the air hammer and power equipment. Small bulldozers are replaced with larger ones. And the rotary building cranes that originated abroad seem to be sprouting like stalks of grass in the cities and fields in every country.

All of this activity, as I said, fortunately for us, occupies a great part of the production manpower, taking care of the demands and requirements of the people in their own country.

When surpluses occur, by instinct and long-training, our foreign neighbors export. They always have, because the maze of countries outside our own has always been exporting and importing and doing business with each other.

So here in the United States it is inevitable that we are getting into the act both on the selling and buying side, doing business with our neighbors.

In every transaction there are three factors:

1) quality;

2) time needed to deliver--and, of course,

3) price

Quality now seems to be better understood around the world. And the interest in and development of national standards and international standards have gone a long way to narrow the spread in quality differences.

Today, the most underdeveloped country can go into production using modern machines, methods, and tooling, and avail itself of our American standards, international standards, and the standards of the country with which they expect to do business.

This is especially noticable in screw threads.

I can well remember, when I was a boy, in our own company we made our own nuts and screws--that was the only way we could be sure they would fit. The ones we purchased wouldn't go together! That's how we happened to get into the fastener business.

Later on, in the United States, our National Standards were developed through the medium of our trade associations and the American Standards Association. This made it possible for things to become interchangable in our own country. Other countries developed their own national standards through their standards associations.

Then, through the International Standardization Organization (ISO), standards of the various countries became more unified. So now this element of production has come of age and left the dark depths of individual skill and know-how; it is now public property.

As for time needed to deliver, it is not a simple problem, but it's a lot more simple now than it used to be--especially if the product lends itself to air freight. You can telephone most spots in the world, and ocean freight, though time-consuming, is improving. However, it is a long way from the overnight delivery that most of our customers have come to expect on standard stock items.

Therefore, anyone doing business on an international basis requires a much greater investment in inventory somewhere along the pipeline, because one cannot fill orders with his shelves empty. In many cases today we find that prompt delivery is more important than price.

Now we come to this thing of price.

Generally speaking, in most manufactured goods, the total wage bill--from producing the raw material completely through to the finished product--is the biggest single item.

The cost of one worker-hour, including fringes, in this country today, runs from three to six times the cost of the same man-hour in other parts of the world. Workers' standards of living do not show this great a difference because living costs elsewhere are much lower than ours. However, this does not enter into our problem.

Wage costs have to be recovered or there can be no enterprise. They not only have to be recovered but there has to be a profit as well, or a company cannot exist. But high worker cost per hour does not necessarily mean a high unit cost, provided the worker produces a high output in return for his high hourly cost to his employer.

And here we have the clue to our national ability or lack of ability to compete in the world today.

I think it is timely to examine the meaning of the word <u>wage</u>. And I must say any definition that I have been able to discover is very fuzzy and inadequate. It seems to me that a wage is a payment made to a person who uses his efforts, mental and/or physical, to produce some goods and/or services for which there is a need in a free, legitimate market.

There must be effort expended by an individual to <u>produce</u>--to produce something for which there is a <u>need</u>--a need existing in the <u>market</u>--a market that is free and within the law.

To pay for goods and/or services not needed is not a wage. This is a gift or a subsidy. Management in private competitive enterprise cannot make gifts and compete. A subsidy can only be paid by government. A payment made to an individual for work not performed, merely because both parties have agreed, serves no justifiable economic purpose in the competitive private enterprise system. It just makes the system less competitive. The only reason we find such practices is that such payments are made under compulsion. A payment made under compulsion, by definition, is a shakedown.

We've all been brought up in our early years to expect a reward in return for our efforts and in proportion to the degree of effort. When we worked hard and did a good job on the examination in school we got a higher mark than when we did a poor job. Every father, mother, boy or girl, teacher, housewife, and clergyman believes in this simple concept. Our society will not accept any compromise on this basic principle of conduct in our young folks. Somehow the idea of getting something for nothing develops shortly after leaving school. It is the grist for the mill of labor organization--to do less and receive more.

The sale of such an idea--morally wrong, physically wrong, ethnically wrong--has been widespread for this reason: There has been no definition of the word <u>wage</u>. Just imagine the opportunities to be pulled off base when two parties bargain on wages and neither can define the word!

Never before have such conditions existed, which, when pushed to their fullest, produce the concept, "Don't do anything, for which you'll be paid any sum that you request!"

Government, business, and labor have all been a party by agreement to such an unbelievable situation.

The time is arriving, or perhaps today has arrived, sooner than we expected, to get costs in line with our foreign competition. The output per one hour of our high worker cost in this country must be much greater than that in a foreign competitive shop if we are to compete. By "worker cost" I mean of every employee on the payroll.

And today, in all too many of our organizations, most of the employees do things other than run the machines that produce the goods. I suppose that the average is two supporting people for every direct machine operator. And--this may come as a surprise--but on any total cost improvement program the total cost of the persons not running the production machines is almost always higher than the total cost of the direct machine operators.

Therefore, the productivity of the largest employee group must be greatly increased, as must the speed of the machines.

This is a job for management--the people who plan, organize, direct, control, and audit. It can't be started at the bottom--the initiative can only be taken at the top.

The initiative to do what? Well, if we are to successfully exist as a profitable company, and there is no other way for corporate existance in private enterprise, then the presence of foreign competition automatically forces one of these three actions:

1) Get the physical output, in terms of every single payroll-hour cost (indirect as well as direct), up high enough so that the unit costs are competitive with our foreign competitors, after the proper allowance has been made for freight, duty, and delivery time.

2) Get out of the business while there is still time to liquidate it.

3) Move your capital abroad and join them.

In our company today we are doing all three of these. We've got the greatest drive on that has ever been seen to increase total payroll-hour output everywhere there is a payroll hour.

We're mopping up unprofitable products and facilities.

One-third of our total employees are now producing in our plants located outside of the United States.

AUTOMATION IN THE BELL SYSTEM

Charles M. Mapes
Assistant Chief Engineer
American Telephone and Telegraph Company
New York, New York

What is automation?

I must admit that I don't know how to define it precisely.

And after this admission I suppose I should fold up my paper and go home--but I'm thankful that I have some company in this failing. Many of us seem to find language a sieve when trying to define this subject. I've read at least 20 definitions of it, and they all differ.

In recent times there has been a great deal said and written on the subject of automation, and almost every speaker or writer has had a unique definition. Let me present, then, my own definition at the outset.

Personally, I see automation as the continuing manifestation of technological change. Although this won't satisfy the purist, it's in this broad sense that I understand it and talk on it today.

First, I would like you to flash back with me over the years and take a look at some of the changes that have occurred in this country since 1920.

The gross national income, in constant dollars, has increased 293 per cent since 1920. Per-capita income, in the same dollar terms, has increased 119 per cent. The number of people employed in the civilian labor force has increased 80 per cent. Although things did not move in a straight line from the 1920 base to the present day peak, the over-all record is good.

It's been a period of tremendous material progress. And at the same time it's been a period of tremendous technological change.

These go together. They are inseparable because through technology we have been making more efficient use of our resources--creating new products and services, and making old products and services better and cheaper.

Consider that in 1920 we had the same land mass to work with as today--yet our production was so much lower.

Some may say, "But we have more people now." But increases in population do not necessarily mean increases in per-capita income, as witness some of the nations of Asia. To me the essential difference has come about because of technological advance and the accumulation of capital.

Science and money meet in technology. And this productive blending is introduced into the economy by industrial engineers and forward-looking management. In our country this blending has been encouraged by a political atmosphere that recognizes the need for profit.

In the period that I have been speaking about I have had some personal say in the channeling of large sums of money into technical areas and have witnessed some of the deep changes in the Bell System since the System began the change to dial in 1920--machine-switching, it was called then.

Why did we automate?

The economist has a simple answer to that --cost.

But it depends on how you view the problem. From the engineer's viewpoint, there is another consideration--the need for a business to continually offer the public something better in its product or service.

One of our aims has been to make it possible for two people (or two machines) to talk with one another almost as effectively as if they were face to face. In 1920 a telephone conversation was more comparable to talking at a distance of 70-80 feet. Today, the improvements we have introduced make telephoning very much like conversing across the table.

Also to improve service we had to compress time. We have to make the establishment of a telephone connection as simple as we can, and then to set it up as fast as possible.

It is apparent that the more time it takes to set up a connection the less satisfactory the service. Machine-switching and better operating methods provided the means for us to compress this time. For example, in the early 1920's it took us ten minutes and longer to set up the connection for a long distance call. Today many of these calls are dialed directly in less than 15 seconds.

This change from manual to dial service

continued until now the local service furnished by the Bell companies is virtually 100 per cent dial and you can dial long distance from 80 per cent of our telephones. In addition, operators now dial calls directly to telephones in the United Kingdom, France, Germany, Italy, Switzerland, Australia, Alaska, Hawaii, and a number of islands in the Caribbean.

How many man-hours of work were eliminated in the process?

I don't know. How can you calculate it?

But did we go down this path just to eliminate jobs?

No, we did it to expand the market for the service by making it better and by bringing the cost within the reach of the many. In the process we increased jobs.

There are telephones in 81 per cent of the households in this country today, compared with 35 per cent in 1920. There are telephones in nearly every place of business, and in automobiles, boats, and planes. And jobs were also created, not eliminated, by expanding and improving the service.

One of the reasons for this tremendous growth in our business is the fact that technological progress has enabled us to keep costs lower than they otherwise would have been. Today it takes the wage-earner about half as long to earn enough to have a telephone as it did 20 years ago.

It makes a good story, but it really doesn't make much sense otherwise to say that if we hadn't changed to dial we would now have to hire all the high school girl graduates in the country to handle the calls. Of course we wouldn't have to, because we wouldn't have the calls to handle.

But let's go back a minute to those percentages of dial service that I quoted--local service 100 per cent customer-dial and long distance service 80 per cent customer-dial. Some might ask, "Doesn't this indicate that the Bell System has almost completed its program of technological change?" The answer, of course, is definitely, "No." For those of us engaged in making plans for the long view, it is apparent that it will take years to put in operation throughout the entire System many of the new things that we are introducing now.

One of the reasons major new programs must be introduced gradually is that seldom, if ever, do we get a breakthrough that can be applied immediately in all situations. Let me give you an example.

In the field of dial-switching we are about to make a major advance. Our first commercial electronic central office will be placed in service at Succasunna, New Jersey, late this year. To a major extent this new office employs solid state techniques and is controlled by a program stored in its magnetic memory. It requires less space, less maintenance, lower first cost, and provides improved service. This type of office has been tested previously in actual service. Now we are getting ready for the first step in a big job--the job of changing the Bell System from an electromechanical to an electronic-switching operation. Yet here the telephone business, as any other business, runs up against the fact that it must have reasonable justification for replacing things that are giving good service. Obviously what we do is pick specific locations where the existing equipment is wearing out, or where major expenditures will be required to provide new services that have been developed.

In these instances a changeout is programmed. But there are thousands of locations where we cannot justify replacement for a number of years.

Just as it took us a number of years to get to our present state of dial-switching, the technological advances now known are going to require another period of years to be fully implemented.

In our business, fluctuations in employment will no doubt occur in the future as in the past, but over the long term, as the public uses more communication service, we believe employment opportunities will increase.

I dwell on the subject of jobs because we wouldn't be meeting here today if technological change merely slipped smoothly into the economy. Instead, it causes friction, displacement. Human beings have to adjust and this is seldom easy and sometimes impossible. Still, industry can do much to minimize the social friction arising out of technical change.

In our business we have tried to plan so that people are not laid off because of technological change.

For example, in changing from manual to dial we plan so that most of the personnel problems are solved by normal force turnover. This is particularly true in the case of operators, where a high turnover rate is usual. (The personnel problem is not as burdensome as it would appear on the surface. Last year, for instance, we had to hire more than 50,000 operators just for replacement.)

When conversions of manually operated offices to dial have been scheduled, we fill the jobs of operators resigning or retiring with persons seeking temporary jobs. Often these are former operators who gave up their jobs when they married, and who are glad to come back on a temporary basis. As the conversion proceeds, regular employees are offered jobs in other communities.

We also take the responsibility for retraining employees who are given new assignments because of technological change. However, they are but a small part of the numbers of employees who change from one job to another for various reasons--to fill a vacancy created by a promotion or a retirement, to balance the force with the workload, to handle growth and development. In all of these situations the Bell System provides the training needed to handle the new job.

Moreover, training of employees going into other positions is only part of the overall training program enabling employees to carry out their assignments better.

One department alone, the plant department, has more than 200 schools throughout the country providing classroom facilities for off-the-job training of installers, linemen, repairmen, and other craftsmen who construct, install, and maintain the many different kinds of telephone plant. Courses range from basic subjects such as electricity and electronics, through telephone installation and maintenance, all the way to electronic switching systems maintenance. The courses take as much as 20 weeks.

This plant school program is the equivalent of a trade school with a full-time enrollment of 5,000 students and 800 instructors.

Since classroom training is usually followed by on-the-job training by the individual's immediate supervisor, it is exceedingly important that the supervisor be well qualified to give maximum assistance. For this purpose, training is also given supervisors in new methods and on new tools and new equipment as they are introduced.

The increasing complexity and technological changes in the engineering side of our business are also being met by the following educational programs:

- Various in-company training efforts.
- Regional Communications Engineering School program conducted on several campuses across the United States.
- Operating Engineers' Training Program conducted at the Bell Laboratories.
- Data Communications Training Program at Cooperstown, New York.
- Western Electric's Graduate Engineering Training Program.

These programs are designed to help our engineers keep abreast of the rapidly changing technology of communications.

The training of our service representatives (employees in our business offices with whom the customer deals) and our operators is by far the largest educational program we have --in matters of sheer numbers of people being trained.

Also, new techniques in educating for specific skills in every field from plant training to marketing methods are being applied in the form of programmed instruction technology. Representative results of this method of training are as follows: in a traffic-training program, the student training time was reduced 27 per cent, and active instructor participation in the training process went down 40 per cent.

I think there is a new awareness of the need for education at all levels of the business organization. You can't be out in front unless you know, and unless you know how. And these days there are just many more things to know and many more facets of know-how. As a result, I think that in the future you will see an intensification of employee education because of technological innovations.

But where does this technological change originate?

In the communications business a good deal of it flows from the Bell Telephone Laboratories.

As you know, our business was born of research, and we have been great believers in it. The other night while preparing this talk I went back over some of the AT&T annual reports and the report for 1920 has this to say on research: "At the close of the year, upwards of 2,500 research and development projects were in hand, all these calculated to improve the service which the associated companies are rendering to the public or to make it more economical."

Since that sentence was written we have spent between two and three billion dollars on research and development. The Bell labs have given us vast improvements in switching, transmission, and literally hundreds of new services which benefit the business community and make our home lives more pleasant.

Developments in the Laboratories have led to Telstars, transoceanic cables, nationwide television networks. While the customer, share owner, and employee have benefited directly from this research, the effects did not die there. In many cases they have rippled out through the economy.

In this regard, I'd like to mention two examples of the effects outside the telephone business.

First, shouldn't we at least give a tip of the hat to the thousands of jobs a growing business is supporting outside its own organization? This year, for example, the Bell System construction program totals three and a quarter billion dollars. Our manufacturing and supply unit, the Western Electric Company, will spend more than one billion dollars on materials, equipment, and services it buys from others. It will buy these from about 40,000 suppliers in approximately 3,800 cities and towns across the country. Compare this with Western's 1920 purchases of $152 million from about 3,000 suppliers.

Second, I'd like to give you a further

dramatic example of this rippling effect--the semi-conductor industry.

The transistor was invented at the Bell Laboratories in 1948. This was the start of a new industry which has grown faster than an athletic adolescent. Last year the gross sales of transistors and kindred devices in the United States were in the neighborhood of 580 million dollars, not including those used by the Bell System.

Semi-conductors are used extensively in our business. They are also used in electronic computers, midget radios, hearing aids, and so on. The transistor, also, plays a vital role in the complex weapons systems on which the nation relies so heavily for its defense.

But back to the Bell System.

We are continuing to introduce technical change into communications with the same objectives that we always had, to improve the service and keep costs low.

Perhaps this is a good time to talk about one area of work where business has to use the latest machines. This occurs where the tasks are literally backbreakers.

For instance, we are currently laying a coaxial cable from the east to the West Coast. For most of its length it will be buried 4 feet in the ground. Furthermore, all of the booster stations along the line, together with the 8 large buildings containing terminal and connecting equipment, will be constructed underground. We call this a hardened cable route and are building it not only for protection against the elements but also for greater insurance of communication reliability in emergency. To hand-dig this entire route would cost too much and would take too long. Earth-moving machinery and cable plows, pulled by large teams of tractors, are doing the job. They are doing it more quickly and at lower cost, although the people operating the equipment must have higher skills than manual workers and consequently receive greater compensation. This is a simple example of how the introduction of technical change is virtually mandatory.

But what about another area, the area of paper work? How can you control the ever widening stream of statistics and reports required by modern business?

Electronic data processors are needed and we are using them.

In 1960, for example, one of the Bell companies introduced an automatic system for billing and collecting customer accounts, using a large-scale data processor. This system, which uses documents placed in machine-readable language at the source, has been quite successful and has served as a pattern for similar installations throughout the Bell System.

The use of electronic data processors will spread to other parts of the business. Personnel records, complicated engineering problems, order taking and filling, material records, are but a few of the areas where these devices will be essential. But, as in the case of other major technological changes, they won't march in and mow us down. Each use will be tested against the criteria of cost and service.

We, as many other businesses, have found that the use of data processors is not just a matter of ordering a machine and filling it with cards. The so-called "software" or programming that is required with major data-processing installations in order to convert a manual process to a machine process has cost more than our earlier studies indicated. This obviously slows down the extension of the use of the new method.

Electronic data processors are being used in our manufacturing unit as well as our operating telephone companies. An interesting case is the production control system in the Kansas City works of the Western Electric Company. There we are installing an integrated information system which will be fully operative by the middle of this year. Employees' time records and job completion data are fed into a data processor for accounting purposes. In addition, a complete check of work orders, inventory of stock, shop orders, economics of doing a job, scheduling, and manufacturing details is maintained, via DATA-PHONE service, by a data processing system. The data processor takes direct action, feeding the necessary information directly to the accounting department, or effectively notifying management of problems arising in the production system.

Long before data processing equipment is installed, we work out plans, as we have done with our dial conversions, to transfer the employees whose jobs would be affected to other assignments. Frequently, in such cases, the employees receive additional training--on-the-job as well as off-the-job for their new positions.

Occasionally some employees affected by automation are, for various reasons, unable to accept a transfer to other locations and cannot be placed in other work. In these relatively few cases severance-pay plans provide for lump-sum payments to the employee, varying in accordance with his length of service and wage rate.

In the Bell System we are still trying to compress time, to make better use of this national resource, to make it easier and faster for our customers to do business. Now, I'd like to tell you of two of our latest efforts in this field.

First, TOUCH-TONE signalling.

At present it takes about ten seconds to dial a local call. Now we have developed a telephone set that will do much better than that. As a result we are introducing a new basic telephone set and making the necessary changes in our central offices to provide TOUCH-TONE calling.

You, no doubt, have seen pictures of a new telphone set with ten buttons like those on an adding machine. This is the set of the future. We have tested and retested it and subjected it to extensive produce and market trials. The result was our initial offering of TOUCH-TONE service in two towns. Experience indicates that it is easier than dialing, but an even more important factor is that it can be done in a bit less than half the time it now takes.

Moreover, customers were almost unanimous in their satisfaction with TOUCH-TONE, stating they particularly liked its speed and convenience.

Naturally, the change-over to TOUCH-TONE service will also be gradual.

The second innovation in our compression of time that I'd like to talk about is a new Traffic Service Position for the telephone operator. These new positions are starting to replace long distance switchboards. They are cordless, with desk consoles tied into an electronic control unit. They enable us to speed long distance calls from coin boxes.

For example, if you are making a long distance call from a coin box, you deposit your dime and dial the number directly. While your call is going through the network, the electronic control unit calculates the rate for your call. This rate is displayed in the console in front of the operator. She then requests you to deposit the required amount, and you talk to the called party. The operator has no more to do with the call. But if you talk beyond the initial period, at the end of the conversation the control unit determines the charge for overtime, displays it on the console, and the operator requests you to deposit additional coins.

These Traffic Service Positions also enable us to speed the handling of collect, person-to-person, and credit-card calls.

TSP, as we call it, is a substantial time saver for the customer and gives him better service. So you can see we are still at the old problem of compressing time.

In summing up I quote a few lines from the Annual Report of the Council of Economic Advisers:

"Even if we wished to, we could not eliminate pervasive and continuous technological and economic change without remaking--on a much inferior basis--the whole fabric of our social and economic institutions. And we would not wish to. Its benefits are essential for continued economic growth, higher standards of living, and the elimination of poverty. Our objective should be to foster and encourage it.

"But recognition of the many benefits of technological change must not obscure the human toll often exacted in this process of job transition."

In the Bell System I think we have been successful in minimizing the hardships caused by technological change. As I have pointed out before, we have procedures set up to do this. But this does not mean that the problem is solved for all time, for the future is never quite like the past and may require modifications in our present procedures and even some new procedures.

Yet, I am convinced that we in the Bell System have to push on with technical change, for only then will we be able to meet the needs of our customers, and that is the reason we're in business.

THE
KAISER STEEL-UNITED STEELWORKERS OF AMERICA
LONG-RANGE SHARING PLAN

TEN MONTHS' PERSPECTIVE

Ralph L. Vaughn
Assistant General Superintendent
Kaiser Steel Corporation
Fontana, California

My presentation will consist of four major topics: First, I will cover a little background information to set the stage. This will consist of a few words about the Kaiser Steel Company itself, the decision to develop the Plan, and the 1959 settlement. Second, I will discuss the establishment of and functions of the Long-Range Committee itself. Third, I will give a brief resume of the Long-Range Sharing Plan. Fourth, I will cover the highlights of our actual experience during the first ten months of operation under the Plan.

BACKGROUND

Kaiser Steel Corporation operates a fully integrated steel mill at Fontana, California, 45 miles east of Los Angeles. From the start of production operations in 1943, the plant has been expanded almost continually and currently has an annual production capacity of almost 3,000,000 ingot-tons. This makes Kaiser Steel the ninth-largest steel producer in the nation and the largest west of the Mississippi.

In addition to the Fontana plant, the Company operates its own iron-ore and coal mines and uses limestone from Company-owned deposits. It also operates three fabricating plants, all located in California.

Total employment is about 10,500 employees, including those at the general and sales office locations. Of this total, about 7,500 work at the Fontana plant. Almost 6,000 of these employees are production and maintenance employees represented by United Steelworkers of America Local 2869, and 500 are clerical and technical employees represented by United Steelworkers of America Local 3677. It is this group of approximately 6500 employees at the Fontana Steel plant that is covered by the Long Range Sharing Plan.

The Kaiser-Steel Wage Structure

Wage incentives have been an integral part of the method of compensation in the steel industry for many decades. In the early days of Kaiser Steel Corporation's operations, shortly after the start of World War II, the Company and the Union negotiated a wage structure. In general the wage structure agreed to was based on the average earnings (including incentive compensation) of the six major steel producers. When the Wage Inequity Program, now more commonly known as the Job Description and Classification Program, was negotiated and installed during 1946-1947 in the basic steel industry, this program was also adopted by Kaiser Steel Corporation. Through this program every job in the plant was described and an appropriate standard hourly wage-rate established. As a result of this job description and classification program, we were able to determine for the first time what portion of our originally negotiated wage rates was the base rate, and what portion was incentive earnings. At this time, we had production incentives on only the open hearth, soaking pits, and blooming mill.

Subsequently, in 1948 these methods of payment were changed by agreement to install individual unit incentive plans where economically practical.

When the Sharing Plan was installed, effective March 1, 1963, approximately 40 per cent of the employees were covered by individual unit incentive plans of various types. The remaining 60 per cent received their respective standard hourly wage-rate and no incentive earnings.

The 1959 Settlement

In 1959 Kaiser Steel participated in industry-level negotiations for the first time as a member of the policy committee consisting of representatives of twelve major companies. These negotiations resulted in a lengthy strike over wage and work-rules issues, beginning July 15. When all attempts at mediation had failed, President Eisenhower on October 9 appointed a Taft-Hartley Board of Inquiry, headed by Dr. George W. Taylor. This board made further efforts to achieve a voluntary settlement, but when these were unsuccessful a Taft-Hartley injunction was issued on October 21. This injunction was stayed, pending review by the Court of Appeals and the Supreme Court, and did not take effect until November 7.

During the period of the strike, frequent discussions were held between Mr. David J. McDonald, President of the United Steelworkers of America, Mr. Arthur Goldberg, Counsel for the Union, and Mr. Edgar Kaiser, Chairman of the Board of Kaiser Steel. These talks were undertaken, on Mr. Kaiser's part, with the full knowledge of the industry policy committee in an attempt to arrive at some basis for settling the major issues involved. All of these men agreed with Dr. Taylor that "there must be a better way" to resolve the complex issues involved in this dispute.

As a result of these private discussions, Mr. Kaiser and Mr. McDonald reached a tentative agreement on economic issues which Mr. Kaiser felt represented a reasonable basis for an industry settlement, but they further agreed that the complex question of "work rules" could not be resolved in the heat of the strike. Instead, they felt a committee study of the many facets of this problem should be made. The industry committee, however, felt they could not accept the committee concept regarding work rules and refused to settle on the basis of this proposal. Mr. Kaiser, on the other hand, was most reluctant to see Kaiser Steel employees resume work under a Taft-Hartley injunction. Therefore, while the injunction was being appealed through the courts, Kaiser Steel withdrew from the industry group and signed a separate agreement with the Steelworkers on October 26, 1959.

The word "strike" by itself does not command much attention. It is too often dismissed as just one of those things. However, when translated to dollars--lost dollars--it should prove quite sobering and thought-provoking. During this one strike, which in the case of Kaiser Steel lasted for 104 days, it has been estimated that our employees lost about twelve million dollars in wages, the Company lost nearly seventeen million dollars, and the government lost approximately nine million dollars in taxes.

The Decision to Develop the Plan

The 1959 settlement, in addition to resolving the economic issues in dispute, committed the Company and the Union to an attempt to "find the better way" which Mr. Kaiser and Mr. McDonald both felt was essential to the future success of the collective bargaining process. This was done through a provision in the agreement establishing a Long Range Committee, consisting of three Public Members and three representatives designated by each party. Among other things, this Committee was empowered to:

> "Recommend for the consideration of the parties the establishment of a long range plan for the equitable sharing of the Company's progress between the stockholders, the employees and the public, giving appropriate consideration to safeguarding the employees from increases in cost of living, promoting stability of employment, reasonable sharing of increased productivity and labor cost saving, providing for necessary expansion and assuring the Company's and the employees' progress."

THE LONG-RANGE COMMITTEE

Membership

The Long-Range Committee was a tripartite group, with George W. Taylor as chairman and with John Dunlop and David Cole as the other Public Members. The parties were fortunate, therefore, in having three Public Members of national stature who were already well known to them through numerous contacts in previous situations.

The Union members initially were David J. McDonald, President; Arthur Goldberg, Counsel; and Charles J. Smith, District Director of District 38, which includes the Fontana steel plant of Kaiser Steel. When Mr. Goldberg resigned, upon his appointment as Secretary of Labor, his place was taken by Marvin J. Miller, Assistant to Mr. McDonald.

The Company members are Edgar F. Kaiser, Chairman of the Board; E. E. Trefethen, Jr., Vice Chairman of the Board; and C. F. Borden, Executive Vice President.

As can be seen from the roster of the members, it was intended that this Committee operate at the highest decision making level and draw on the knowledge of public members of the highest repute.

Committee Functions

At its first meeting, which took place on March 9-10, 1960, the Committee established the primary objectives which were felt must be accomplished before any economic "Plan" could be expected. These involved a thorough review of such things as the previous experience with technological change, the grievance procedure, communications between the Company and its employees, the existing incentive program and the development of procedures to prevent strikes.

Once the necessary background information was obtained and a subcommittee had successfully assisted in the development of an improved grievance procedure, the Long-Range Committee was prepared to face their major responsibility--that of considering a long range economic program. Toward this end, a four-man subcommittee of Company and Union representatives was appointed to work on this program. It was the responsibility of this subcommittee, in regular consultation with the Long-Range Committee, to develop a program which would meet with the approval of the full Committee.

Development of the Long-Range Sharing Plan

The development of a plan for recommendation to the parties involved a tremendous amount of work. A great deal of background material was developed by staff groups of both the Company and the Union. Many meetings of the subcommittee and the full Committee were then devoted to reviewing data, evaluating possible approaches and recommending further possibilities.

Two important points stand out in regard to the methods used by all concerned in developing a plan. The first is that no time limit was imposed at any level. Dr. Taylor emphasized this philosophy that "you can't put a time limit on inventiveness," and at no point was this approach violated. Only in this way did they feel free to take the time to explore all avenues and attempt to arrive at the most workable approach to this complex problem.

The second "ground rule" was that no one was committed to any concept until the whole plan was approved. This "nothing is agreed to until all is agreed to" concept allowed each individual or group to suggest an idea, explore it thoroughly with any or all participants and then discard it as unacceptable. This, in no small measure, removed the atmosphere of a "negotiation" from the discussions and enabled each participant to contribute his ideas freely and openly. While important to the success of the Committee operation, this ground rule produced one problem--it made it impossible to issue "progress reports" to the parties, the employees in general or the press. This was not desirable from the standpoint of communications, but greatly facilitated the work of all concerned.

Recommendation and Adoption

The initial responsibility of the Long Range Committee to develop an economic program was completed on December 16, 1962, when they approved and recommended a Long-Range Sharing Plan to the parties. On behalf of the Union and of the Company, Mr. McDonald and Mr. Kaiser agreed to accept the recommendation of the Committee--subject, however, to ratification of the Plan by the membership of the local Unions involved. In keeping with their obligation to the employees affected, the members of the Long-Range Committee announced their recommendation at mass meetings of employees on the two succeeding days. Along with this brief introduction to the Plan went the promise from the Committee that Union representatives would fully explain the Plan in detail to smaller meetings prior to the employees being requested to vote on its adoption. Such meetings, consisting of fourteen 4-hour sessions attended by over 5,000 employees, were held early in January, 1963, and on January 11 the employees voted 3966 to 1403 to adopt the Plan for installation at the Fontana steel mill, effective March 1, 1963.

THE LONG-RANGE SHARING PLAN

General

The Long-Range Sharing Plan is an involved document. This is made necessary by a number of factors, including:

1) The size and complexity of the operations involved;

2) the attempt to achieve a number of objectives within a single plan;

3) the already complex concepts of compensation and employee protection included in the existing agreements between the parties;

4) the existence of an extensive incentive program already in operation;

5) the need to cover all possibilities under the Plan with a reasonable degree of precision.

In order to present an over-all view of the Plan without the many qualifications included, a summary has been developed. It must be remembered, however, that many of the qualifying factors are very important in the actual operation of the Plan. Unless changed or modified by the provisions of the Plan, all other agreements between the Union and the Company remain in effect under their terms.

Objective

The objective was the equitable sharing among the stockholders, the employees and the public, of the Company's future economic progress.

Specific guidelines included:

1) To promote stability of employment;

2) to safeguard employees against increases in the cost of living;

3) to provide for equitable sharing of increased productivity;

4) to encourage the necessary expansion of the Company.

Plan Coverage

1) This was a single, plantwide plan, covering all United Steelworkers of America employees at Kaiser Steel Corporation, Fontana.

   a) Includes P&M 2869 and C&T 3677.

Additional Security

1) Objective, through cooperative effort, is to obtain the greatest possible increase in productivity as rapidly as improvements can be made.

2) How do we do this with two seemingly incompatible requirements.

   a) On one hand, existing work must be done by fewer employees, or more work must be done by the same number of employees.

   b) On the other hand, productivity must be improved without a loss of employment or of income for individual employees which might otherwise result.

3) Also, inability to improve past practices has frustrated the Company for some time.

4) Likewise, the Company's ability to reduce forces through technological improvements (automation) has haunted the employees.

5) It soon became apparent that, if the plan was to be a success, in addition to providing that increases in productivity be shared appropriately between the Company and the employees, it must also provide additional employment and income security in order to induce the greatest possible increase in productivity. Thus, the following measures are included in the plan.

Employment Security

1) Appropriate protection is provided against the loss of opportunity for employment because of technological changes, new or improved work methods, or any other change in operations not resulting from a decrease in man-hour requirements caused by a decrease in finished steel production, or a change in product or production requirements.

   a) This protection is provided by the establishment of a plant-wide employment reserve.

      (1) Employees therein will be assigned to perform work functions throughout the plant.

   b) This is a protection of numbers of employees, not of individuals by name.

2) The maximum employment obligation is limited to actual 1961 experience.

   a) Obligation is calculated monthly.

   b) Obligation is reduced through attrition, or

   c) through improved productivity, when such improvement is achieved during a period when no employee is on lay-off status.

3) Individuals must be employed by the Company for 26 weekly pay periods to become entitled to this protection.

4) Lay-offs are made through the employment reserve on the basis of KSC dates, rather than from the lowest job in each line of progression.

5) This provision does not protect employees laid off to reduce the working force because of reduced levels of production.

Income Security

1) Protection is provided against loss of income when employees are demoted due to changes in work practices resulting from technological improvements, or new or improved work methods.

2) Earnings protection is in the form of a displacement differential.

   a) This differential is based on the difference between the rate of the job the employee was entitled to before the change, and the rate of the job worked after the change.

   b) It is limited to individuals in the line of progression as of the date the change was made, and is eliminated by:

      (1) Payments made in 52 weekly pay periods;

      (2) the employee attaining a job of equal or higher job class;

      (3) the employee refusing a promotion to a permanent vacancy;

      (4) an elapse of three calendar years from the time it was first established;

      (5) terminations.

3) Short work-week payment is allowed if it was worked as a result of conditions where the employees would otherwise be eligible for displacement differentials, provided the employees affected are available for 40 hours of work.

4) Payment of displacement differentials and short work-week benefits is made from total sharing plan gains.

Sharing Gains

1) Standards are composed of a base, a manpower standard, and a material and supply standard, each expressed in dollars per finished ton of steel produced.

   a) Standards are developed for various products in each mill, to result in an adequate reflection of changes in product mix, as well as in changes in operating levels.

   b) Standards are based on actual 1961 experience.

   c) Yield improvement and uses of technology are automatically included, since, unlike normal incentive-plan standards, these standards will not be changed, once established.

d) Nonsteel by-products are handled as manufacturing credits.

e) Kaiser-produced raw materials calculated on the basis of cost and standard are equal, with appropriate adjustment for changes in quality.

(1) This is necessary so that Fontana employees neither gain nor lose as a result of changes in quality or raw-material costs produced at other locations.

f) Measured gains each month are calculated by comparing actual labor, material, and supply costs with the weighted standards.

(1) The reduction from standard multiplied by the number of finished tons produced in that month is the measured gross gain.

(a) Such savings are not related to profits or to sales.

(b) Deductions from gross gains are made for displacement-differential payments, short-week payments, and certain capital expenditures.

2) Using 1961 experience for standards, as outlined, the effects of volume and increased capacity are automatically comprehended.

Protection against Inflation

1) One problem is to avoid perpetual standards changes reflecting changes in wages and material and supply costs.

a) Appropriate BLS indices reflect these movements in the industrial economic structure.

2) Also, standards must be set for material and supply costs.

a) These are adjusted each month by percentage change in the BLS Wholesale Price Index for each steel-products category.

3) They must be set for labor costs.

a) These are adjusted each month by percentage change in the BLS Consumer Price Index.

4) The base point of the BLS indices was the year 1961.

5) This feature of the plan satisfies several basic objectives:

a) It avoids push-pull inflation, a shortcoming of the present bargaining system;

b) it is a substitute for cost-of-living as such;

c) it comprehends industry (WPI) and national (CPI) economic factors.

d) it comprehends the Company's ability to pay to the extent that is practical, without getting into the area of profits or Company selling prices;

e) it eliminates pressures of contract-deadline negotiations.

Technological Investment

1) There are capital expenditures to reduce product costs on existing facilities.

2) Actual savings are made only after the Company gets back its capital investment.

a) Since gains are shared, the cost to produce those gains is also shared.

3) As a protection, the costs of capital expenditures are prorated as a product cost during those months in which they are producing a reduction in actual product costs. This continues until an amount equal to the capital expenditure itself has been prorated.

a) Prorations are made in an amount equal to whichever is least:

(1) One-third of the actual reduction in product cost on that facility, or

(2) one-sixtieth of the capital expenditure.

4) There is always a plus to be shared as other gains can never be decreased.

Sharing Ratio

1) The gross employees' share will be whichever is larger:

a) 32.5 per cent of total net-dollar gains, or

b) the same percentage of the total cost that standard-labor cost is to total-standard cost.

2) This 32.5 per cent is the approximate average of employment cost to manufacturing cost over the last ten years.

Funding of Benefits

1) A portion of the employees' share may, from time to time, as the parties decide, be allocated for the improvement of an existing benefit or for a new benefit.

   a) The benefits are holidays, vacations, insurance, pensions, S.U.B., reduced hours of work, and the like.

   b) All employees participate in these benefits.

2) This funding is identified as the Wage and Benefit Reserve.

3) a) The purpose of this reserve is to provide for payment of fringe benefits without periodically reducing the payout of monthly employees' share.

   b) It is accomplished by subtracting a fractional percentage each month from the gross employee pool and placing it in the Wage and Benefit Reserve.

   c) The amount in the reserve is reviewed every six months and the percentage is adjusted as required.

      (1) The intent is that the benefits and reserve are equal each year--there is no long-range build-up.

Distribution of Employees' Share

1) The employees' share, after subtraction for fringe benefits, is distributed to the employees on a weighted proration.

   a) Each individual or unit is assigned to one of five groups, based on historical and equitable earnings relationships.

2) The proration is divided into six groups, and is applicable until Group A earns 10 per cent.

   a) The employees remaining on incentive are excluded from Long-Range Sharing Plan participation.

   b) The highest-to-lowest earnings ratio under the Long-Range Sharing Plan is 4:1. For example:

Group	Earnings
A	10.0
B	17.5
C	25.0
D	32.5
E	40.0
F	.0

3) The amount remaining in the employees' share after the application of weighted proration is distributed equally on the basis of each individual's standard hourly wage rate, multiplied by the appropriate average percentage.

Existing Incentives

1) The aim is that the Long-Range Sharing Plan replace all existing incentives as quickly as can be reasonably accomplished.

   a) This should be done at no loss of present earnings to incumbent employees.

2) No new individual incentives will be installed.

3) The employees on the unit whose incentive plan resulted in incentive earnings during the thirteen-week period just prior to a Company offer, have the option, expressed by a majority vote of employees on that incentive, when offered by the Company, to:

   a) Accept an elimination of the plan, and receive the difference in a lump-sum payment equivalent to two and one-half years, or

   b) decline the adjustment, in which case the following conditions will prevail:

      (1) There will be no participation in the Long-Range Sharing Plan;

      (2) the plan will be adjusted to 135 per cent and the difference established as individual out-of-line differential;

      (3) new employees will receive pay of the appropriate category under the Long-Range Sharing Plan.

4) Future general wage increases will be added to the standard hourly wage rates, but will not change the basis for calculation of individual incentive plans.

5) Further, employees have an option to

accept or decline a lump-sum payment to eliminate out-of-line differentials, expressed by a separate majority vote of the employees on that unit having each type of differential, when offered by the Company.

6) Various options for employees on present incentives, and employees having out-of-line differentials, may be offered and reoffered by the Company at its discretion.

   a) If no offer is made to employees on the present incentives within two years, and if this plan has not equalled earnings paid under the individual incentive plans, the incumbents will participate with Group A of the Long-Range Sharing Plan.

7) Employees on existing incentives may, at any time, elect to withdraw from coverage of such a plan in favor of full participation under the Long-Range Sharing Plan.

Minimum Guarantee

1) Any wage and benefit adjustments agreed to by the Union and major basic steel producers shall be put into effect in the manner agreed to between the Company and the Union.

2) When total sharing-plan payment is less than the total amount resulting from application of industry general-wage increases and comparable additional fringe benefits not now provided, the Company will make up the difference.

   a) This will be a cost to the Company and not considered a deficit against future employee sharing-plan earnings.

Plan Duration

1) The plan will continue in effect, subject to review and revision annually at each anniversary date.

2) The plan may be terminated by either party upon four months' notice to the other party, served within the 12 months following the fourth anniversary date of this plan, and each four years thereafter.

TEN MONTHS' PERSPECTIVE

General

It was recognized as soon as the Sharing-Plan concept began to take shape that the nature of the Plan and its goals were such that an extended period would be required for it to develop its full potential. It follows that any evaluation of the Plan and its operation at this early date is necessarily tentative, based on too little experience and time to permit an objective analysis of factual data pertinent to all facets of the Plan. This is not to say that certain aspects of the Plan cannot be evaluated.

The initial operation of the Long-Range Sharing Plan has been most encouraging from the standpoint of all concerned. Company production costs have been greatly reduced and employee cash distributions have been larger than might have been anticipated in advance. The initial acceptance of the Plan and the cooperation of the individuals affected represent a start toward the long-term improvements in attitudes and relationships which were regarded as basic to the ultimate success of this Plan.

Cost Reduction

There are several ways that the effectiveness of the Plan in controlling and reducing costs can be evaluated. First is consideration of the payments that have been made to participating employees. During the ten months since the installation of the Plan, approximately three million dollars have been paid to Kaiser employees. Each of these dollars also represents two dollars' savings that has accrued to the Company for improving the stockholders' equity and meeting tax obligations.

To give you a quick idea of the earnings pattern, month by month, here is a rundown:

> March, the initial month, averaged 55 cents per hour or 21.5 per cent of the standard hourly wage rate; April, 66 cents or 25.8 per cent; May, 50 cents or 19.5 per cent; June, 62 cents or 24.1 per cent; July, 40 cents or 15.8 per cent; August, 24 cents or 9.5 per cent; September, 46 cents or 18.0 per cent; October, 45 cents or 17.6 per cent; November, 42 cents or 16.4 per cent; and December, 30 cents or 11.8 per cent.

Another yardstick is the profit picture since installation of the Plan. Before getting into specifics, I want to emphasize that the Sharing Plan is not a profit-sharing plan as it is so often misconstrued to be. Payments to employees are based on labor, and material and supply savings. Profits do not enter into the calculation of gains and have no effect on whether there are gains to be shared. It is clearly possible for the Company to make no profit or even operate at a loss and still have gains to be shared. It is also possible for there to be no gains even though there are profits.

Profits, however, are affected by cost reduction. In a profitable period, profits are increased by cost reduction. Similarly, if operations result in a loss for a period, the net loss can be lessened through cost reduction activity.

In this light then, let us examine the profit results during the first ten months under the Long-Range Sharing Plan.

At the beginning of 1963, we prepared a forecast of sales and earnings for the year. Our tonnage prospect was for approximately 70 per cent of capacity, and profit and loss expectations were for a small loss which we chose to call break-even. At that time we gave only token recognition to the impact of the Sharing Plan which was subsequently approved by the Fontana workers.

For the year of 1963, net earnings were 11.3 million dollars after provision for preferred and preference stock dividends. For 1962, we recorded a 5.2 million dollar loss. But, here is the interesting point--our sales tonnage remained virtually unchanged from that forecast back in January. The point here is that this sharp earnings improvement did not come from increased sales volume.

To some extent the earnings picture has been helped by a mid-April price increase on hot and cold rolled sheet and strip, but the main credit for the earnings rise is attributable to manufacturing cost improvements. By any reasonable standard of comparison, cost performance during mid-1963 was the best in the Company's history. Several major factors have combined to bring about this excellent cost performance. It is not possible to segregate these causes with any degree of accuracy. However, there is no question but that the Sharing Plan was an important contributing factor.

Management cost-control programs which started back in mid-1962, improvements in production facilities, and the influence of the new Sharing Plan, all combined with an upswing in sales volume back in March to produce spectacular cost improvements. For example, the second quarter of 1963 costs of finished steel products ran approximately $12.50 per ton below the average for 1962 and this differential is after allowing for the Sharing-Plan costs for the hourly and salary personnel at Fontana. Mention should be made that we do have a parallel salary plan which is based on the same criteria as the well-publicized plan for the Union workers. This is a key factor since we now have Union personnel and the Management team pulling toward the same set of goals. Mutuality of interest is a factor which may tend to reverse the traditional patterns of suspicion and conflict between the workers and the supervisory group.

Before concluding the appraisal of earnings, let me be clear on one point. Kaiser steel is far from satisfied with the level of corporate earnings which has been experienced for the year of 1963. While the results are encouraging in comparison to 1962's loss and earlier prospects for 1963, it is simply not a satisfactory level for a Company of our size. We are determined to obtain further cost improvements--we know a significant potential remains--while at the same time expanding sales and attracting new industry to the West.

<u>Employee Participation</u>

The initial acceptance of the Plan and the cooperation of the individuals affected represent a good start toward the long-term improvement in attitudes and relationships which are regarded as basic to the ultimate success of the Plan.

There are many examples of the spirit of cooperation and interest that have developed.

Employees have formed groups to work with supervision in determining more economical methods and materials for accomplishing jobs. Individual employees have submitted proposals for cost-saving improvements.

To facilitate a free flow of communications for employees and to encourage participation in cost-reduction activity, a Sharing-Plan Savings Program was developed and is in operation. The program provides the framework for individual employees to participate actively in developing and implementing their proposals for generating savings, and has produced an excellent response from employees. A monthly paper called <u>Sharing-Plan News</u> and reporting on individual and group progress is sent to each employee's home.

As isolated examples, these individual ideas and proposals might not seem to add up to important savings to a plant the size of the Fontana plant. However, compounded manyfold, they are important, and when considered as an indication of what can be anticipated for the future, they engender optimistic expectations for the Plan to approach its full potential.

<u>Employment Security</u>

The additional security provisions of the Plan covering technological improvements, the employment reserve, the displacement differential, and the short-week benefit, have not yet been applied to the extent that the sharing of gains provision has been applied.

Employees displaced due to technological and work methods changes have been provided employment in the Employment Reserve and have performed functions required for the continued operation of the plant. During the first ten months of Plan operation, 53 jobs were afforded this protection. This was done under the basic ground rule that employment-reserve employees shall not be assigned jobs that displace any other employee; that prevent the recall of an employee from lay-off; or that reduce the hours of work of any employee below 40 hours per week. Further, permanent job assignments have been made from the Employment Reserve, thus providing continuity of regular employment for employees.

In this instance, Kaiser Steel's historic experience of normal attrition exceeding displacement due to technological change has held true, thus providing continuity of employment in the manner intended when the employment-security section of the Sharing Plan was developed.

Besides providing continuity of employment for displaced employees, the Plan has also provided income security to employees. Displacement differentials have been paid to a total of 155 employees to maintain their earnings when they have been assigned to lesser-paying jobs as a result of technological change.

This experience indicates that the employment-security provisions of the Plan have provided continuity of employment and earnings for employees during the relatively short period the Plan has been in effect. However, we recognize that the employment-security feature of the Plan, potentially one of the most important concepts, has not yet been tested to any significant extent. We are just beginning to face these employment-security and automation-displacement questions and to work them out in actual practice. Furthermore, several years may be required to measure the impact of business cycles, productivity, attrition, and automation to judge the real value of this part of the Plan.

Company-Union Relationships

A mature relationship characterized by a spirit of cooperation and constructive attitudes on the part of Kaiser Steel, its employees, and their representatives, is a primary requirement for the success of the Long-Range Sharing Plan. It would be presumptuous at this time, or any time, to claim the complete achievement of this goal.

The plant-management group at Fontana has much the same attitude as the top management people in Oakland. The early results are far better than anyone had really hoped. So far there have been amazingly few serious problems. Coordination between the Accounting, Labor Relations, Industrial Engineering and Union personnel involved with the Plan's operation has been excellent.

Despite early success, the plant-management people feel that the surface has been barely scratched. The supply and material savings have come on fast, but a big potential remains both in labor and material savings.

Beginnings of a new atmosphere in labor/management relations are apparent. Plant management can now approach problems of work practices previously considered too hot to handle in the face of violent opposition. Some supervisors, previously frustrated, now feel that they are able to get their message across to the workers and can motivate a constructive response.

Comparing Company-Union relationships in a more traditional vein, there has been a dramatic change in the Union-grievance situation. In 1961, there was a backlog of over 500 grievances that had bogged down in the grievance procedure and were headed for arbitration. Recently, there were fewer than 70 grievances in process, and only a few--if any--of these were expected to require arbitration. Also, the filing of grievances has been greatly reduced. Where in the past we might have had as many as 100 grievances filed in a month, present experience is showing about 25 to 30 per month.

The over-all result is that the relationship of the parties has matured under the Sharing Plan, and there is every reason to expect it to continue in the future. There is nothing like mutuality of interests to obtain cooperation and teamwork.

Cautions

The initial success of the Long-Range Sharing Plan suggests that a few words of caution must be added for those who are regarding it from a distance. This is said not to disparage the Plan, but to point out portions of it which have not yet been fully tested and evaluated or which might otherwise be misinterpreted.

The Long-Range Sharing Plan was carefully designed over an extended period of time to deal with conditions existing at Kaiser Steel's Fontana steel mill. Although the principles involved in this program have value in other situations, their application was tailored to a specific set of circumstances which might not exist in a different setting.

The second caution to be sounded is one of time. If the Plan is to live up to its promise as a long-range plan, it must be tested in these terms. To date, we cannot state that the Plan has been exposed to some important tests: It has not faced the full impact of fluctuations in levels of operations over the extremes of a business cycle, it has not coped with major capital expenditures or the accompanying technological changes, it has not dealt with the full range of possibilities relating to existing incentive plans, nor has it had adequate time to fully reflect basic changes in the attitudes and behavior of the participants. It is in this latter area, in particular, that the full potential of the Sharing Plan is expected to develop in the future.

These cautions are included here to reflect the desire on the part of the Company to have any evaluation based on a full knowledge of all the facts. Anything less would be a disservice to the free collective-bargaining process which the Company and the Union are attempting to preserve and strengthen in their own relationships.

Conclusion

In closing, let me state once again that only the early returns are in--they have been good and we believe that we have established a strong basis on which to proceed with the project --but it may be literally years before we are able to make any significant judgments as to the lasting importance of this new approach to labor/management relations. Finally, and we all hope FINALLY, we end with what we began to seek over three years ago--industrial peace.

The basic concept of this Long-Range

Sharing Plan is that we share the gains from all factors of manufacturing cost improvement as they are obtained. Therefore, the full monetary amount that the Company can afford for work performed is paid as it is earned. This eliminates the need for the stress and strain of periodic negotiations on economic issues, both as to how much and when such increases should be forthcoming.

Acceptance of this concept means a radical but enlightened change from past Management-Union relationships. For this Plan to be successful, there must be a transition from individual negative forces to a molding together of positive forces, in order for all concerned to realize the potential benefits that exist. This transition will require a great deal of patience, education, and understanding, because it is difficult to change old habits and ways of thinking that have existed for so long. But once the transition is complete, the creative abilities of every employee can be focused on solving our mutual problems, rather than so often wasting our energies, clawing and scratching each other like a bunch of tom cats.

Then, and only then, can we approach any measure of industrial peace; each man recognized for making his contribution in his own way regardless of status, and satisfied that he is receiving the fair reward of his efforts.

KAISER STEEL

LONG RANGE SHARING PLAN

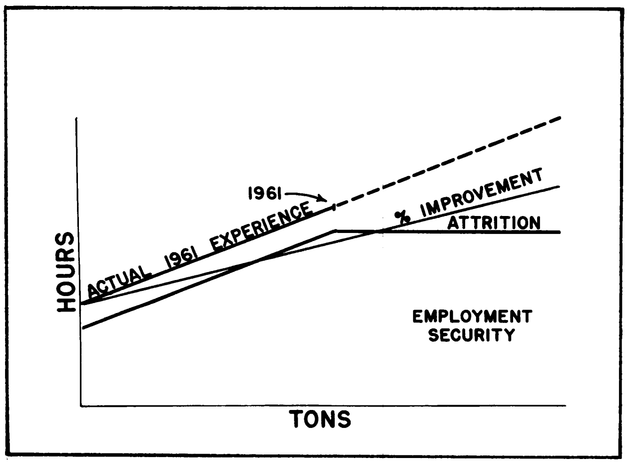
TRAINING AIDS

MASTER OBJECTIVE

"TO DEVELOP A METHOD TO ENCOURAGE THE OPTIMUM COOPERATION OF ALL LABOR-MANAGEMENT EMPLOYEES IN ATTAINING A CONTINUAL REDUCTION OF MANUFACTURING COSTS, AND TO SHARE EQUITABLY IN THE ECONOMIC PROGRESS RESULTING THEREFROM."

SPECIFIC OBJECTIVES

1. STEEL NUMBER ONE METAL
2. JOINT PROGRAM
3. MAINTAIN PREROGATIVES
4. HIGH HUMAN RELATIONS
5. STABILITY OF OPERATIONS
6. CUSTOMER SATISFACTION
7. SHARE REWARDS
8. ELIMINATE INEQUITIES
9. 100 % COVERAGE
10. EMPLOYMENT SECURITY
11. INCOME SECURITY
12. FORMULA WITH OPTIONS
13. BROAD FACTORS
14. ABILITY TO PAY
15. COMPANY GROWTH
16. INDUSTRIAL PEACE

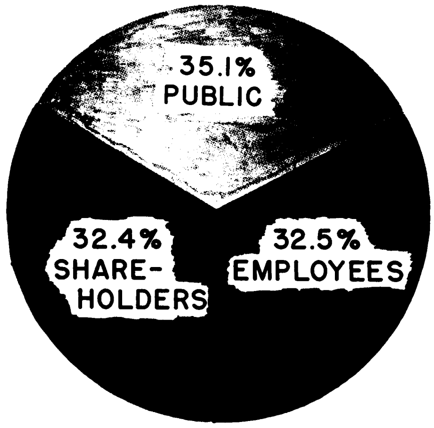


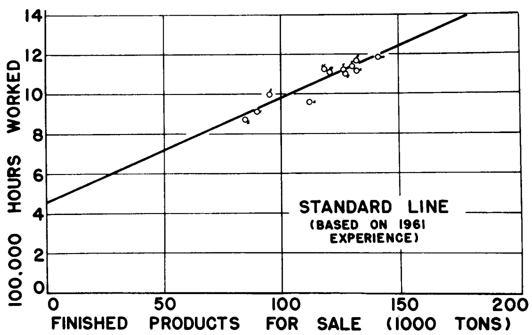
APPLICATION OF BLS INDICES

	TOTAL STDS. APPLIED	STEEL PRICE INDEX	CON-SUMER PRICE INDEX	TOTAL ADJ. STDS.
MATERIALS & SUPPLIES	$6000	1.10⊛		$6600
LABOR	$4000		1.05★	$4200
TOTAL	$10000			$10800

⊛INDEX HAS INCREASED 10% SINCE 1961
★INDEX HAS INCREASED 5% SINCE 1961

SHARING RATIO





INCENTIVE PLAN OPTIONS

OPTIONS MAY BE OFFERED BY THE COMPANY AT ITS DISCRETION.
ASSUME EARNINGS = 150%

OPTION 1

ACCEPT ELIMINATION OF INCENTIVE PLAN.
RECEIVE LUMP SUM PAYMENT OF:
HOURS PAID DURING LAST 3 MONTHS X 50% X SHWR X 10
OR
HOURS PAID DURING NEXT TWELVE MONTHS X 50% X SHWR W.I.G.
PARTICIPATE IN THIS PLAN AT TWO FACTOR LEVELS BELOW ASSIGNED FACTOR FOR 30 MONTHS. THEREAFTER, AT ASSIGNED FACTOR.

CAPITAL EXPENDITURES

ASSUME:
CAPITAL EXPENDITURE = $ 12000
REDUCTION IN PRODUCT COST = 1000

CHARGE AS CURRENT COST LESSER OF:
1/3 OF REDUCTION = $ 333
1/60 OF CAPITAL EXPENDITURE = 200

IF REDUCTION IN PRODUCT COST = $ 450
1/3 OF REDUCTION = 150
1/60 OF CAPITAL EXPENDITURE = 200

OPTION 2

DECLINE ELIMINATION OF INCENTIVE PLAN.

PLAN ADJUSTED TO PAY 135%.

INCUMBENTS RECEIVE 15% O-L-D.

INCENTIVE NOT CALCULATED ON ANY FUTURE GENERAL WAGE INCREASES.

NO PARTICIPATION IN THIS PLAN.

DISTRIBUTION-EMPLOYEES SHARE

GROUP	FACTOR
A	2.0
B	3.5
C	5.0
D	6.5
E	8.0
F	.0

1. FACTORS APPLICABLE UNTIL GROUP "A" EARNS 10%, THEN ALL RECEIVE SAME PERCENTAGE.
2. GROUPS ASSIGNED BASED ON HISTORICAL & EQUITABLE EARNINGS RELATIONSHIPS.
3. UNITS REMAINING ON INCENTIVE EXCLUDED.
4. UNIT ACCEPTS LUMP SUM PAYMENT, PARTICIPATES AT TWO FACTORS BELOW ASSIGNED FACTOR FOR ABOUT 30 MONTHS.
5. UNITS NOT OFFERED OPTIONS WITHIN TWO YEARS, PARTICIPATE IN GROUP "A".

ROSTER OF ATTENDANCE

Berkeley

NAME	BUSINESS AFFILIATION	ADDRESS
ACKER, G. L.	Crown Zellerbach Corporation	2101 Williams Street San Leandro, California
ALLEN, J. G.	Friden, Inc.	2350 Washington San Leandro, California
AMES, Paul H.	FMC Corporation	1125 Coleman Avenue, Box 367 San Jose 3, California
ANDERSON, J. Donald	Transit Tank Company	1215 South 10th Street Richmond, California
ANDERSON, James G.	Sylvania Electric Products, Inc.	P. O. Box 188 Mountain View, California
ANDERSON, Lloyd	FMC Corporation	P. O. Box 480 Santa Clara, California
ASHLEY-WING, H. H.	Friden, Inc.	2350 Washington San Leandro, California
BAIN, W.	Friden, Inc.	2350 Washington San Leandro, California
BEACHAM, R. C.	Cutter Laboratories	4th and Parker Streets Berkeley, California
BEASLEY, Steven	Colgate Palmolive Company	2700 - 7th Street Berkeley 10, California
BEATY, James P.	Colgate Palmolive Company	2700 - 7th Street Berkeley 10, California
BERLO, Glennon A.	U.S. Air Force	SMAMA, McClellan AFB Sacramento, California
BERNARDO, Jose A.	Pacific Clay Products	P. O. Box 6065 Stockton, California
BERNHARD, Quentin W.	Safeway Stores	Box 660, Oakland, California
BILLS, Robert W.	Western Pacific Railroad Company	526 Mission Street San Francisco, California
BLAKE, Robert E.	Ford Motor Company	P. O. Box 1101 San Jose, California
BONZO, C.	Johns Manville	P. O. Box 1587 Stockton, California
BOTTICHER, W. K.	U.S. Navy	U.S. Naval Weapons Station Concord, California
BRANDT, Robert G.	NAS - Alameda	O & R Department, Division 640 Alameda Naval Air Station Alameda, California
BRAVINDER, Jack H.	Pacific Telephone Company	760 Market Street, Room 662 San Francisco, California
BRENNAN, E. F.	Richmond-Chase Company	Box 1030, San Jose, California
BROWN, Lawrence A.	Mare Island Shipyard	Vallejo, California

NAME	BUSINESS AFFILIATION	ADDRESS
BROWN, Robert J.	Pacific Telephone Company	177 Post Street San Francisco, California
BRUGGE, Edward S.	H & B Concrete Specialties Co.	1120 Thomas Avenue San Francisco, California
BRUNTON, Charles W.	NAS - Alameda	O & R Department Alameda Naval Air Station Alameda, California
BUCHLI, Edward A.	United Air Lines, Inc.	International Airport San Francisco, California
BUCHTER, C. G.	Columbia-Geneva Steel	Pittsburg Works, P.O. Box 471 Pittsburg, California
BURGELIN, L. B.		4001 Moorland Street Vallejo, California
BURRIS, Tracy	Tri Valley Growers	240 Battery Street San Francisco 11, California
BUTLER, Gilbert	Tri Valley Growers	240 Battery Street San Francisco 11, California
CALLAHAN, Thomas F.	Crocker-Citizens National Bank	One Montgomery Street San Francisco, California
CERQUI, Donald E.	Diamond Walnut Growers, Inc.	P. O. Box 1727 Stockton, California
CETINICH, John N.	Southern Pacific Company	65 Market Street, Room 623 San Francisco, California
CLARK, J. H.	Columbia-Geneva Steel	Pittsburg Works, P.O. Box 471 Pittsburg, California
CLARK, William W.		255 Grapewood Street Vallejo, California
CLAUGUS, Harold W.	Procter and Gamble Company	P. O. Box 7718 Sacramento, California
CLEMONS, Harry R.	U.S. Navy	Military Sea Transportation Service Pacific, Fort Mason San Francisco, California
CLOW, Wallace	Tri Valley Growers	240 Battery Street San Francisco 11, California
COCHRANE, John E.	Libby, McNeill and Libby	P. O. Box 3512 San Francisco, California
COIL, Samual	Moore Business Forms, Inc.	5750 Hollis Street Emeryville, California
COLBRANDT, Irwin T.	NAS - Alameda	Naval Air Station Alameda, California
CONNOLLY, W. L.	Grove Valve and Regulator Co.	6529 Hollis Street Oakland 8, California
CROW, R. T.	Columbia-Geneva Steel	Pittsburg Works, P. O. Box 471 Pittsburg, California
DARLING, Robert E.	U. S. Air Force	SMAMA (SMME), McClellan Air Force Base, California
DAVIS, Thornton R.	Cutter Laboratories	4th and Parker Streets Berkeley, California
DEAN, George M.	Pacific Telephone Company	760 Market Street San Francisco, California

NAME	BUSINESS AFFILIATION	ADDRESS
DECHERD, Gene	United Air Lines, Inc.	International Airport San Francisco, California
DIETERICH, James W., Jr.	Clearprint Paper Company, Inc.	1482 - 67th Street Emeryville, California
DITTMAN, Norman Gene	Aerojet-General	10501 Croetto Way Rancho Cordova, California
DODDS, Jack W.	Lockheed Missiles and Space Co.	1111 Lockheed Way Sunnyvale, California
DOUCETT, Walter L.	FMC Corporation	Box 580 Santa Clara, California
DOUGLAS, Glen H.	General Foods	100 Halcyon Drive San Leandro, California
DOWNEY, B. D.	Southern Pacific Company	65 Market Street San Francisco, California
DRYER, P. A.	Mare Island Naval Shipyard	Vallejo, California
ERNENWEIN, Brodie R.	IBM	Monterey and Cottle Roads San Jose, California
FACTOR, Louis	Max Factor and Company	1666 North Highland Avenue Hollywood 28, California
FALCON, Carl	E. C. Buehrer Associates	253 - 4th Street Oakland 7, California
FARNHAM, Cal	NAS - Alameda	Alameda Naval Air Station Alameda, California
FEITEN, W. P.	United Air Lines, Inc.	International Airport San Francisco, California
FILLIEZ, William	Raychem Corporation	Oakside at Northside Redwood City, California
FITZSIMMONS, Laurence	Pacific Telephone Company	760 Market Street, Room 662 San Francisco, California
FONTES, William	Friden, Inc.	2350 Washington San Leandro, California
FRATZKR, Karl	Castle & Cooke Terminals	965 Nimitz Highway Honolulu, Hawaii
FURLAN, Allen	Columbia-Geneva Steel	Pittsburg Works, P.O. Box 471 Pittsburg, California
GILES, James J.	Twelfth Naval District	P. O. Box 81 San Bruno, California
GORDON, B. G.	NAS - Alameda	Alameda Naval Air Station Branch 212 O & R Alameda, California
GRAHAM, William E.	Raytheon Company	350 Ellis Street Mountain View, California
GREENWALD, Hugh M.	Aerojet-General Corporation	Sacramento, California
GREGORICH, Edward E.	National Seal	Broadway at National Avenue Redwood City, California

NAME	BUSINESS AFFILIATION	ADDRESS
HANKS, W. C.	Lockheed Missiles and Space Co.	P. O. Box 504 Sunnyvale, California
HANSON, Roland S.	Beckman Instruments	2200 Wright Avenue Richmond, California
HANSON, W. C.	Moore Business Forms, Inc.	P. O. Box 71, Salem, Oregon
HARBAUGH, Elizabeth	NAS - Alameda	Supply Office, Bldg. 8 Alameda Naval Air Station Alameda, California
HARMON, Edward	Tri Valley Growers	240 Battery Street San Francisco 11, California
HAROUFF, Elbert D.	Mare Island Naval Shipyard	Vallejo, California
HARRIS, M. V.	Friden, Inc.	2350 Washington San Leandro, California
HAUPTMAN, Fred	Tri Valley Growers	240 Battery Street San Francisco 11, California
HECHINGER, Ben L.	United Air Lines, Inc.	International Airport San Francisco, California
HELMS, Jerry	Fibreboard Paper Products Corp.	1st and L Streets Antioch, California
HENDREN, Dale	Owens-Corning Fiberglas Corp.	P. O. Box 89 Santa Cruz, California
HENDREN, Jim	Fibreboard Paper Products Corp.	1st and L Streets Antioch, California
HENDRICKS, Paul E.	Southern Pacific Company	65 Market Street, Room 1001 San Francisco, California
HERMANN, John I.	Fairchild Semiconductor	545 Whisman Road Mountain View, California
HILL, Robert W.	Cresap McCormick & Paget	2800 Eaton Avenue San Carlos, California
HODSON, Robert	Tri Valley Growers	240 Battery Street San Francisco 11, California
HOLE, W. L.	California Packing Corporation	215 Fremont Street San Francisco, California
HOLETZ, William	Tri Valley Growers	240 Battery Street San Francisco 11, California
HOLLINGSWORTH, C. A.	The Armstrong Rubber Company	P. O. Box 129 Hanford, California
HORINE, Alfred W.	NAS - Alameda	Public Works Department Alameda Naval Air Station Alameda, California
HOUSE, Robert H.	NAS - Alameda	Supply Office, Bldg. 8 Alameda Naval Air Station Alameda, California
HUBBERT, J. D.	Columbia-Geneva Steel	Pittsburg Works, P.O. Box 471 Pittsburg, California
HUBER, J. G.	Johns Manville	P. O. Box 1587 Stockton, California

NAME	BUSINESS AFFILIATION	ADDRESS
HUFFMAN, Richard E.		1417 Carl Avenue Vallejo, California
JARVIS, Elwood H.	Southern Pacific Company	65 Market Street, Room 623 San Francisco, California
JEWETT, H. P.	Oakland Public Schools	1025 Second Avenue Oakland, California
JOHNSON, Bert W.	Sylvania Electric Products, Inc.	P. O. Box 188 Mountain View, California
JOHNSON, Donald R.	International Paper Company	P. O. Box 608 San Jose 6, California
JOHNSON, John J.	Johnson and Johnson	4100 Bayshore Boulevard Menlo Park, California
JONES, Kenneth B.	NAS - Alameda	O & R Department Alameda Naval Air Station Alameda, California
JONES, W. W.	California Packing Corporation	215 Fremont Street San Francisco, California
JOSSIS, S.	Grove Valve & Regulator Co.	6529 Hollis Street Oakland, California
JURSCH, Charles F.	Southern Pacific Company	65 Market Street San Francisco, California
KELLEY, William M.	Eitel McCullough, Inc.	301 Industrial Way San Carlos, California
KNAPP, Sinclair	Bethlehem Steel Company	870 Devonshire Avenue San Leandro, California
KOCH, Commander R. H.	NAS - Alameda	Aero. Engineering Office Alameda Naval Air Station Alameda, California
KLAPPERICH, Michael	Moore Business Forms, Inc.	5750 Hollis Street Emeryville, California
KREBS, Jan	Mare Island Naval Shipyard	Vallejo, California
L'AMOREAUX, Ray C.	C and H Sugar	Crockett, California
LARSEN, James W.	Moore Business Forms	5750 Hollis Street Emeryville, California
LASCURETTES, Neil W.	Varian Associates	528 Kendall, Palo Alto, California
LASELL, L. W.	IBM Corporation	Monterey and Cottle Roads San Jose, California
LEVEQUE, Alfred E.	Mare Island Naval Shipyard	Vallejo, California
LEY, Regis F.	IBM Corporation	Monterey and Cottle Roads San Jose, California
LIEN, R.	Raytheon Company	350 Ellis Street Mountain View, California
LIVELY, Philip D.	FMC Corporation	1125 Coleman Avenue San Jose 3, California

NAME	BUSINESS AFFILIATION	ADDRESS
LORD, Charles V.	Pacific Gas and Electric Company	245 Market Street San Francisco, California
LOUD, Robert E.	Colgate Palmolive Company	2700 - 7th Street Berkeley, California
MAGLIDT, H. Wilson	Sandia Corporation	Graphic Arts Department Sandia Base Albuquerque, New Mexico
MANNARINO, Jack	NAS - Alameda	Alameda Naval Air Station Alameda, California
MIELICH, Dell	Moore Business Forms, Inc.	5750 Hollis Street Emeryville, California
MIRKO, Bryce M.	NAS - Alameda	O & R Department Alameda Naval Air Station Alameda, California
MOORE, George	Hewlett-Packard Company	1501 Page Mill Road Palo Alto, California
MOSELEY, Robert C.	Pacific Telephone Company	177 Post Street San Francisco, California
MULKEY, O. C.	Columbia-Geneva Steel	Pittsburg Works, P. O. Box 471 Pittsburg, California
McALLISTER, E. L.	Tri Valley Growers	240 Battery Street San Francisco 11, California
McARTHUR, Bruce N.	FMC Corporation	P. O. Box 580 Santa Clara, California
McJUNKIN, H. K.	Tidewater Oil Company	Avon Refinery Martinez, California
McLEOD, Denny A.	Bigge Crane and Rigging	P. O. Box 67 San Leandro, California
NAYLOR, C. J.	Matson Terminals	480 Main Street San Francisco, California
NICOLAISEN, Terry D.	Crown Zellerbach	P. O. Box 1057 Antioch, California
NIEDERHAUS, Ken	Libby, McNeill and Libby	P. O. Box 3512 San Francisco, California
ODINEAL, Charles N.	IBM Corporation	Monterey and Cottle Roads San Jose, California
OHRTMAN, Don A.	NAS - Alameda	Alameda Naval Air Station Alameda, California
O'LEARY, James	Raychem Corporation	Oakside at Northside Redwood City, California
OLSON, Richard E.	FMC Corporation	1125 Coleman Avenue San Jose 3, California
OSTMAN, Stanley W.	NAS - Alameda	Alameda Naval Air Station Alameda, California
OTTENHEIMER, R. J.	The Armstrong Rubber Company	P. O. Box 129 Hanford, California

NAME	BUSINESS AFFILIATION	ADDRESS
OVADENKO, Donald M.	Quality Casting Systems	2054 University Avenue Berkeley, California
PADDOCK, Robert M.	Mare Island Naval Shipyard	Vallejo, California
PAGE, Bernard	Wells Fargo Bank	50 1st Street San Francisco, California
PERIN, Raymond J.	Perin Company, Inc.	128 Starlite Street South San Francisco, California
PETERSEN, R. S.	Lockheed Missiles and Space Co.	Sunnyvale, California
PETRIS, G. C.	Moore Business Forms, Inc.	5750 Hollis Street Emeryville, California
PHILBROOKS, B. D.	Columbia-Geneva Steel	Pittsburg Works, PO.Box 471 Pittsburg, California
POHL, Robert W.	Lockheed Missiles and Space Co.	557 Arroyo Seco Santa Cruz, California
PRESHO, William J.	Southern Pacific Company	65 Market Street San Francisco, California
RANK, Robert C.	Lybrand, Ross Bros. & Montgomery	1 Bush Street, 6th Floor San Francisco, California
RASKIN, Robert A.	Owens-Illinois Glas	P. O. Box 888 San Jose, California
REARWIN, W. Heath	Friden, Inc.	2350 Washington San Leandro, California
RICHTER, G. H.	IBM Corporation	Monterey and Cottle Roads San Jose, California
ROLOFF, Russ	Kawneer Company	600 Parr Boulevard Richmond, California
ROOD, W. E.	Columbia-Geneva Steel	Pittsburg Works, P.O. Box 471 Pittsburg, California
ROTH, R.	Friden, Inc.	2350 Washington San Leandro, California
RUDNICK, William	Varian Associates	611 Hansen Way Palo Alto, California
RUNCKEL, G. M.	Columbia-Geneva Steel	Pittsburg Works, P.O. Box 471 Pittsburg, California
RUNYON, Harlen E.	Eitel McCullough, Inc.	301 Industrial Road San Carlos, California
RYDER, R. F.	Crown Zellerbach Corporation	2101 Williams Street San Leandro, California
SACKETT, H. L.	Raychem Corporation	Oakside at Northside Redwood City, California
SAUNDERS, B. N.	NAS - Alameda	O & R Department, Code 642 Alameda Naval Air Station Alameda, California
SCALES, Ronald	Moore Business Forms, Inc.	5750 Hollis Street Emeryville, California

NAME	BUSINESS AFFILIATION	ADDRESS
SCHUCHTERMAN, Henry	Tri Valley Growers	240 Battery Street San Francisco 11, California
SCHUMACHER, Richard S.	Owens-Corning Fiberglas Corp.	P. O. Box 89 Santa Clara, California
SHALLENBERGER, Charles	Mare Island Naval Shipyard	Vallejo, California
SHERRY, Lester E.	Mare Island Naval Shipyard	Vallejo, California
SILVER, Sterling H.	Colgate Palmolive Company	2700 - 7th Street Berkeley, California
SIMMONS, George A.	NAS - Alameda	Alameda Naval Air Station Alameda, California
SISCO, Robert C.	East Bay Water	P. O. Box 4616 Oakland 23, California
SMITH, Ross	Safeway Stores	Box 660, Oakland, California
SMYTH, Fred H.	Central Valley National Bank	301 - 20th Street Oakland, California
SPURGEON, William	Moore Business Forms, Inc.	5750 Hollis Street Emeryville, California
STANTON, E. C.	Friden, Inc.	2350 Washington San Leandro, California
STEEN, Milt V.	Lockheed Missiles and Space Co.	1111 Lockheed Way Sunnyvale, California
STENGELE, Frank H.	Southern Pacific Company	65 Market Street San Francisco, California
STEWART, Stephen G.	C and H Sugar	Crockett, California
STONE, W. R.	Columbia-Geneva Steel	Pittsburg Works, P. O. Box 471 Pittsburg, California
STREBEL, Frank R.	NAS - Alameda	Alameda Naval Air Station Alameda, California
STRONG, D. M.	Colubmia-Geneva Steel	Pittsburg Works, P.O. Box 471 Pittsburg, California
SUELFLOHN, Ervin G.	Southern Pacific Company	65 Market Street, Room 438 San Francisco, California
SUSSENBERGER, John K.	Fairchild Semiconductor	545 Whisman Road Mountain View, California
SYLVESTER, G. D.	Mare Island Naval Shipyard	Vallejo, California
TATE, Frank	Tri Valley Growers	240 Battery Street San Francisco 11, California
TEGELER, Fred A.	Western Pacific Railroad Company	526 Mission Street San Francisco, California
THACHER, B. L.	Johns Manville	P. O. Box 1587 Stockton, California
THOOLER, S.	Matson Terminals	480 Main Street San Francisco, California
THOMPSON, Richard	Philco - WDL	Palo Alto, California

NAME	BUSINESS AFFILIATION	ADDRESS
TITLEY, John	E. C. Buehrer Associates	253 - 4th Street Oakland 7, California
TOBIN, Lee E.	San Francisco Naval Shipyard	Code 144 San Francisco, California
TORBURN, Donald I.	Datamec Corporation	345 Middlefield Road Mountain View, California
TRAPP, William A.	International Paper Company	P. O. Box 608 San Jose 6, California
TRITT, Edgar H.	NAS - Alameda	Alameda Naval Air Station Alameda, California
TRYON, W. W.	Columbia-Geneva Steel	Pittsburg Works, P. O. Box 471 Pittsburg, California
WALDE, Leonard O.	Safeway Stores, Inc.	5232 Claremont Avenue Oakland, California
WALKER, Bernard O.		1196 Linden Way Napa, California
WEBBER, James B.	Raychem Corporation	Oakside at Northside Redwood City, California
WEBSTER, Dale A.	NAS - Alameda	Bureau of Naval Weapons Alameda Naval Air Station Alameda, California
WEIBEL, D. E.	American Radiator & Standard Sanitary Company	San Pablo Plant, Box 1866 Richmond 1, California
WENDEL, Donald N.	Southern Pacific Company	153 Market Street San Francisco, California
WILLIAMSON, S. R.	Mare Island Naval Shipyard	Vallejo, California
WINKLER, Allen J.	Langendorf United Bakeries	1160 McAllister Street San Francisco, California
WILBURN, C. E.	Tri Valley Growers	240 Battery Street San Francisco 11, California
WILLETS, Richard M.	FMC Corporation	Box 530 Santa Clara, California
WITMER, Clint	Tri Valley Growers	240 Battery Street San Francisco 11, California
VAN STOLK, J.	Columbia-Geneva Steel	Pittsburg Works, P.O. Box 471 Pittsburg, California
ZIPP, Joseph T.	NAS - Alameda	Alameda Naval Air Station Alameda, California

ROSTER OF ATTENDANCE

Los Angeles

NAME	BUSINESS AFFILIATION	ADDRESS
ABENDSCHEIN, I. D.	Autonetics	P.O. Box X-1 Anaheim, California
ANDERSON, Bruce	Anchor Hocking Glass Co.	4855 E. 52nd Place Los Angeles, California
APPLETON, William O.	Wayne Mfg. Company	1201 E. Lexington Street Pomona, California
AUSTIN, Robert B.		2019 Durazano Drive Hacienda Heights, California
BACON, Stanley F.		3500 W. 79th Street Inglewood, California
BARTLETT, Larry B.	Hughes Aircraft Company	5842 W. 95th Street Los Angeles, California 90045
BATTERSBY, E.	North American Aviation, Inc.	International Airport Los Angeles, California 90045
BENNINGHOVE, John R.		5188 W. Pt. Loma San Diego, California
BEST, Richard C.	North American Aviation, Inc.	4141 Century Boulevard Inglewood, California
BOCHNIARZ, Jim	United Parcel Service	1201 W. Olympic Boulevard Los Angeles, California 90015
BOWDEN, D.	Litton Systems, Inc.	15901 Strathern Avenue Van Nuys, California
BOYER, J.	North American Aviation, Inc.	International Airport Los Angeles, California 90045
BRASSELL, C. M.	Los Angeles Times	Times Mirror Square Los Angeles, California 90058
BREEDLOVE, Richard M.	Southern California Gas Co.	P.O. Box 3249, Terminal Annex Los Angeles, California 90054
BROWN, E. P.	Firestone Tire & Rubber Co.	2525 E. Firestone Boulevard Los Angeles, California 90054
BROWN, R. W.	Eastman Kodak Company	1017 N. Las Palmas Avenue Hollywood, California 90038
BUCHMANN, Stanley	Aerojet-General	8329 Valley View Buena Park, California
BUCKEL, Carl W.	Litton Systems, Inc.	5500 Canoga Avenue Woodland Hills, California
BUGBEE, James M.	Federal Aviation Agency	5651 W. Manchester Avenue Los Angeles, California 90009
BUKRINSKY, H.	Packard Bell Electronics	12333 W. Olympic Boulevard Los Angeles, California 90064
BULLARD, Duane R.		1856 Fortuna San Diego, California

NAME	BUSINESS AFFILIATION	ADDRESS
CARROLL, Clarence M.	Southern California Gas Co.	Box 3249 Terminal Annex Los Angeles, California 90054
CASEY, Vincent J.	Pacific Telephone Company	500 Federic Burbank, California
CATALDI, C. L.	North American Aviation, Inc.	International Airport Los Angeles, California 90045
CATHEY, Sam	United Parcel Service	1201 W. Olympic Boulevard Los Angeles, California 90015
CHRISTENSEN, W. G.	Mobil Oil Company	612 South Flower Street Los Angeles, California 90054
CLARK, ERNEST R.	Star-Kist Foods, Inc.	528 Tuna Street Terminal Island, California
CLARK, George E.	Standard Oil Co. of Calif.	2931 San Juan Drive Fullerton, California
CLARK, Henry L.		10940 Bellagio Road Bel Air, California
COHEN, Kenneth P.	Librascope	808 Western Avenue Glendale, California
CONSTANTINE, Gabriel	The National Cash Register Co.	2815 W. El Segundo Boulevard Hawthorne, California
COPELAND, C. H.	Hughes Tool Company Aircraft Division	Centinela at Teale Culver City, California
COPPOCK, Fred	Southern California Gas Co.	P.O. Box 3249, Terminal Annex Los Angeles, California 90054
CORSETTI, SAM	Dixon Boiler Works	1625 Naud Street Los Angeles, California 90012
CRAIG, Clifford N.	U. S. Navy	3421 Poe Street San Diego, California
CURRIER, Lester	The City of San Diego	Civic Center San Diego, California
CZARNECKI, John	Vickers, Inc.	3201 Lomita Boulevard Torrance, California
DAILACIS, U.	Autonetics	P.O. Box X-1 Anaheim, California
DAVID, D. D.	Autonetics	3370 E. Anaheim Road Anaheim, California
DAVIS, E. F.	Lockheed-California Company	P.O. Box 551 Burbank, California
DE LISLE, L. M.	Halsey Machine & Mfg. Co.	1485 South Willow Rialto, California
DEMSKY, Harvey		1202 N. Fuller Avenue Los Angeles, California 90046
DE SANZE, Richard E.		2989 Serrano San Bernardino, California
DE VOSS, Donald W.		812 North Maple Montebello, California

NAME	BUSINESS AFFILIATION	ADDRESS
DIETRICH, William		25798 Date Street San Bernardino, California
DI MARE, Vincent L.	Norton Air Force Base	603 E. Sonora Street San Bernardino, California
DIXON, R. T.	Dixon Boiler Works	1625 Naud Street Los Angeles, California 90012
DOHERTY, Dennil L.	Norton Air Force Base	26764 Mansfield Highland, California
DOUGHTY, N. E.	Aerojet-General Corp.	11711 Woodruff Avenue Downey, California
DRISCOLL, H. F.	Autonetics	P.O. Box X-1 Anaheim, California
EASTIN, William	Cupples Products Corp.	1450 Rincon Street Corona, California 91720
EIDEL, J. G.	Atomic International	8900 De Soto Canoga Park, California
ELDER M.	North American Aviation, Inc.	International Airport Los Angeles, California 90045
ELIASSEN, Randolph	Security First National Bank	411 South Main Street Los Angeles, California
ERWIN, Randolph C.	Pacific Airmotive Corp.	2940 North Hollywood Way Burbank, California
FELDMAN, S.	Litton Systems, Inc.	15901 Strathern Street Van Nuys, California
FERRERI, J. J.	Atomics International	8900 De Soto Canoga Park, California
FIELDER, William F.	Hughes Aircraft Company	2060 E. Imperial Highway El Segundo, California
FOGARTY, John L.	Southern Counties Gas Co.	P.O. Box 2736, Terminal Annex Los Angeles, California 90054
FOSS, O. A.	North American Aviation, Inc.	International Airport Los Angeles, California 90045
FOTTER, Millard J.	Calif. State Polytech. College	Rt. 1, Box 19H San Luis Obispo, California 93401
FRASER, Alton	Technology Instrument Corp.	850 Lawrence Drive Newbury Park, California 91320
GATES, L. A.	Autonetics	9150 E. Imperial Highway Downey, California
GERECKE, William W.	Haskins & Sells	523 West Sixth Street Los Angeles, California 90014
GEYER, E. W.	North American Aviation, Inc.	12214 Lakewood Boulevard Downey, California
GIBSON, Herbert E.		P.O. Box 998 Vandenberg Air Force Base, Calif.
GILBERT, Lloyd	Aerospace Corp.	2400 El Segundo El Segundo, California

NAME	BUSINESS AFFILIATION	ADDRESS
GILLIS, Cameron	Globe Oil Tools Company	11630 E. Burke Street Los Nietos, California 90606
GLASS, Clayton B.	U.S. Navy Area Audit Office	929 South Broadway Los Angeles, California 90015
GONZALES, A. R.	Atomics International	8900 De Soto Canoga Park, California
GORANSON, Dean A.	Lindy Pen Company	9601 W. Jefferson Boulevard Culver City, California
GOULD, Vernon H.	Albert C. Martin & Assoc.	333 South Beaudry Los Angeles, California 90017
GRADY, Charles	Arthur Andersen & Co.	1320 West Third Street Los Angeles, California 90017
GREENE, F.	General Precision, Inc. Information Systems Group	808 Western Avenue Glendale, California
GREER, Jordan	Douglas Aircraft Company	3000 Ocean Park Boulevard Santa Monica, California
GRIFFIN, Richard E.	North American Aviation, Inc.	5868 West 78th Street Los Angeles, California 90045
GRILL, C. E.	Bendix-Pacific Division Electronics Center	15825 Roxford Street Sylmar, California
GUTHEIM, James R.	Microdot, Inc.	6655 Etiwanda Reseda, California
GUTHREY, D.	General Dynamics/Pomona	P.O. Box 1011 Pomona, California
HADEN, Larry	The City of San Diego Administrative Management	Civic Center San Diego, California
HAMILL, A. L.	Datanamics, Inc.	7810 Burnet Avenue Van Nuys, California
HANSEN, H.	Litton Systems, Inc.	15901 Strathern Street Van Nuys, California
HAPGOOD, H. C.	Pacific Telephone Company Room 459	740 South Olive Street Los Angeles, California
HARGIS, W. W.	General Precision, Inc. Information Systems Group	808 Western Avenue Glendale, California
HARTMAN, L. B.	Librascope	1256-B, 25th Street Santa Monica, California
HARVEY, Horace J.	U.S. Naval Supply Center	1389 Windmill El Cajon, California
HARVEY, William C.	U.S. Navy Area Audit Office	929 South Broadway Los Angeles, California 90015
HAW, R.	North American Aviation, Inc.	International Airport Los Angeles, California 90045
HATFIELD, W. W.	North American Aviation	12214 Lakewood Boulevard Downey, California
HAYES, WILLARD J.	Autonetics Navigation System Division	408 Larry Lane Placentia, California

NAME	BUSINESS AFFILIATION	ADDRESS
HEESE, L. A.	Autonetics	9150 E. Imperial Highway Downey, California
HEIN, John W.	Southern California Gas Co.	P.O. Box 3249, Terminal Annex Los Angeles, California 90054
HEIN, Wilbur G.	Varec, Inc.	2820 North Alameda Compton, California 90224
HENDERSON, G.	Litton Systems, Inc.	15901 Strathern Street Van Nuys, California
HENRY, William E.	Globe Oil Tools Company	11630 E. Burke Street Los Nietos, California 90606
HERMANN, John Adam		3177 Harrison San Bernardino, California
HOFFMAN, Lee	National Cash Register Co.	2815 W. El Segundo Boulevard Hawthorne, California
HOLLISTER, Frank M.	Douglas Aircraft Company	3855 Lakewood Boulevard Long Beach, California
HOWES, Richard P.		3591 Thor Los Alamitos, California
HOY, E. C.	Litton Systems, Inc.	5500 Canoga Avenue Woodland Hills, California
HUNT, George A.	North American Aviation, Inc. Space & Information Division	12214 Lakewood Boulevard Downey, California
IRWIN, Ralph W.	Procter & Gamble Mfg. Co.	1601 West Seventh Street Long Beach, California
IVANS, Wayne W.	Halsey Machine & Mfg. Co.	1485 South Willow Rialto, California
JACHEL, H. V.	Southern California Edison Co.	P.O. Box 231 Los Angeles, California 90053
JARDINE, John E.	Hughes Aircraft Company	2020 Oceanside Boulevard Oceanside, California 92057
JENSEN, W. S. (2)	Preco, Inc.	6300 E. Slauson Avenue Los Angeles, California 90022
JOHNSON, Aaron M.		2200 Pacific Coast Highway San Diego, California
JOHNSTON, Robert K.	Lockheed Aircraft International	510 West Sixth Street Los Angeles, California 90014
JOLLIFF, G. N.	Autonetics	P.O. Box X-1 Anaheim, California
KAHLEN, H.	Johns-Manville	P.O. Box 9067 Long Beach, California
KANE, Eneas D.	California Research Corp.	Box 446 La Habra, California
KASPAR, Hans	Rocketdyne	6633 Canoga Avenue Canoga Park, California 91304
KEATING, P. F.	Douglas Aircraft Company	3855 Lakewood Boulevard Long Beach, California

NAME	BUSINESS AFFILIATION	ADDRESS
KEEN, G. M.	North American Aviation, Inc.	12214 Lakewood Boulevard Downey, California
KEMPER, Jack W.	Norton Air Force Base	San Bernardino, California
KENNEDY, Edward R.	North American Aviation, Inc.	12214 Lakewood Boulevard Downey, California
KENNY, G.	North American Aviation, Inc.	International Airport Los Angeles, California 90045
KIDWELL, Richard	Aerospace Corporation	2400 E. El Segundo El Segundo, California
KLEINSMUTH, P. L.	Atomics International	8900 De Soto Canoga Park, California
KLEMENTOWSKI, James	National Cash Register Co.	2815 W. El Segundo Boulevard Hawthorne, California
KOERNER, Carl T.	The Pacific Telephone Co.	740 South Olive Street Los Angeles, California 90055
KOPOTIC, Robert	The City of San Diego Administrative Management	Civic Center San Diego, California
KRAVE, Robert F.	Microdot, Inc.	72 North Naomi Avenue Arcadia, California
KRINSKY, Joseph S.	Pacific Missile Range	Point Mugu, California
KUNKE, T. R.	Autonetics	P.O. Box X-1 Anaheim, California
LAHMEYER, P. M.	Firestone Tire & Rubber Co.	2525 E. Firestone Boulevard Los Angeles, California 90054
LAMAR, Bill	Farmers Insurance Group	4680 Wilshire Boulevard Los Angeles, California 90054
LAMPE, R.	Autonetics	P.O. Box X-1 Anaheim, California
LANCASTER, C. F.	North American Aviation, Inc.	International Airport Los Angeles, California 90045
LAUE, Pete	General Precision, Inc. Information Systems Group	808 Western Avenue Glendale, California
LAUVER, Hugh		464 Mercury Lompoc, California
LEHMUTH, Henry III	Airesearch Manufacturing Co.	9851 Sepulveda Boulevard Los Angeles, California
LEONHARDT, John J.	Hughes Aircraft Company Field Service & Support	P.O. Box 90515, Bldg. 102, M/S 6 Los Angeles, California 90009
LETZ, Charles M.	Ellison Machinery Company	160 West 33rd Street Los Angeles, California 90007
LYONS, Lee L.	Pacific Telephone Company Room 405	5400 Van Nuys Boulevard Van Nuys, California
MAC COON, Grant K.	Grant Piston Ring Company	241 North Westmoreland Los Angeles, California 90004
MACKAY, Douglas D.	Pacific Pumps, Inc.	5715 Bickett Street Huntington Park, California

NAME	BUSINESS AFFILIATION	ADDRESS
MAC KENZIE, I. M. Jr.	Mobil Oil Company	612 South Flower Street Los Angeles, California 90054
MALOM, C. L.	U.S. Rubber Tire Company	5675 Telegraph Road Los Angeles, California 90022
MANDEL, M. Milo	Columbia Pictures Corp.	1438 N. Gower Street Hollywood, California 90028
MATUKAITIS, Albert Joseph	Huffman Manufacturing Co.	513 Stewart Covina, California
MC CUE, W. R.	General Dynamics/Pomona	1675 West Fifth Street Pomona, California
MC Dermott, Robert F.	U.S. Borax-Chemical Corp.	300 Falcon Street Wilmington, California 90744
Mc EWEN, J. R.	Mobil Oil Company	612 South Flower Street Los Angeles, California 90054
Mc KANE, John J.	Hughes Aircraft Company	P.O. Box 90515, Bldg. 106, M/S 6 Los Angeles, California 90009
Mc MILLEN, Charles H.	Federal Aviation Agency	P.O. Box 1689 Fort Worth, Texas 76101
Mc MINN, R. A.	Menda Company	727 South Ninth Avenue City of Industry, California
Mc NELL, Phillip F.		3220 Larkdale Place San Diego, California
Mc QUADE, P. R.	Vector Electronic Company	1100 Flower Street Glendale, California
MELLINGER, Harry		1221 Catalina San Diego, California
MELTON, C. M.	Hughes Tool Company Aircraft Division	Centinela at Teale Culver City, California
METSCHAN, Joseph	Farmers Insurance Group	4680 Wilshire Boulevard Los Angeles, California 90054
METZGER, Donald P.	Bunker-Ramo Corporation	8433 Fallbrook Avenue Canoga Park, California 91306
MILLER, William D.	Davis Wire Corporation	6315 Bandini Los Angeles, California 90022
MISKO, W. J.	Beckman Instruments, Inc.	2500 Harbor Boulevard Fullerton, California
MOLER, M. H.	Bendix-Pacific Division	15825 Roxford Street Sylmar, California
MOLLET, H. W.	Atomics International	8900 De Soto Canoga Park, California
MOORE, James H.	Autonetics-AFPRO	3370 Anaheim Road Anaheim, California
MORGAN, R. E.	Beckman Instruments, Inc.	2500 Harbor Boulevard Fullerton, California 92634
MOULD, Donald T.		9228 Ahman Whittier, California

NAME	BUSINESS AFFILIATION	ADDRESS
MURROW, James R.	Johns-Manville	P.O. Box 9067 Long Beach, California
MUSSER, George	Litton Systems, Inc.	5500 Canoga Avenue Woodland Hills, California
NADEAU, Arthur R.	Aeroquip Corporation Marman Division	11214 W. Exposition Boulevard Los Angeles, California
NETZ, Charles		22831 Burbank Boulevard Woodland Hills, California
NEWMAN, E. D.	Librascope Division	808 Western Avenue Glendale, California 91201
NILSSON, Noel R.	North American Aviation	1019 Modena Place Anaheim, California
NOTKIN, S.	North American Aviation, Inc.	International Airport Los Angeles, California 90045
O'NEAL, R. D.	Litton Systems, Inc.	5500 Canoga Avenue Woodland Hills, California
ORIANS, James R.	North American Aviation, Inc. Space & Information Division	12214 Lakewood Boulevard Downey, California
OSBORN, W. C.	Northrop Norair	3901 West Broadway Hawthorne, California 90250
OSBORNE, G. M. Jr.	Autonetics	P.O. Box X-1 Anaheim, California
PAPP, A.	North American Aviation, Inc.	International Airport Los Angeles, California 90045
PARRY, R.	Litton Systems, Inc.	15901 Strathern Street Van Nuys, California
PATTERSON, E. J. Jr.	Southern Counties Gas Co.	P.O. Box 2736, Terminal Annex Los Angeles, California 90054
PAUL, P. F. Jr.	Autonetics	P.O. Box X-1 Anaheim, California
PAULL, Alvord	Pacific Telephone Company Room 103	1441 Sixth Avenue San Diego, California
PAULSON, W. H.	Standard Oil Co. of Calif.	605 West Olympic Boulevard Los Angeles, California 90015
PETERS, Donald		420 Kansas Street El Segundo, California
PHILLIPS, Alvin E.		464 Cumbre Monterey Park, California
PHILLIPS, J. A. III		1525 Monterey Road South Pasadena, California
PHILLIPS, M.	North American Aviation, Inc.	International Airport Los Angeles, California 90045
PLAMBECK, E. M.	Kaynar Manufacturing Co., Inc.	P.O. Box 3001 Fullerton, California
POLIQUIN, J. J.	North American Aviation, Inc.	International Airport Los Angeles, California 90045

NAME	BUSINESS AFFILIATION	ADDRESS
POVLSEN, Paul K.	Manchester Tank & Equipment Co.	2880 Norton Avenue Lynwood, California
PROCZ, Frank J.	TRW - Space Technology Labs.	616, 29th Street Manhattan Beach, California
PROUD, G. L.	Autonetics	P.O. Box X-1 Anaheim, California
PUGMIRE, R.	North American Aviation, Inc.	International Airport Los Angeles, California 90045
RADAMAKER, Ted	Commission for Administrative Services in Hospitals	1515 North Vermont Avenue Los Angeles, California 90027
RADCLIFFE, James A.	Southern California Gas Co.	P.O. Box 3249, Terminal Annex Los Angeles, California 90054
RASMUSSEN, R.	North American Aviation, Inc.	International Airport Los Angeles, California 90045
RATHLESBERGER, Howard	Airesearch Manufacturing Co.	9851 Sepulveda Boulevard Los Angeles, California
REIFSCHNEIDER, Mollie	Manchester Tank & Equipment Co.	2880 Norton Avenue Lynwood, California
REINDL, Daryl	North American Aviation	9300 Second Avenue Inglewood, California 90009
REMMES, Joseph A.	Hughes Aircraft Company	Centinela & Teale Streets Culver City, California
REZAC, Ronald A.	Norton Air Force Base	1096 Fifth Street Calimesa, California
RITCHEY, James C.	Firestone Tire & Rubber Co.	2525 E. Firestone Boulevard Los Angeles, California 90054
ROBERTS, John E.	Northrop Norair	3901 West Broadway Hawthorne, California
ROBINSON, Bill J.	American Airlines, Inc.	7000 World Way West Los Angeles, California
ROBINSON, Douglas I.	Hughes Aircraft Company, Inc. Dept. 36-39-10, Bldg. 351,M/5668	2060 East Imperial Highway El Segundo, California
ROBISON, Stuart W.		536 Ninth Street, Box 996 Trona, California
ROMER, L. C.	U.S. Electrical Motors	Anaheim, California
ROSEN, ROBERT		2020 Redcliff Street Los Angeles, California 90039
RUSSELL, C. R.	Richfield Oil Corporation	P.O. Box 75007, Sanford Station Los Angeles, California 90005
RYMER, R. R.	U.S. Electrical Motors	200 East Slauson Avenue Los Angeles, California
SADIL, R. J.		15929 Sharonhill Drive Whittier, California
SCAPELLATI, Salvatore	Lockheed-California Company	10917 Plainview Avenue Tujunga, California

NAME	BUSINESS AFFILIATION	ADDRESS
SCHAUB, A. F.	Atomics International	8900 De Soto Canoga Park, California
SCHEFFER, Paul		825 Maryhurst Claremont, California
SCHINDLER, J. D.	Autonetics	P.O. Box X-1 Anaheim, California
SCHNABEL, E. A.	Autonetics	3370 E. Anaheim Road Anaheim, California
SCHNEIDER, K. O.		2248 Continental Avenue Costa Mesa, California
SCHNEIDER, L. E.	Port of Los Angeles	P.O. Box 151 San Pedro, California 90733
SCHUYLER, L. D.	Bendix-Pacific Div. Electronics Center	15825 Roxford Street Sylmar, California
SCOVILLE, R. R.	Vector Electronic Company	1100 Flower Street Glendale, California
SEAGEL, D.	Atomics International	8900 De Soto Canoga Park, California
SEAMOUNT, Daniel T.	University of California	P.O. Box 112 Riverside, California 92502
SHARK, John Oliver		25567 Dartmouth Hemet, California
SMITH, Clyde L.	Times Mirror Press	1115 South Boyle Avenue Los Angeles, California 90023
SMITH, M. F.	Autonetics	9150 East Imperial Highway Downey, California
SNEATHEN, GEORGE M.		1005 East Grand Boulevard Corona, California
SNELL, F.	Packard Bell Electronics	12333 West Olympic Boulevard Los Angeles, California 90064
SOLTIS, Michael	General Dynamics/Pomona	1675 West Fifth Street Pomona, California
SOMMER, R. M.	Pabst Brewing Company	1910 North Main Street Los Angeles, California 90031
STANFORD, Ralph C.	Southern Counties Gas Company	P.O. Box 2736, Terminal Annex Los Angeles, California 90054
STANLEY, Joe	United Parcel Service	1201 West Olympic Boulevard Los Angeles, California 90015
STEIN, Arthur L.	Interpace, International Pipe & Ceramics Corp.	2901 Los Feliz Boulevard Los Angeles, California
STERN, David M.	Gordon Enterprises	5362 Cahuenga Boulevard North Hollywood, California
STONE, Donna	USAF, Norton Air Force Base	1485 Toluca Drive San Bernardino, California
SULLIVAN, J. L.	Autonetics	3370 East Anaheim Road Anaheim, California

NAME	BUSINESS AFFILIATION	ADDRESS
SUMPTER, James L.	Eastman Kodak Company	1017 North Las Palmas Avenue Hollywood, California 90038
SWANSON, HARRY W.	North American Aviation, Inc.	12214 Lakewood Boulevard Downey, California
SWIKARD, Edward L.		3019 Rendezvous Road Lemon Grove, California
SYLVESTER, G. E.	General Dynamics/Pomona	P.O. Box 1011 Pomona, California
TAMBLYN, G. A.	Autonetics	P.O. Box X-1 Anaheim, California
TAMURA, Harry H.		4662 Hamer Drive Placentia, California
TAYLOR, Floyd	Lockheed-California Company	P.O. Box 551 Burbank, California
THOMAS, Robert A.	Department of the Navy Bureau of Yards & Docks	1220 Pacific Highway San Diego, California 92119
THOMPSON, C. A.	U.S. Electrical Motors	200 E. Slauson Avenue Los Angeles, California
TSCHAN, W. F.	U.S. Rubber Tire Company	5675 Telegraph Road Los Angeles, California 90022
TUMPNEY, Bill	United Parcel Service	1201 W. Olympic Boulevard Los Angeles, California 90015
TUPPER, Leonard D.	City of Los Angeles	757 South Berendo, Apt. 107 Los Angeles, California 90005
TURK, John G.	Richfield Oil Corp	Box 787 Wilmington, California
TURNER, W. G. (3)	Aluminum Company of America	5151 Alcoa Avenue Los Angeles, California 90058
VAN BLARCORN, J. T.	North American Aviation, Inc.	12214 Lakewood Boulevard Downey, California
WADHWANI, Pahlaj	National Cash Register Co.	2815 West El Segundo Boulevard Hawthorne, California
WASHINGTON, James R.	American Hard Rubber Company	3211-15 East 26th Street Los Angeles, California 90023
WATKINS, H. D.	H.D. Watkins & Associates Suite 102	470 San Vicente Boulevard Los Angeles, California 90048
WATSON, George M.	Wayne Manufacturing Company	Pomona, California
WEAVER, H. L.	Union Carbide Chemicals Co.	P.O. Box 407 Torrance, California
WEIR, Keith C.	Sandia Corporation	Sandia Base Albuquerque, New Mexico
WENZEL, Warren A.		629 North Ardmore Los Angeles, California 90004
WHITENECK, L. L.	Port of Los Angeles	P.O. Box 151 San Pedro, California 90733

NAME	BUSINESS AFFILIATION	ADDRESS
WIBERG, H. E.	U.S. Rubber Tire Company	5675 Telegraph Road Los Angeles, California 90022
WIESE, Robert W.	Atomics International	P.O. Box 309 Canoga Park, California
WINFIELD, Charles	Eldon Industries	152 Via Undine Newport Beach, California
WINIK, L. J.	General Precision, Inc. Information Systems Group	808 Western Avenue Glendale, California
WISLER, Richard A.		5199 Berryman Avenue Culver City, California
WOOD, D. R.	Southern California Gas Company	810 South Flower Street Los Angeles, California
WOOD, F.	Packard Bell Electronics	12333 West Olympic Boulevard Los Angeles, California 90064
WOODBRIDGE, Charles L. (2)	Autonetics	3770 Anaheim Road Anaheim, California
WOOLDRIDGE, E. J.	Scantlin Electronics	2231 Barrington Avenue Los Angeles, California 90064
WORTMAN, Marshall	Revue Studios	Universal City, California
WREDT, Robert C.		4077 Hatton Street San Diego, California
WYTHE, F.	North American Aviation, Inc.	International Airport Los Angeles, California 90045
YOH, George W.	Marman Division Aeroquip Corporation	11214 West Exposition Boulevard Los Angeles, California
YOUNG, D. T.	North American Aviation, Inc.	12214 Lakewood Boulevard Downey, California
YOWELL, James Neal	Kimberly-Clark Corporation	2001 East Orangethorpe Avenue Fullerton, California
ZUBRO, Walter	Cupples Products Corp.	1450 Rincon Street Corona, California 91720

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