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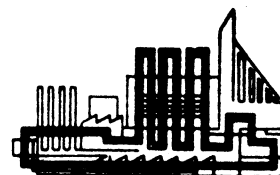
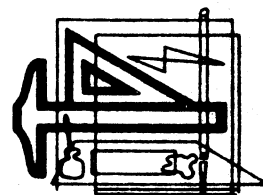
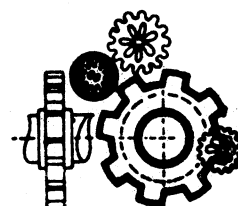
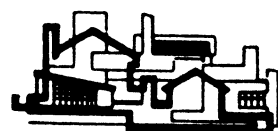
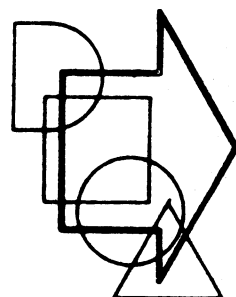
FOURTEENTH

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UNIVERSITY OF CALIFORNIA

BERKELEY

February 2 and 3, 1962

LOS ANGELES

PROCEEDINGS
FOURTEENTH 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 2 and 3, 1962**

In Cooperation with:

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

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**Editor: Edward V. Sedgwick, Conference Coordinator
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FOREWORD

Edward V. Sedgwick
Editor and General Chairman
14th Annual Industrial Institute

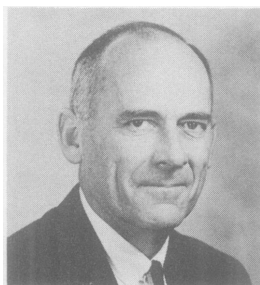
In the academic world there is a tendency to combine disciplines and to develop new disciplines that cut across traditional lines, whenever there are areas of mutual interest. The merging of management and engineering in certain fields and the cross-breeding of accounting, economics, engineering, mathematics, physiology, psychology, and statistics to produce the profession of Industrial Engineering are well known.

Along another dimension a similar tendency is recognizable among business, education, government and labor groups. The presence of leaders from these groups at these Institutes is further evidence of an ever-widening scope of mutual interest. Further, many of the Institute speakers as well as the participants, are consultants (a relatively new addition to our economy) who may serve business, education, government and labor alike. Such tendencies toward vertical merging and horizontal segmenting of disciplines and economic groups are the inevita-

ble result of a dynamic and fluid economy. Our economy demands the constant communication of ideas among all its components merely to service the economic system, not to mention the need for communication of ideas in order to promote economic growth.

These Institutes, therefore, take on added significance when you consider their purpose, which is "to present to industrial engineers and managers the latest developments in research and practice in these fields. The content of the papers will be of interest to line and staff personnel in both large and small companies."

To fulfill this purpose, we have selected speakers who are equipped to give the broad-gauge approach to problems that is so essential to modern management. This superb group of speakers covers many disciplines and "wears many hats." To all of them I wish to express my sincere thanks for a job well done.

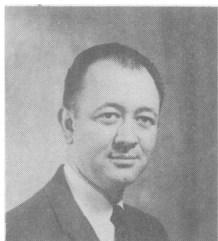


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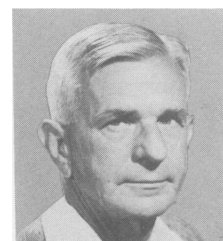
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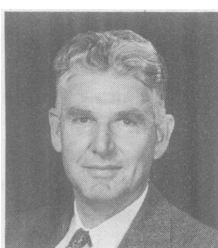
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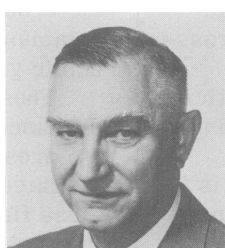
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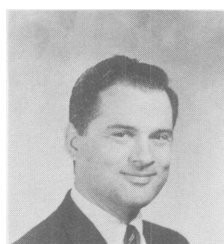


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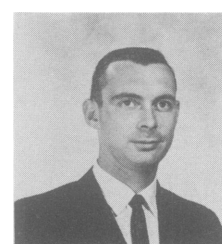
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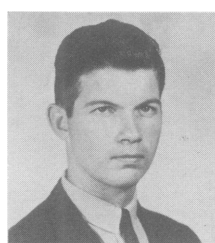
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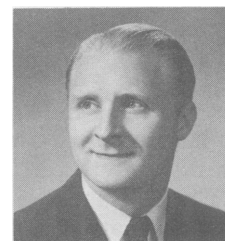
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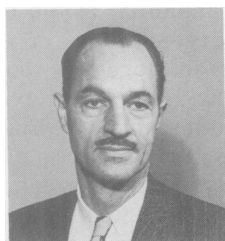
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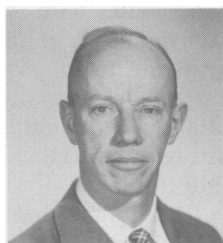


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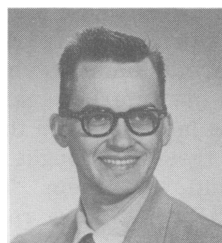
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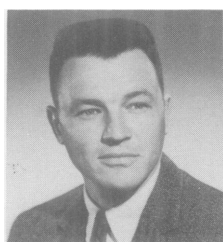
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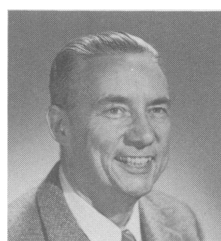
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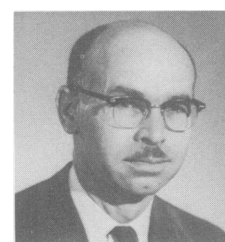
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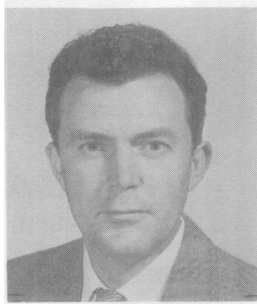
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WELCOMING REMARKS

BERKELEY

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

Two years ago I had the opportunity of welcoming you to the Institute, and am happy to be honored again with this privilege. The continuing success of the Industrial Engineering Institute should be a source of gratification to those who began it fourteen years ago, and to all who have worked to make it successful in the years since. Certainly it is an example of the kind of cooperative venture between Industry and the University that helps us both and which might well be a model for many areas in which we are mutually concerned. I am also pleased that it is an occasion for cooperation among several branches of the University – Business Administration, Industrial Relations, Engineering, University Extension, and the two campuses.

This fourteenth anniversary of the Institute is also the hundredth anniversary of the Morrill Act, which set up the Land-Grant Colleges and which is being celebrated by many occasions this year throughout the country. Chancellor Murphy stressed this Institute in Los Angeles last year as one of the successful fulfillments of obligations in the spirit of this act, and I also would like to remind you of this for this meeting in Berkeley.

When we talked two years ago it was clear that two of the major challenges facing the industrial community of this country were automation and the growth of industrialization in the emerging nations. Certainly the programs of the Institute over the past several years have reflected these challenges and I am sure have contributed solutions to them. These challenges and the opportunities which they represent are no less today, but at this time our community is aware of a new source of challenge from our industrial friends of Western Europe, especially through the impact of the European Common Market.

The conclusion from the point of view of Indus-

trial Engineering is much the same for this challenge as for the earlier ones. It is important that the tools of this profession be put to use to improve the productivity and efficiency of our industrial plant as much as possible. This includes the use of the newest tools as well as the oldest, and even the oldest ones are relatively young as I understand the development of this field.

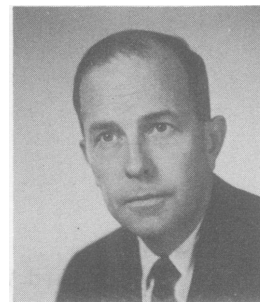
Now it is the responsibility of the University as well as the research organizations of your companies to help develop even more new tools for the use of future Industrial Engineers. Professor Shephard, present Chairman of our Industrial Engineering Department, told you last year of some of the steps being taken in the department to prepare for the new trends, and hopefully to contribute ideas to these trends. Thus, the curriculum of the Department was modified, with strengthening in the new and growing areas of Operations Research and Ergonomics (Man-machine systems) as well as in the classic stems of Industrial Engineering Management and Metal Processing. The Operations Research Center had been formed and has since worked closely with the Department in this area. These steps have been very successful, with student enrollments growing (in fact nearly doubling) during this one year at the graduate level. The Center is well established with a distinguished staff and a creditable list of accomplishments to date, so we hope we are now in a position to contribute even more to the future tools of this field.

I am sure that this meeting and exchange of ideas can help all of us in the development of the new tools as well as the use of existing ones. I again welcome you to the conference and wish you all success in it.

WELCOMING REMARKS

LOS ANGELES

Franklin D. Murphy
Chancellor
University of California
Los Angeles, California



Mr. Chairman and Gentlemen:

I am very happy to have the opportunity to welcome you to this campus under the auspices of what the current issue of *Time* magazine calls "in breadth and depth the most extensive program of adult education and extension education in the United States." I welcome you because your presence here reflects not a peripheral, but a very central part of the functions of a great American state university.

It is my conviction that the American Republic has made but one really unique contribution to the theory of education. It was the concept of the land grant college or university which, by the way, celebrates its hundredth anniversary this year. It was just one hundred years ago, in what was then an underdeveloped country, that the American people, in their intuitive wisdom and perhaps their Yankee practicality, declared that they would turn the resources of higher education to the exploitation of this underdeveloped continent.

At the time, education was a scholarly, somewhat esoteric pursuit, in spite of the fact that three of the four disciplines of the first great medieval universities of the 12th and 13th century were professional in nature — medicine, law, and theology. It was nonetheless true that up until the middle of this century, the pragmatic relationship between centers of learning and the daily needs of the people was tenuous if it existed at all. The Morrill Land Grant Act changed all this, declaring plainly that the people have a huge responsibility, first of all, to support institutions of higher education, and secondly, to increase the impact of these institutions on the manifest needs of the people. As a result, a large number of state universities — people's universities — were created. These universities, designed to serve the people and owned by the people, are exemplified in the great statewide University of California.

At the time the land grant tradition began, agriculture and the productive capacity of the soil was beginning to be as something other than the handing down of primeval traditions from generation to generation. Agriculture was brought into the university and became through the years a very precise science. This was also the point in history when engineering was taken from the back of machine and blacksmith shops, out of the hands of mechanics' apprentices, and put into the classrooms and laboratories of our universities. It is my view that, in no small measure, perhaps in the largest measure, the explosive development of this nation into the most powerful and productive agricultural-industrial complex in world history is due to the fact that at all levels education has been oriented toward the ongoing technological-economic development of the nation. This is true for the production of research resources and advanced personnel on the one hand, and for providing the huge reservoir of competent and skilled technicians on the other, to which our secondary schools have made the major contribution.

The kind of program in which we are participating today reflects this continuing responsibility of the state university, and, at the same time, takes into cognizance the explosion of human knowledge characteristic of our times. This kind of program, therefore, is not peripheral to the function of UCLA. It is not something that we endure simply to remain popular among the constituency. It is not something appended to the major mission of the fulltime undergraduate or graduate student. It is, in fact, central in our understanding of our obligation.

I hope that your days at UCLA this year are as productive as they have been in years past for those of you who have come again. I welcome and thank our guests who come to lecture to you, and I hope that all of you together have a happy and felicitous experience at UCLA. Thank you very much.

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SUPERVISORY AND TECHNICAL ACTIVITY ANALYSIS

Hugh A. Bogle
Chief Industrial Engineer
E. I. du Pont de Nemours & Co.
Wilmington, Delaware



Mechanization, automation, and concomitant increases in the technological complexity of industry have greatly increased both the proportion of technical and supervisory personnel in the industrial population and their importance to the success of a business.

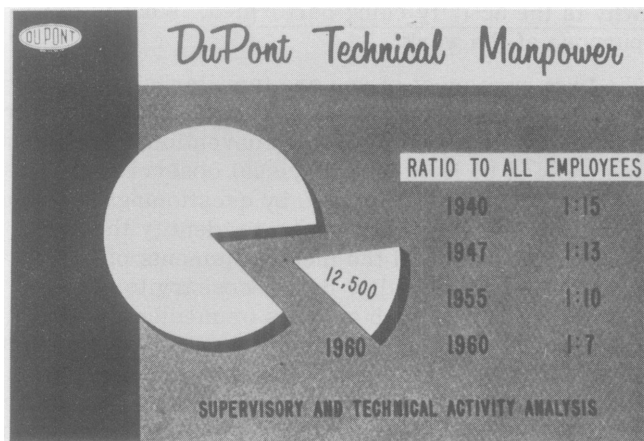


Figure 1

Both the scarcity of competent technical personnel and their cost require the most effective utilization of their skills. Industrial engineering techniques have long been available for control of operators (production workers) and more recently for maintenance and other indirect workers. However, the non-standard, non-repetitive, and creative characteristics of technical work have precluded the use of these techniques. Management of technical and supervisory personnel has been based more on intuitive judgment than on specific information about individual effort. Important decisions on organization, work assignment, facilities, and supporting services for technical and supervisory personnel have often been made by management, on the basis of subjective opinion rather than on factual information.

Until recently it was generally accepted that the effort of supervisory and technical personnel was not a measurable entity. Although this viewpoint still finds many adherents, most managers and executives have come to accept the philosophy that any type of manpower must be skillfully managed and that management of supervisory and technical manpower, unsupported by full facts, can lead to less than optimum utilization of this important and expensive skill. Therefore, a need exists for a method

for gathering information or facts that can be used objectively in directing the efforts of this important group of employees.

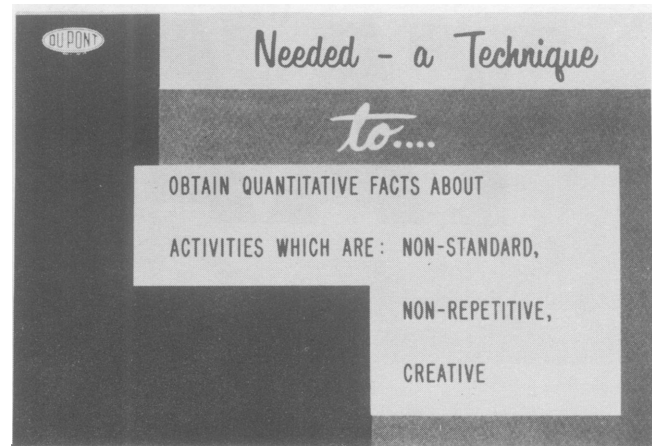


Figure 2

This fact-gathering method should offer the following advantages:

1. Provide an accurate account of how much effort is being expended on each part of the assigned duties.
2. Provide a clear picture of working conditions in the group under study.
3. Point out abnormal conditions or undesirable influences, so that these may be studied and eliminated or reduced in scope.
4. Point the way to methods or procedural changes for necessary work and provide clues as to where more extensive methods studies can be justified.
5. Indicate organizational weaknesses and areas where redistribution of skills can result in more economic use of manpower.
6. Provide individual anonymity. Studies of this nature should be directed at improving organizational effectiveness and not at reporting poor performance of an individual. It is important to avoid any inference of individual discipline or punitive action to maintain group morale and cooperation.

7. Provide information on not only what is being done but also on the purpose for doing it. In supervisory and technical work physical activity does not necessarily connote productivity. In fact, a technical man sitting in his office with his feet on the desk may be generating new ideas and producing more effectively than if he were energetically moving papers in a file drawer.

In the Du Pont Company, we have designed a plan based on the work sampling technique which includes all the above requirements and advantages.

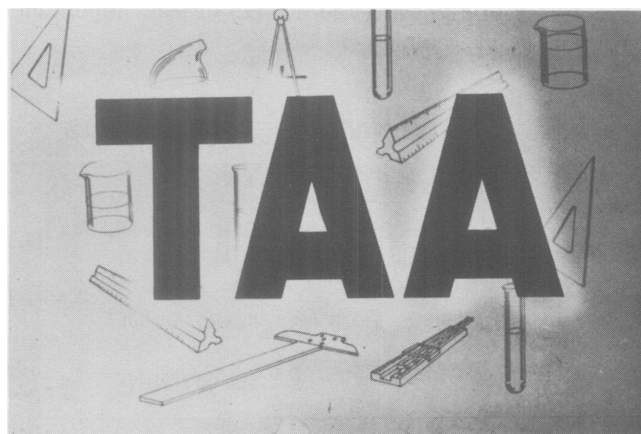


Figure 3

We call this plan Technical Activity Analysis, or TAA for short. Information is developed on five points:

1. **WHO** is performing an activity.
2. **WHERE** is the activity taking place.
3. **WHEN** is the activity taking place.
4. **WHAT** is the nature of the activity.
5. **WHY** is the activity being performed.

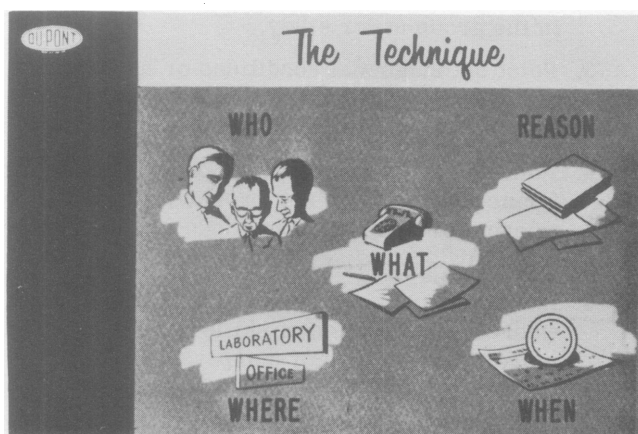


Figure 4

Amplify each of these areas:

Who is performing the activity. Here we refer to

the organizational level and group of the individual being observed. Is it the junior engineer, engineer, senior engineer, or supervisor in the Primary Research Group. This identification renders it possible to make both horizontal and vertical comparisons of groups and personnel levels in the organization without the necessity for recording individual names.

Where is the activity taking place. This gives us a picture of personnel movement and adequacy of location.

When is the activity taking place. The time and date of observation is often needed in analyzing for cyclic trends in activities.

What is the nature of the activity. What is being done at the time of observation, e.g., telephoning, writing, handling papers, walking, etc.

Why is the activity being performed. What is the purpose of the work.

I am sure most of you are familiar with work sampling and will have recognized that the first four points are items covered in a conventional work sample and can be identified by visual observation. It is the last item, "Why," which, by questioning, develops the additional detail necessary to identify the purpose of the work and the mental elements of technical work. Occasionally, it is necessary to include additional points, such as tools or medium being used to perform the activity, or the area of business, but generally the above five points are sufficient.

Now let's look at the operation of a Technical Activity Analysis. The first step is to select the group to be studied. Similarity of function is the prime consideration in determining which people in an organization should be included in one sample group, as the inclusion of persons with unrelated functions may upset the statistical validity of the information developed. In general, a horizontal sample of persons having the same job level in an organization has a greater homogeneity than a vertical sample of different job levels. However, we have made successful studies of entire groups where group activity was closely related, as, for example, sampling both scientists and technicians in a research group.

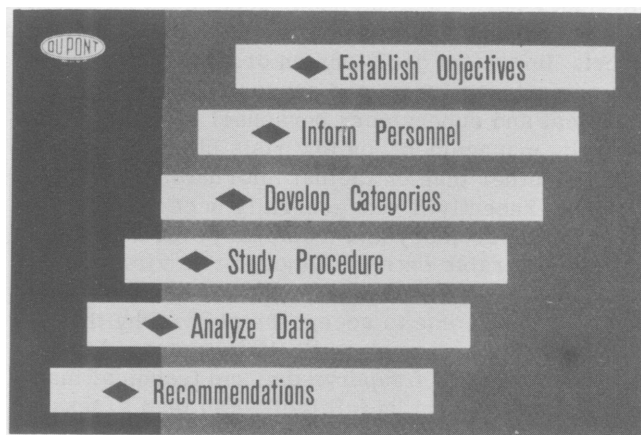


Figure 5

The next step is to establish the objectives of the study, that is, the questions to be answered and the type of information needed. It is very important to have a clear statement of the objectives and of the information needed as a basis for design of the sampling system

Before any concrete steps are taken toward conduct of the study, every person in the group to be covered should be acquainted with the purpose and mechanics of the study. Whenever any effort is made to gather information about the activities of people, they may react negatively because of their fear of how the information will be used. Three points should be stressed:

1. Technical Activity Analysis is concerned only with information on the organization as a whole or by general subgroups, and *not* on individual performance. In fact, observations of a single individual in the frequency used are statistically meaningless.
2. The procedure cannot provide information on quality of work. It provides only quantitative information on group effort.
3. Technical Activity Analysis permits the group to improve conditions. Assurance can be given that quantitative information on inequities in distribution of activities and inadequacies of facilities will be used to justify improvement.

At the same time, the observer for the study should be selected so that he may participate in developing procedural details. Preferably, he should be a senior member of the organization being sampled, with broad enough experience to quickly recognize the activities he encounters. Also, he must be reliable and consistent and should enjoy the respect and confidence of the organization as well as having tact and diplomacy to a high degree. He should be fully relieved of regular duties to concentrate on the study.

The next step is to establish categories or subdivisions for the main areas of information discussed previously. These categories serve as slots or counters for recording the number of times an activity was observed during the study. The benefit derived from the study will be in proportion to the care exercised in category selection, as these must be designed to provide answers to management's questions and suggest a course of action to attain objectives. Very narrow categories require more careful observation and are more difficult to classify consistently. If found to be too complex, narrow categories can later be grouped into broader categories; however, broad categories cannot be subdivided after the study has been completed. For example, one of the "What" categories might be "Dictating" and this would provide satisfactory information on group effort in this area; however, if it were desirable to know the division of dictation between machines and stenographers, a finer breakdown would be required.

A listing of categories which might be used by

two typical types of organizations are shown in Charts I and II:

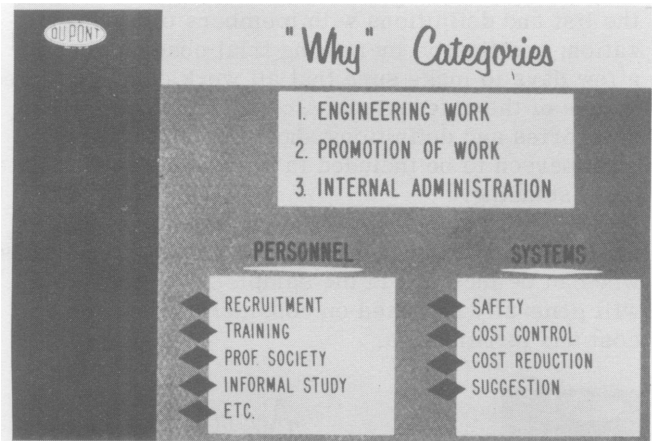


Figure 6

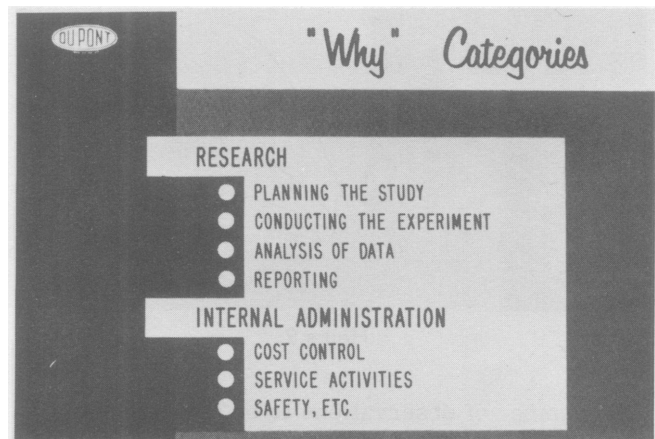


Figure 7

Each category should be clearly defined so that observations can be consistently classified. Definitions should be very specific; for example, distinction between a meeting and a discussion can be arbitrarily set for a group by the number of participants; as, four or more for a meeting and two or three for a discussion.

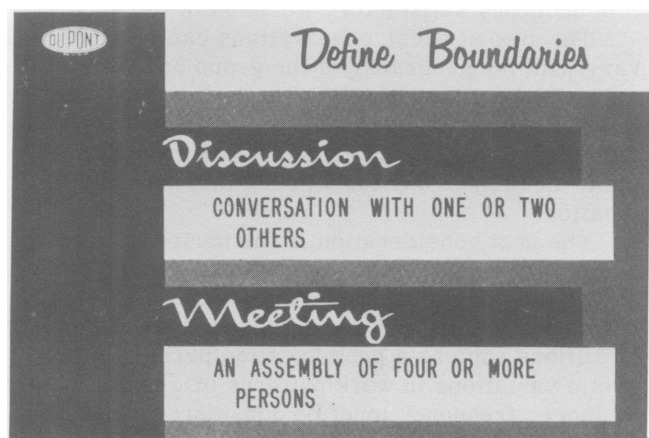


Figure 8

After preliminary categories have been developed based on the information needed, they should be carefully checked for completeness: first, by review of the list and definitions with members of the organization, and finally, by making trial observations for a few days to make sure that all work can be covered by one of the categories. A copy of the final list of categories and definitions should be distributed to each person to be included in the sample to facilitate understanding.

If the chosen group is properly homogeneous, there is no maximum limit to the number of persons who can be included in the sample. The minimum will generally be based on considerations of study cost and justification.

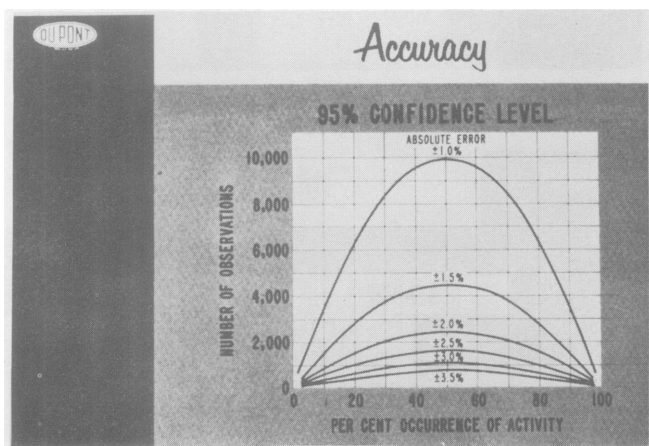


Figure 9

The number of observations to be taken are controlled by the degree of acceptable deviation, or to put it another way, by the degree of accuracy of information required. As an example, at a confidence limit of 95 per cent, if a given activity takes place 15 per cent of the time, we must make 5,100 observations to have a deviation of ± 1 per cent, but only require 205 observations for a deviation of ± 5 per cent. As a rule of thumb, 2,500 total observations will give an accuracy of ± 2 per cent except for extremely low or high occurrence, and we have found this accuracy satisfactory for most of our studies.

The rate at which observations can be made will vary with the geography of the group and with the observer's familiarity with the activities being observed. Our experience has varied from as few as 40 observations per day for widely scattered groups to as many as 125 per day for a group in a concentrated location.

The next consideration is the period of time during which the sample will be made. This period should include as representative a cross section of work as possible, and should generally avoid unusual conditions such as a peak vacation period. Also, cyclic variations in work patterns of weekly, monthly, or longer frequency must be considered. In most cases, we have found that daily samples over a one-month period give a satisfactory cross section.

For statistical validity, it is necessary for the observations to be at completely random intervals and in random order of sequence; therefore, some statistically reliable procedure of selecting the individual and the time of observation must be followed. There are many ways of accomplishing this varying, such as putting the names of all persons in the group to be studied in a container, mixing thoroughly, and drawing a name. The name obtained then becomes the subject of observation at that time; afterwards, one places the slip back in the container, mixes, and selects another for the next observation, and so forth. A more convenient procedure which we have used frequently is based on the use of random numbers and tabulating cards. After the sample size has been decided upon, we divide the total number of observations by the number of people in the group; we then write the name of each individual on this number of cards. Afterwards, a number from a table of random numbers is punched in each card. Sorting the cards by numerical sequence will change the randomization from number to names, and by dividing the cards into groups for each day of the planned sample period, the number and order of observations for each day is obtained. As it is necessary for all aspects of the observations to be randomized, the starting time for observations should be randomly varied from day to day; and if the entire day is not to be spent in observation, the periods for other activity should be randomly distributed over the day.

To avoid bias, observations must be made instantaneously and information on Who (level and group), When, Where, and What categories is recorded. To determine *why* the activity is taking place, it is necessary to ask a few questions and discuss the action at the instant of observation. If the observer has a thorough knowledge of the work of the group, he will need only a very brief discussion and will also be able to judge the reliability of this information to a considerable degree. If the observer finds that he is being given misinformation, it can be assumed that the study has not been understood by the group and that further "selling" is needed.

In many technical groups, a considerable part of the work may take place at some location other than the individual's office. For example, engineering consultants will do much of their work at the client's location. In such instances, failure to consider work at other locations would give a very incomplete picture of group activities. In our studies, where the individual was away from his office at the time of observation, a check list was left indicating the time at which the observer called and requesting the individual to record his activity at this instant and its purpose. Obviously, this procedure introduces a degree of error into the study, depending on the individual's accuracy of memory; however, we have found risk of error preferable to missing an important part of the activities. It is important for the individuals in this group to record the information

immediately on return to their office in order to minimize possible error.

The recording medium for observations will vary according to the complexity of the category structure. In simplest form, it can merely list the various categories and use checks to indicate those noted during the observation.

Figure 10

The advantages of using mechanical office equipment for handling the observations has led us to use tabulating cards for both recording and manipulating the results of observations. This method requires that the category structure be translated into a numerical code structure so that the results can be recorded in numerical form.

After the required number of observations have been made, the results must be summarized for analysis.

RESEARCH ORGANIZATION			
1	Independent Work		
	Reading	10.8	
	Thinking	1.9	
	Calculating	6.9	
	Laboratory Work	12.8	
	Observing	1.6	
	Total		34.0
2	Written Communications		
	Writing	9.2	
	Dictating	.9	
	Sketching	.9	
	Total		11.0
3	Verbal Communications		
	Superior	8.9	
	Subordinate	6.8	
	Others	23.9	
	Total		39.6
4	Other Activity		
	Walking	3.8	
	Personal	3.0	
	Total		6.8
5	Away - Not Recorded		8.6
(All figures are in %)			
Composite Nature of Activity			
223			

Figure 11

The minimum summary will be a table for each of the category groups, i.e., *Who*, *Why*, etc., showing the percentages of observation for each category. Examination of these will answer many of management's questions and usually pose other questions. For example, in the *What* area, it may be found that a high percentage of time is observed in report preparation.

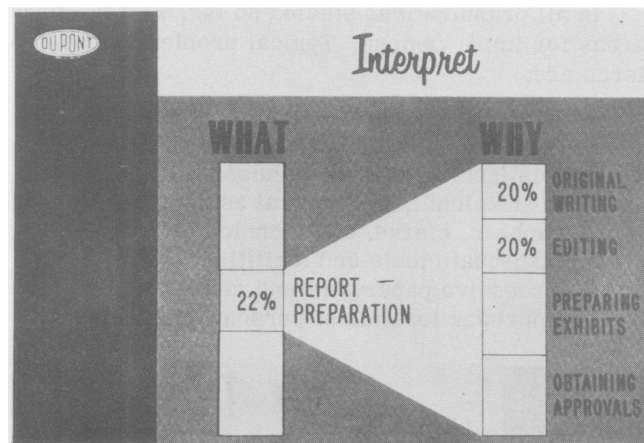


Figure 12

By tabulation of these cards, further cross-correlation with *Why* categories may give a clearer insight into the problem — and, in our experience, it was obvious that the approval procedure was taking too much time. If mechanical tabulating is used, any number of “crosscuts” can be made of the information to facilitate analysis.

Analysis of the results should be made by management with assistance from the observer and, in many instances, it has been found desirable to include all members of the group involved. The first step of analysis is to identify categories not contributing to the group objectives or non-productive effort, and secondly, to compare distribution of effort by subgroups, where possible, and with estimates of optimum distribution. While there is seldom any ideal allocation of effort available, management will usually have a clear idea of what they consider a good distribution for effective operation and will be able to identify problem areas for further investigation.

We have found Technical Activity Analysis to be of value wherever a number of technical or supervisory personnel are used. A variety of functions that have been studied are included in Figure 13.

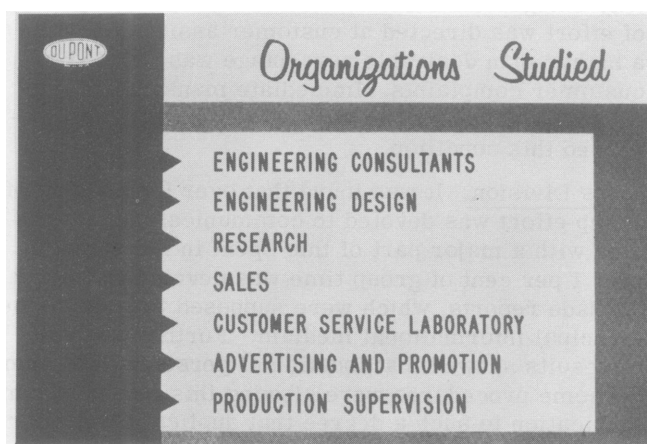


Figure 13

In all organizations studied so far, we have found areas for improvement. Typical problems encountered are:

1. Ineffective organizational structure.
2. Overlapping and duplication of functions.
3. Communications problems.
4. Insufficient non-technical assistance — stenographers, clerks, and technicians.
5. Inadequate tools and facilities.
6. Excessive paperwork and red tape.
7. Improper location of personnel.

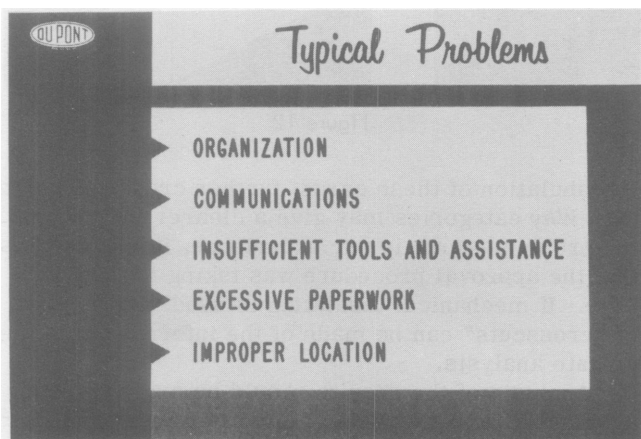


Figure 14

Specific examples of study findings are:

Research Laboratory. It was found that communications consumed over 50 per cent of group effort and the greater part of this effort was spent on administrative detail rather than on direct research. Recommendations were made for further study of communication methods and for more specific assignment of administrative detail to supervisory levels in order to increase the effort on direct research work.

Customer Service Laboratory. Over 60 per cent of group effort was spent in the laboratory and less than 20 per cent in customer plants. In the tabulation of *Why* categories it was noted that less than 25 per cent of effort was directed at customer assistance while a higher than desirable percentage was devoted to customer complaints. Immediate management emphasis on assistance in customer plants sharply reversed this condition.

Sales Division. It was found that over 60 per cent of group effort was devoted to communications categories with a major part of this spent in meetings; only 1 per cent of group time was devoted to review of trade reports, which were supposed to provide the principal informational medium. Further analysis of results showed that location of personnel and cumbersome procedures were slowing this means of communication to such a degree that duplication of effort was occurring. Recommendations were made for reorganization to shorten lines of communication, and for simplified procedures to improve information flow.

Advertising and Promotion Section. This group was responsible for translating merchandising objectives into advertising and promotional campaigns and for guiding and coordinating implementation by advertising agencies. Because of the liaison responsibility, it was anticipated that the amount of group effort devoted to communications would be high. However, when this was found to be over 70 per cent, a detailed study of organization structure and operating procedures was conducted. A complete reorganization of the function was recommended in order to shorten lines of communication, to reduce the number of supervisory levels, and to place responsibility for production decisions as close to the point of action as possible. Improved procedures to reduce production time were also developed.

Engineering Consulting Section. This group provides engineering consultation to all Company departments and has the typical administrative and supervisory problems of a consulting organization. The objective is to keep the engineers occupied in their engineering specialties and to keep the selling, scheduling, and other indirect and non-productive activities at a minimum.

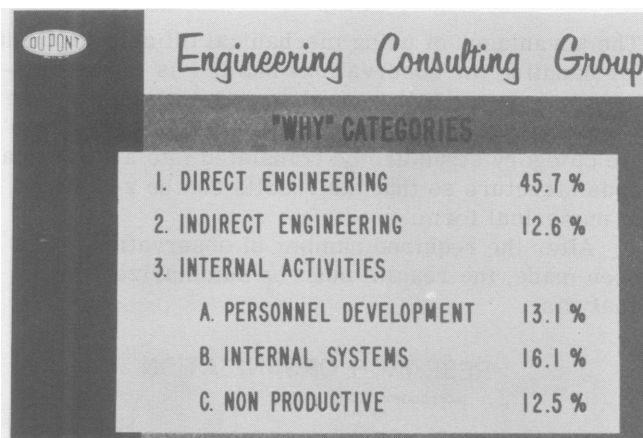


Figure 15

An activity analysis revealed that only 45 per cent of group effort was going to direct engineering work and that the remainder was spent in indirect and administrative activities. Further analysis of results indicated that 28 per cent of the time was spent in meetings, that too much writing was done manually rather than by dictation, and that some of our internal control systems were unnecessarily complex. Management, supervision, and the engineers worked cooperatively in developing improvement ideas and a program for implementing them. A training program in conference leading was conducted to improve meeting effectiveness; additional dictating equipment was made available; and stenographic services were reorganized to provide more assistance to the engineers in non-technical clerical work.

Goals were developed for more effective distribution of effort during the next year and additional

samples were taken at intervals to see what progress was being made. Chart III shows the accomplishment.

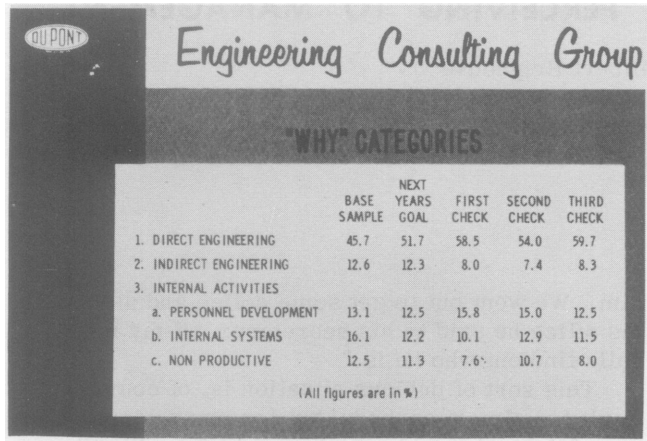


Figure 16

As you can see, this program was very successful and resulted in an increase of 14 percentage points in direct engineering work from 45.7 per cent to 59.7 per cent. This was an increase of 30 per cent in direct engineering, the essential part of the business.

In summary, Technical Activity Analysis is a specialized form of work sampling for analyzing the efforts of supervisory and technical employees. It can provide an accurate picture of how group effort is being expended, but *does not* indicate the effectiveness or quality of this effort. It can develop factual information to guide management but in itself does not provide for corrective action. It has provided an excellent basis for profitable improvement programs in a number of widely varied technical organizations, and has been a valuable aid in improving the utilization of supervisory and technical skills.



THE APPLICATION OF PERCEIVING TO MANAGEMENT

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Observation is a process that is of great practical importance to all of us. But in addition to observing we always put interpretations on what we see, and then we frequently add an emotional connotation to what we have observed. So the total perception is much more than simply what is in the object itself. If I hold this thing up, for example, we can observe an object of rather odd shape, but in the mind it is immediately perceived as a coffee cup. The interpretation of this round thing as having the meaning coffee cup is the process of perceiving. I have used here the example of looking at something, but obviously we also perceive with the ears — we give interpretations to what we hear; and in addition we perceive with the nose, with the tongue — for example the flavor of coffee as against tea — with the touch senses, with the muscle senses and with a number of other sense organs. All of these involve the process of perceiving.

I am going to try to make several points about perceiving today. There won't be anything which is frightfully startling — I suspect that all of you have observed and thought about everything which I am likely to be able to bring up in the course of my talk. What I hope to do, though, is to systematize to some extent our knowledge of perceiving, and to remind you of some things that you already know. In the last thirty seconds or so I shall try if I can to suggest one or two practical applications. The most important applications, though, I cannot suggest because they are the ones that you might want to think of for yourself. I would appreciate it very much if, after I have got pretty well through, you would like to ask some questions or voice some disagreements, so that we can get some feedback.

First, for a very quick definition. Perceiving is the process by which we come to understand our world, the way in which we give meaning to our sensory inputs. People want to have meaningful sense experiences. It is disquieting to most of us to have an ambiguous situation. In fact, for many people it is intolerable. They can't stand to be in a spot where things aren't as clear as possible. I have a friend who has been suffering some anguish because the organization in which he works is one which is subject to almost continuous flux, and his particular department has been going through a more dynamic series of organizational changes lately than is normal even for them. He expressed his perplexity about it a little while back when I was visiting with

him. We went out to get some coffee and as he left his office he said to his secretary: "If my boss calls find out who he is."

This sort of dubious situation is, of course, difficult for almost anybody, but for many people it is very frightening and anxiety-producing. We like our structures to be as clear as possible. In a few minutes I would like to give you one or two demonstrations of this point partly with some slides and partly in one or two other ways. But we might just point out on our way that in the twentieth century we have far more opportunities to find ambiguities in the world than was true in, say, the tenth century. In the tenth century the world was pretty settled. A man found out very early where he belonged. If he was a serf he was going to remain a serf. If he was a knight he would remain a knight. Social mobility was unknown. And this was true not only of this earth, with its layers of people; it was also just as true of Heaven above and Hell below, because there too you had very clear organizational layouts. There was God with His cherubim and seraphim and archangels, and so on down to the ordinary work-a-day angels. And then you had an inverted pyramid down below. At the bottom there was Satan, then his super devils, and on up to the level of the imps. The whole universe could be encompassed in this double pyramid with God above, Satan down below, and human beings somewhere in between, with every one of the human beings in a nicely compartmentalized world.

The problems of identity which are so common today were unknown a thousand years ago. Today, due to all sorts of benefits of civilization, we have more doubts than men had then: far more excitement, but also more anxiety. And that is where our perceptions come in.

By the very nature of our human constitutions, if we cannot see meaning in situations, then we typically assign the meaning from inside ourselves. These interpretations which we assign may not be correct, but they are satisfying. What this means, of course, is that if you, as an industrial engineer, have a particularly good idea for getting an improvement in some function, there on the other side is some character who sees it wrong from the very start. Having begun by seeing it wrong, he holds on to his incorrect perception of what you are trying to do to him, and he typically will hold on to it till death do you part. And once he has made an incorrect set of decisions based upon his perceptions, it

is very hard for him, if he is an ordinary human being, to give these up. Perceptions are like old shoes that we cherish because they fit. This means of course, practically, that if, from the beginning, we can help people to get good perceptions, we don't have to overcome the double barrier of breaking down the ones that were incorrect.

One of the characteristics of perceiving, which is a constant source of fascination to any of us who take the time to observe this kind of thing, is how differently different people can see the same situation. You have all observed it many times. No two people — no ten people — see even a very simple incident in just the same way. So important is this fact, that one psychologist, Professor Woodworth of Columbia, has said: "We see things not as they are but as we are." And while this isn't 100 per cent true, it is certainly true to a very considerable degree.

I am a little leery about telling stories, because I have discovered from sad experience that almost any story that is new to me is old to most other people. But I want to try an old one or two anyway, just to illustrate some points about perceiving. One of my hesitations is that I know that you had a number of speeches yesterday and some this morning, and I haven't had a chance to find out what stories have been told. Stephen Leacock told about how he was on a lecture circuit for Cambridge University in which the University would send him to different English and Scottish cities once a week. There were several others in the same stable and he found that he was one week ahead of a celebrated geographer. He also began to hear that this geographer, dedicated completely to his field, was a very dull and dry man. However, in the middle of his speech he had one pale little story. Leacock told this story when he himself was lecturing in Manchester, and mentioned that the following week Professor So-and-so, the geographer, would doubtless tell the same story. Then Leacock added: "I would appreciate it if, when Professor So-and-so next week tells this story, you would give it a nice reception." So, the following week when the geographer told the story, the audience roared with laughter. He was highly gratified, and the *Manchester Guardian* the next morning made some comments about the ready wit of the geographer as compared to the forced humor of the professional humorist of the week before. So, if I am telling a story now that someone told yesterday, I would appreciate a laugh anyway.

There is a favorite old story of mine about the young engineer who has just been promoted to his first managerial responsibility. He has become a group leader and, because he is a highly conscientious fellow, he finds a great deal to do. This keeps him running around in circles. And after some weeks of frantic activity on his part, his wife says: "Honey, relax. You don't have to take everything so seriously." "You don't understand," he says; "I am a member of management now. I'm a wheel." And at this point he takes a piece of paper and a pencil

and he draws himself a wheel. He says: "Now I'm not a very big wheel, but my boss — the section head — he is; and then there is the chief engineer; and way up there is the president of the company. And every time the president makes a quarter turn in his chair, I spin around twenty-seven times."

What are the causes for the different interpretations people give? One important reason, of course, for differences in perception is that we have had different past experiences, and these past experiences cause us to have different forms of interpretation. We know from the past what we can anticipate under certain situations. You know the story about the final college examination where the questions, given orally, are of the "What would you do if . . ." kind. There happen to be all girl students in this class. The first question is: "Imagine that you are the only survivor of a shipwreck and here you are all alone in a little boat. You see an island in the far distance and you manage to row toward it. But, as you get close, you find that all along the shore there are men. As you get a little nearer, you can see that they are sailors, and they are all beckoning towards you. What would you do?" The first girl to come up is a very timid little English girl and she says: "I would turn the boat around and I would try to row away to some safer landing place." The second girl is Irish and feisty, and she answers: "I'd go into the shore, but as I got near, I'd pick up one of the oars and I'd go out there fighting." The third girl is French and says: "I understand the situation, but what is the problem?"

Let's take another example of how our past experiences affect what we see. If you will examine first the tables at which we have been sitting. If I should ask you to describe what shape the top of the table has, I suspect that most of you would say that it is rectangular. Is that right? I think it is too. But, the only way in which one could actually get a rectangle on the retina of the eye would be to move into a position perpendicular to the center of the table and at some distance away. If I were a few hundred feet in the air, looking down on the center of this table, my eyes would get approximately a rectangle. Yet, without actually getting up in the air and looking down that way, we all know that it is a rectangle. We perceive these tables as rectangular automatically, even though they actually form rather peculiar geometric shapes on the eye. Now we can do this, of course, because of a great deal of past experience. We have seen so many rectangles that we know how they look from all kinds of directions. We live, in some respects, in a rectangular world. I suspect that if you engineers designed everything it would be completely right angular and ugly as all hell. Doors, windows, books, notepads, tables, and desks are usually rectangles, and we see them from all sorts of directions.

But up here I have a trapezoid. This little device was developed by Professor Adelbert Ames of Dartmouth. Using it, he was able to demonstrate how our perceptions of rectangles from the past affect

how we see at present. You will notice that this is a trapezoidal window: two sides are parallel and two sides converge. This, of course, is the shape that a rectangle will have on the eye when seen from one side — a door down the wall there will, for most of us, appear to be a trapezoid. Now, in a few moments, I want to turn on the motor and the light. We will need the room lights off. Some of you may be a little close for a good demonstration here. Most people need to be a minimum of fifteen or twenty feet away.

The curious point is that, very likely, you don't all see this window doing the same thing. For some of you it probably is rotating; for others it is oscillating. How many of you can see it as rotating? Will you raise your hands? Not very many. How many see it as oscillating? Most of you. Now, if we ask through how many degrees it oscillates, we will get some variations. How many of you think it is oscillating through about 180° ? How many through 130° or 140° ? Now, 90° ? When you see it oscillating, how many of you see the big end nearest you? Yes, many of you. And the little end near you? Just a few. Let's now put another little object on the window and see what happens. This is simply a little red plastic box. But it doesn't seem the same to each of us.

Let's put the box in the middle of the window and you may see it melt through, so to speak. Those of you in the field of metals and materials may ask: "What kind of material can you use to cause it to behave like this?" Now, to give you a little more of a clue to what is happening here, let us remove the box; instead, we will hang this green tube right through the window. This is a curious gadget, isn't it? Perhaps it tells us some things, first, about our own habits and, second, about the necessity for modesty in regard to our perceptions. Our own perceptions seem so right that it is difficult to question them. I know that other people don't see things straight, but my own perceptions seem correct, until I study an object like this window and realize that what I think is so cannot be so.

Now let's take a look at a slide or two. I show this first one because many people have trouble assigning a meaning to it. But if you have done much photography — especially time photography — then it doesn't bother you at all. It is actually a photograph of the Santa Ana Freeway taken from the Boyle Avenue Bridge about 7:00 p.m. one winter evening. The exposure was sixty seconds.

Now, as I mentioned, we bring to our perceptions certain anticipations. For instance, a good many people can predict how the company controller will look. (A slide of a fish is shown.) Similarly, consulting industrial psychologists are perceived this way. (Slide of the rear end of a horse.)

Another demonstration of how past experience affects us: you will notice in this photograph some rivetheads and several dents. The rivetheads are convex — is that right? — and the dents are concave. Let's turn the slide over. Now the rivetheads are depressions to most people and the dents become

bumps. Of course, the reason is simply that past experience tells us that the light comes from above us as a rule, and we tend to interpret the concave and the convex in terms of the direction from which we think the light should come.

Now, suppose that a group of individuals saw these slides of four cups or goblets; and suppose that we showed this sequence of four slides of faces to a different group of individuals. If we showed both groups the same fifth slide — this one — you can well imagine that the first group, which saw the four cups, will tend to see another cup. The second group, which saw four profiles, will see a face in this one. It is our past experience then which moves us to get certain sorts of perceptions.

Another very important influence which affects how we perceive is our emotional state. If we are feeling happy a given incident or material will have a largely different meaning for us than if we are feeling depressed or angry. This has been studied experimentally in a number of different ways. In one investigation, for example, groups of observers were shown a photograph of some people jitterbugging. These observers had had various experiences just before they saw the photograph. Those who had had experiences which made them anxious tended to see the jitterbug picture in a threatening way. Some saw a danger that the jitterbugs might dislocate the spine, others that they might cause the floor to give in, and still others saw it as evidence of the moral decay of our civilization. People who had had things that made them angry tended to see in this picture something very unpleasant. "Why the hell don't they go to work instead of goofing off?" — this sort of thing. But those who approached the picture in a happy frame of mind tended to like it because it is a picture of people enjoying themselves. ("How wonderful that they can have a good time.") So our emotions make a profound difference in what we see. So, of course, do our bodies, particularly the energy fatigue level. If we are feeling buoyant and jubilant, any situation is viewed quite differently than when we are exhausted. If we are hungry, an object is seen differently than when we are satiated.

Another quite important determinant of what we see, of course, is what we are expecting, what we call technically the "mental set." This works very much like an alarm clock: once set, the mechanism is prepared to behave in a certain way at a certain time. You and I develop these "sets" in different ways. You may have observed how a sound in the middle of the night leads the young mother to identify it at once as the baby crying out, whereas the husband may sleep through it. In my freshman year in college I happened to stay in a rooming house. The good lady who ran it lived just off the front door, whereas we fellows lived upstairs. The first evening that I was out late, I took off my shoes as I came to the front steps and crept up quietly so as to not awaken the landlady. But she was out in a flash. When the more normal guys came tearing up the steps and slamming the door she never heard them.

The gross noise got no attention — it was what she expected — but tiptoeing meant burglars. This is a good illustration of mental set.

Curiously, of all the structures of the body that give us mental set, some of the most important are the muscles. One example would be to think of the fellows lined up for the 100-yard dash. When the starter says "Get on your mark," and "Get set," the fellows are so prepared by training that their muscles are all ready the instant the gun goes off to propel them down the track. We can't try this very well in here because those muscles are too big. But let's try studying this right where we sit. It happens that, of all the muscles of the body, some of the most sensitive in terms of nerve supply are the ones around the mouth and vocal organs. With your help, I would like to see if we can get the feel of the set of these muscles. I am going to ask you to make some sounds with me. We will start with some that have the vowel "o" in them, for the simple reason that to make a good round "o" takes a particular posture of the mouth which we can recognize if we study it. Let's see how well you can observe the feeling of your mouth, larynx, and throat as you make "o" sounds. I am going to ask you to make these in unison and make them good and round, and drag it out just a little so that you can get the feel. The first example is a very simple little word for a popular drink at the soda fountain — Coke. Will you all say with me when I lower my hand — "Coke." Good and loud and round, and notice how it feels. Are you all ready? Coke. Good. If someone comes and nudges you in your ribs he is giving you a — let's all say it together — "poke." Right. If someone tells a funny story, he is telling a — "joke." The white of the egg is the — "yolk." No, it's not! But at that time it wasn't easy to think of the word albumin, was it? This is mental set.

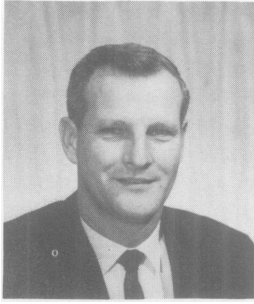
And now let's look at a slide which will demonstrate some aspects of set. This is an old slide called "My wife and my mother-in-law." If we don't say anything further, we find, in a group of men, that about two-thirds will see the wife first and the other third will see the mother-in-law first. We can change this proportion quite easily. If before I showed the slide I had said something like this: "I am going to show you an old-fashioned picture of a beautiful young lady," something like 75 to 80 per cent would see the young lady first. If, on the other hand, I had said I am going to show you a picture of an old hag, most of you would have seen *her* first.

The relative intensity of different motives will

also determine our characteristic forms of perceiving. What about that pleasant situation, for example, of a raise in pay? To the chap who has a strong motive toward independence a raise in pay is a means by which he can move toward the wonderful day when he can quit this organization and start his own company. On the other hand, to the good organization man a raise in pay is a sign that "They love me. I belong." To the man who is very much concerned with security, the raise in pay represents a safe investment of about 2-1/4 per cent, which in thirty years will mean so much extra on his retirement. And for the fellow who doesn't give a damn about the future, but lives for the moment, the raise in pay means that he can buy a new skin-diving outfit. So the same event will have a different meaning according to the relative strength of these and other motives.

If I had to say what sort of perceptions are most significant, I would answer that the most important perception for any one of us is how we perceive ourselves. The second most important is how we perceive people around us. The third is how we use language to receive perceptions. Language is one of the very important reasons why we see things differently, and frankly, as a psychologist, I am not surprised at how often people misunderstand one another; the amazing thing to me is how often we do understand. Considering all the barriers there are, of which language is one very important one, it is a great accomplishment when two individuals are able to reach real understanding. It is a goal worth working for, but it is a terrifically difficult goal.

Now, what I have been saying today may or may not have practical value for you. This is because only you can perceive its meaning. It relates in part to the importance of understanding one's own filters. This comes about only through the willingness to observe *how* one filters. What are the kinds of things that I am willing to let into my mind and what are the ones that I reject? Am I willing to accept the fact that when someone won't buy my good idea, it isn't necessarily because he is lame witted? He has a different sort of a background. He has a different set of emotions. He has different motives. He has a different mental set. And all these things add up to a perfectly logical set of reasons, from his point of view, why he sees things the way he does. If I can come to accept this and if he can come to accept my differences, then we can reach a point of mutual acceptance and mutual understanding.



DYNAMIC CONTROL OF AN OPERATIONAL COMPLEX

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A timely flow of pertinent information to decision-making personnel is essential for management control of a modern business. Decisions are based on reports that reflect production rates, costs, deliveries, vendor shipments, manhours, schedules, inventory — every facet of a company operation.

Librascope's Operational Control System (LOCS), now in operation, provides a carefully disciplined control of this data; provides it where it is needed and when it is needed; and provides it at machine speed and with machine accuracy.

LOCS is a control medium for an entire business complex or a series of complexes; it does not just control a single function such as accounting or inventory. The salient features of LOCS are:

1. Data is handled manually only once. Subsequent use of a part number, delivery date, cost figure, or any basic fact is printed out by the System.
2. A comprehensive report on any required information — an entire project or the status of a single part (ordered from a vendor or made internally), the cost of any part, the total investment to date in a project, a complete inventory — can be produced on demand.
3. The System is kept informed on the progress of a project by information entered at remote dispatch stations — in receiving, inspection, production shop, or at any key spot where an event takes place. The event can be the completion of a part, the withdrawal of a tool or material from stock, a purchase-order initiation or completion, or any event that normally transpires in a business complex.
4. Management reports are based on a comparison of the current status of a project, or any detail of a project, with a predetermined standard of performance. The reports are practically concurrent with events.
5. The raw information entered into the System can be correlated into numerous vital reports whenever necessary, so that all information required to control a manufacturing process is instantly available.

THE NEED FOR MANAGEMENT CONTROL

In the not-too-distant past most businesses were small, and owners kept such records as were necessary in a single memo book. Very little, if any, accounting needed to be performed for the government.

Today, due to the increased growth and complexity of business and the stringent requirements of the government, record keeping has become voluminous.

An illustration of this is the fact that the number of clerical or white-collar workers has risen 450 per cent during the past 50 years, while the number of industrial workers has risen only 80 per cent. (1) Furthermore, it is well established that the cost of clerical labor is following a definite upward trend and will continue to do so in the foreseeable future.

The amount of data which has become necessary for control in modern industry is staggering. One company, operating at about the \$40-million sales level, was found to be manually handling about 10,000 pieces of data daily in production and inventory control alone. The opportunity for mishandling, losing, or improperly recording information is obvious. It is no wonder that information becomes "lost in process," reports are so late as to be worthless, and accuracy therefore disappears. It is interesting to note that if we process a piece of information thirty times, with ninety-nine per cent accuracy, the chances of the final data being incorrect are one in four.

If management must exercise control from reports produced by such archaic, error-prone methods, then, indeed, it is attempting to operate with too little information which has been produced too late and is less than factual at best. Not only are these indictments true, but, more important, management can be, and often is, shielded from the truth by such methods. It is no wonder that the question, "Why didn't I know about this before such a condition developed?" is heard so often from top management who are the victims of such methods.

Properly designed dynamic operational control systems can not only prevent the conditions stated, but they can also present to management much

information that heretofore was considered as being unavailable. And this information can be presented in real time, accurately, and in a form which promotes dynamic control.

The Industrial Engineering Department at Librascope, recognizing the need for operational control systems, especially in the burgeoning electronics industry, approached its management for permission not only to design such a system, but also to implement and install it in our own company. My appearance before you today is evidence that management's reply was affirmative and that our system is implemented and installed. One of Librascope's credos has always been, "Find a need and fill it." Producing large and complex systems containing many thousands of different parts posed a difficult control problem for us. The need was to perfect a system which would solve this problem. We have filled our own need and solved our problem with the Librascope Operational Control System. I might add that while it is my good fortune to have been chosen to present the story of the Librascope Operational Control System (LOCS), its success was due to the work of many people in the Industrial Engineering Department, and especially to its manager, George B. Clark.

SYSTEMS CONSIDERATION

Many businesses have some type of electronic data processing system installed in one or more areas. These applications may vary from computer-based systems to unit records and may appear in diverse areas such as payroll or inventory control.

At the time we began to consider LOCS, Librascope's only EDP application was in payroll accounting, and operational control was entirely manual. Therefore, an early choice had to be made between (a) converting the manual system to unit record and later computerizing it, or (b) converting directly from manual to computer. The final decision was to follow the latter course of action. Concurrent with this, the decision was also made to develop the system as an integrated concept.

Some of the problems these decisions posed for the systems designers can be gathered from the statement of Malcolm and Rowe:

It is obvious that the interlinkage between decision points, as well as the density of information flow, has a direct effect on the nature of the organizational structure required for successful operation. Thus, the constraints of the existing organization must be ignored, and the specifications for an effective organization to make required decisions should be based on the system design activity. (2)

These problems will be covered in greater detail later in this paper.

Early in the design of the system, careful consideration was given to its effect on personnel and

their reaction to the possibility of the installation. Librascope's management was concerned, as any alert management should be, that its employees might be confused as to the intention of the proposed system and apprehensive over its impact on their jobs. Management decided that the best course was to meet the situation head on. Therefore, regularly scheduled meetings were conducted with all personnel with the object of explaining the system to them. Employees were told why the system was being designed, how it would operate, and what its effect would be on company operations and on their jobs. It had been determined that expansion, transfer, normal attrition, and in addition, retraining and upgrading in the system, would take care of any employees who were made surplus by the installation of LOCS.

Management's honest approach, its consideration for employee welfare, and the employees' own interest in the system created a healthy climate for the system designers. Without this attitude on the part of management it is difficult to see how the system could ever have been achieved.

Although systems analysis and development, research into other systems, and equipment considerations took place concurrently and influenced one another, they must be treated, in a paper of this type, as if they had occurred serially.

The Industrial Engineering Department at Librascope undertook two large-scale research studies for this project. One of these had as its object the disclosure of any type of electronic data processing equipment which might in any way be usable in the system. This study included foreign and domestic equipment, as well as equipment not yet marketed but on which some specifications were available. Although this was an extensive and time-consuming task, it did pay dividends. When equipment was selected for the system, it was with the assurance that no other piece of equipment would turn up which would have made the system design any easier.

The other study had as its object the survey of the specifications of any similar existing system on which information was available. This research disclosed that there were a number of systems under consideration. Some of these were for private companies for their own use; others were being considered by data processing equipment manufacturers for possible sale. Again, as in the equipment study, the results of this research were invaluable in disclosing what had been done and therefore need not be redone by the systems designers for LOCS.

Incidentally, the latter study disclosed that, as well as could be determined at that time, there were no systems in effect which offered real-time control of a complete operational complex. There were various systems in effect which controlled some part of a complex, such as production control or procurement, or which utilized a computer on a part-time basis, but none which offered that which the Librascope Operational Control System, has achieved for its management.

DEVELOPING THE SYSTEM

LOCS was developed entirely by our Industrial Engineering Department. However, other departments, both staff and line, made important contributions to the success of LOCS, and credit is due them for their efforts.

The system itself was designed with three basic requirements in mind. First, to produce a system which would generate those reports ideally suited to give each level of management the tools needed for purposeful decision making. Second, to utilize as inputs to the system only the basic data necessary to accomplish the reporting function. Much of the so-called essential data in many businesses, when critically analyzed, turns out to be protective logging. The third and last requirement was to design a dynamic system. Another term used by the military to indicate what is meant here by "dynamic" is "real-time control." In LOCS, dynamic or real-time control means that active information is processed directly into the centralized computer simultaneously as an event occurs. It is then immediately available for use and, as will be illustrated later, can compare itself with certain control criteria and issue a call for corrective action.

One of the basic tools which was used for systems analysis and design by the industrial engineers

was the familiar flow chart. True, additional symbols had to be invented for this purpose, yet one of the most rudimentary tools of the industrial engineer again proved its value and flexibility. Using these charts, data flow was depicted, for every area and department which in any way affected or was affected by the system. The charts were analyzed in detail to determine which information was essential to performance and which was extraneous. They were also analyzed to determine ideal information flow without regard to organizational constraints.

It became quite obvious, in studying the flow charts, that the same identical data was being re-processed and therefore recopied many times. This led to the inclusion in the design of the system of what is best described as the "captured-data" concept. Once data has been generated or "captured" in the system, it is never again manually prepared. The system has been so designed, and the information flow so arranged, that whenever data is necessary it is at hand in some form capable of regenerating itself.

To achieve simplicity of design, the industrial engineers working on LOCS used the concept that the company "buys" everything needed to make an end item, either from an outside vendor or from itself. (See Figure 1). Therefore, except for documents for internal control and manufacturing

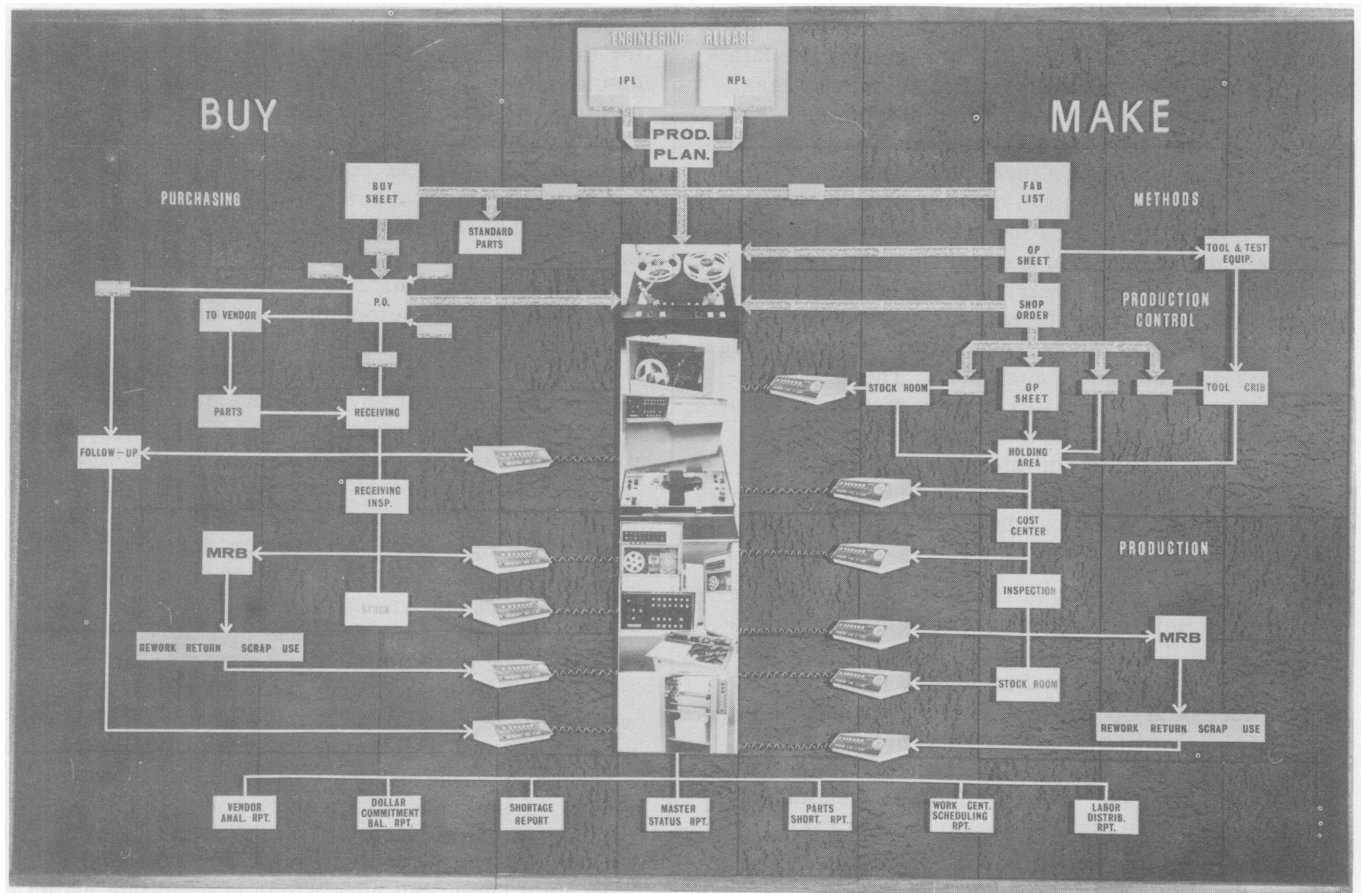


Figure 1

instructions, the system design for "make" follows very closely the design for "buy."

A system of the magnitude of the Librascope Operational Control System, affecting as it does the very core of the operations of the company, cannot be perfectly designed and installed in one fell swoop. Rather, the full concept of the system is first laid out, certain portions of this concept are then selected for closer analysis and implementation, and then these portions are installed.

Their installation should not and does not mean that any "present" system is discontinued. It is imperative that the two systems function in parallel until the newer system has been thoroughly debugged and proven in operation. The fundamental basis upon which all LOCS design concepts have been orientated has been that of a totally integrated, real-time, collection, storage-retrieval, and display system — corporate-wide in scope — for necessary industrial operational information.

Many organizations have designed and installed EDP systems that plan and control individual areas, departments, or segments of business; however, very little work has been recorded paralleling the work Librascope is doing on totally integrated, operational systems such as the aforementioned.

Librascope has pioneered not only new systems concepts in this field, but also new equipment and programming thereon.

To justify portions of the system, to learn by doing, and to prove the practicability of heretofore untried portions of the total system, implementation has been divided into "phases." LOCS Phase I encompasses all operations from engineering release to shipping, inclusive. As additional phases of LOCS are implemented, the system will encompass more and more, until total operational control from receipt of order through shipping is achieved.

LOCS PHASE I

To follow the presentation of Phase I, it will be helpful to present a brief outline of some of the equipment involved and its operation.

Dispatch stations are strategically located in widely dispersed areas throughout the plant — in Receiving, Receiving Inspection, Stock Rooms, Tool Rooms, and in the Production Work Centers. Data is continuously updated and entered directly into a centrally located computer simultaneously as an event occurs in an area controlled by a dispatch station.

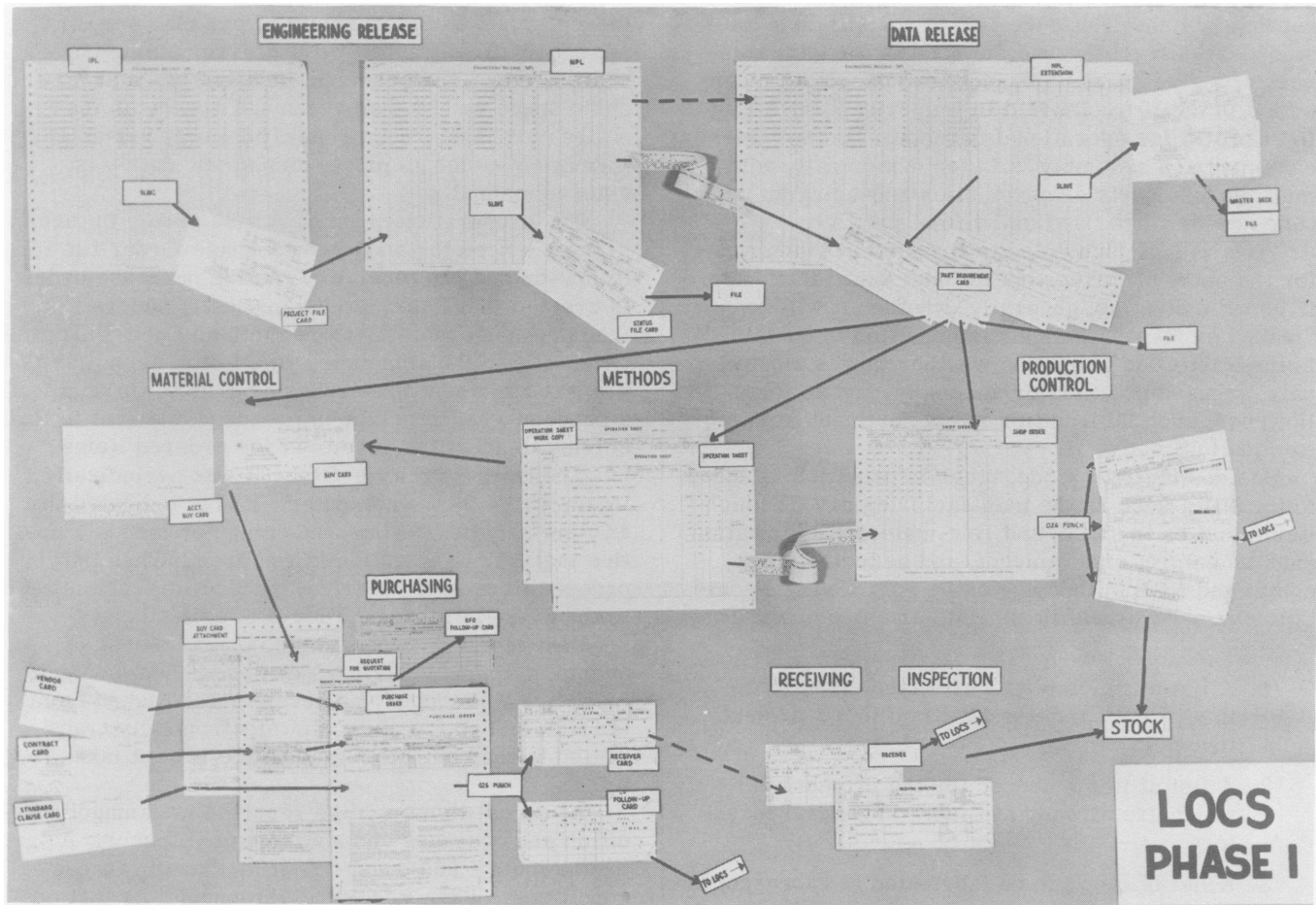


Figure 2

Input centers are also located throughout the plant — in Engineering Release, Production Planning, Manufacturing Planning, Purchasing, and Production Control. Each input center is equipped to automatically originate purchase orders, shop orders, and other documents requiring action. Punched cards and punched paper tape are simultaneously prepared for the entry of data from the input center into the computer, for transfer of data from one center to another, or to serve later for data entry from the dispatch stations to the computer.

The delivery of engineering drawings and specifications to the Engineering Release Group is the initial action in Phase I. (See Figure 2.)

These items are machine-prepared in Indented Parts List (IPL) form. An IPL lists each item in a project in "gozinto" or Christmas-tree order. It contains necessary identifying information for the item, such as part name, number, using assembly, amount used, PERT or Line of Balance number, and so forth.

The IPL is entered into the computer file for later Master Status reporting. The IPL is necessary for identifying which and how many parts constitute a subassembly and which subassemblies make up an assembly and a completed product. Identical parts, however, are listed repeatedly under various subassemblies. Thus, the IPL is not workable as an operational tool where the need is for total numbers of a given part. The identical information contained in the IPL is sorted in Numerical Parts List (NPL) form for operational purposes. In the NPL each part and assembly is listed numerically with multiple-use parts or assemblies appearing as many times as they are used in the final product.

The NPL is forwarded to Production Planning for the entry of further operational data. Each item is coded indicating, generally, whether it will be "make" or "buy." Further information is contained in the Part Code indicating whether this is a detail part, subassembly, major assembly, and so forth. However, such information is not pertinent to this explanation.

Besides the Part Code, other information is added to the NPL, such as the manufacturing day or which item must be in stock, and raw-material information, such as nature, size, amount, and so forth. The completed NPL is then sorted by Part Code. From this sort several additional lists are available. They are:

1. A list of items to be purchased directly for this project and which will go into a project inventory;
2. A list of items needed for the project but which are already available in general inventory;
3. A list of items to be fabricated at Librascope. This list is re-sorted to produce a list of raw material.

PURCHASING CYCLE

The list of items to be purchased directly for the project is forwarded to the Purchasing Department. This list is accompanied by a separate card (Buy Card) for each item. These cards are prepared automatically as a by-product in the preparation of the list.

In Purchasing, the list serves as a control of the status of the cards, each card being sent to the proper buyer for procurement action. The buyer receives the card in a specially designed envelope bearing "blocks" for data entry on its face. The buyer completes the blocks with such information as vendor number, contract number, terms, delivery, standard clause numbers, and so forth.

The Buy Card and special envelope are given to a purchase-order typist who prepares the purchase order on a Flexowriter programmed to accept manual entry, read punched cards, and simultaneously prepare other punched information. Because of these features, the preparation of the purchase order is vastly simplified.

The purchase-order typist, by using the codes on the envelope, selects previously prepared punched cards containing the information indicated by the buyer when he completed the blocks. By "feeding" these cards into the read unit of her machine, they are automatically typed without error on the purchase order. Furthermore, they are typed at machine speed rather than at manual speed. In the entire purchase order preparation, only variable information — such as price, terms, and date — is entered manually.

The preparation of the purchase order, in turn, creates a need for an Open-Purchase-Order file for follow-up and for receiving. As the purchase order is created, the following automatically occurs: (a) the purchase order is entered into an Open-Purchase-Order file in the computer, (b) a follow-up notice is prepared and sent to Purchasing Follow-Up, and (c) a punched-card receiver is prepared and sent to Receiving to await the receipt of the ordered items.

The Open-Purchase-Order file is periodically interrogated by the computer. If it is indicated that an item may be overdue, the computer issues a notice that follow-up action is required. When the ordered items are received, this fact is transmitted to the Open-Purchase-Order file, using the pre-punched receiver card. In the normal course of events, shipping containers can be opened, contents identified, the identifying receiver card taken from the file, and notice of receipt electronically transmitted to the computer in about the time it takes to tell it.

At times, items will be received in damaged condition and overages and shortages will occur. A means must — and does — exist for handling these conditions. When Receiving personnel note that one of these conditions exists, they transmit the receipt

of the items in the usual fashion; however, they add a code to the message which indicates the condition. When the message is received in the computer file, an emergency circuit is also activated.

The emergency circuit consists of several printers linked to the computer. Located in such control areas as, in this example, Purchasing and Purchasing Follow-Up, the printers send out the emergency message that a critical situation exists and special action must be taken. A report of these emergencies and the corrective action taken is maintained to assure that they were properly and promptly corrected.

If the ordered items are received without need for corrective action, they pass directly into Receiving Inspection. The punched-card Receiver accompanies them through inspection results. The results of Receiving Inspection are entered directly in the Open-Purchase-Order file.

If the items are correctly received, pass inspection, and enter stock, the open purchase order is cleared for payment and inventory is updated to show the receipt of the items.

MANAGEMENT REPORTS

The concept of Management Reports generated by LOCS follows the "exception principle."

Reports are based on comparisons between actual events in an operational routine and a pre-determined standard. A running account of an operational routine is entered in the computer files as the events occur. Comparing this account with the standard produces useful reports — reports which require action, and which are not needless piles of useless history.

Reports of this type which occur in the purchasing cycle are numerous. A few will serve to illustrate this principle.

The Past-Due Material Report is produced when material ordered will be past due when received unless corrective action is taken. This report continues to indicate this condition until action is taken which will clear it up.

The Vendor-Analysis Report analyzes vendor action statistically. It indicates how often and by how much time a vendor misses shipments, what percentage of his items pass inspection, how often his shipments are short, and how often they are over. This statistical information is used for many purposes. It may disqualify a vendor entirely, or it may be used to prompt action if his shipment threatens to arrive late. However, if a vendor practically never misses a shipping date, always ships what is ordered, and generally ships material that passes inspection, then computer notification of his action and consequent follow-up need not be as stringent as with a vendor whose performance record is quite the opposite.

The Dollar Commitment Balance Report, as a final example, is particularly useful to the financial

people. It is possible to generate this report at any time. It indicates, as its name implies, the open dollar commitment for all purchase orders. Its uses are obvious for those concerned with financial details.

MANUFACTURING CYCLE

The list of items which are to be fabricated at Librascope is sorted from the Numerical Parts List and forwarded to Manufacturing Planning — or the Methods Department, as it is called at Librascope. Here the first action is the preparation of an Operation Sheet.

The Operation Sheet is standard in form, indicating manufacturing instructions, load centers, standard times for set-up and run, and tools needed. A copy of the completed Operation Sheet and a punched-paper tape which is automatically produced as a by-product of its preparation, are forwarded to Production Control.

Production Control determines the quantity of the item to be manufactured, the number of lots this quantity will be divided into, and the manufacturing schedule. It then prepares the Shop Order.

Since the Shop Order duplicates much of the information contained in the Operation Sheet, the punched tape (produced when the Operation Sheet is prepared) is utilized to automatically prepare the Shop Order. Variable information concerning quantity, lot, and schedule is entered manually by Production Control personnel. Standard time per piece for each operation, multiplied by the amount to be manufactured, is computed automatically for the Shop Order.

By-products of the preparation of the Shop Order are a Work Ticket, one for each operation and inspection, and Material and Tool Withdrawal Cards.

The Operation Sheet, Shop Order, Work Tickets, Withdrawal Cards, and any necessary illustrations make up the Shop Order Release Package. When the package is released to the shop, an Open Shop Order File is created in computer memory. This file resembles the Open-Purchase-Order file noted earlier. The Release Package is sent to the dispatch station indicated by the first operation on the Shop Order.

Notification of the withdrawal of tools, material, or parts is transmitted immediately to the Open Shop Order File. The medium for this transmittal is the item's withdrawal card. If the items are not available at the time needed, this fact is transmitted to the emergency circuit. Emergency printers in the proper area (Tool Control in this case) note that the Shop Order is stopped because of a missing tool and corrective action is taken immediately.

The operator assigned to complete the initial operation is given his tools, material, and instructions. A card, identifying the machine he will use, and the Work Ticket, which notes standard time per piece, are used to transmit the start of this operation to the Open Shop Order file. Time, date, and

shift are sent automatically with every transmission. Thus, the Open Shop Order File shows the first operation has been started, at a certain time, by a particular operator. When the operator completes the operation, the computer is notified as to time, date, shift, and number of pieces manufactured.

The computer closes out the first operation on the Shop Order, computes actual time per piece, and compares with standard time. The latter piece of information is held for later variance reporting.

If it is ever necessary to determine the status of a part in progress, the computer may be easily interrogated. It will issue a line-by-line report of the progress of the particular item. Operations completed, number of pieces made, and the operation now in progress will be indicated. Ready access to accurate information of this type is invaluable, especially when manufacturing or engineering changes are being considered.

The Shop Order is processed from dispatch station to dispatch station, operation by operation, in the manner just described, until the completed items are inspected and stocked. As with the procurement cycle, the last transmission carries the completed items into inventory.

MANUFACTURING MANAGEMENT REPORTS

A procedure similar to that followed in the procurement cycle is used in generating a number of manufacturing management reports.

A Performance Report — Standard versus Actual — has been alluded to earlier and needs no further explanation.

A Work Center Scheduling Report is prepared from a computer analysis of Shop Orders. This report indicates exact work loads for each center for the next fifteen days. Since the report is updated and issued weekly, each foreman knows exactly which jobs are coming to his center, and of these he knows which have slipped, are exactly on, or have exceeded schedule. In this way he can adjust his work force and load to operate his department most efficiently and to correct schedule deficiencies.

MASTER STATUS REPORT

Perhaps the most significant report prepared by the Librascope Operational Control System is the Master Status Report. This is a report of the over-all status of every project, prepared by project. It indicates, in sufficient detail for the using manager, where each component of the project is located, from Engineering Release through Shipping. Using the exception principle, it indicates only those components which are behind schedule, and the reason for the slippage. The Master Status Report is issued weekly, bi-weekly, or monthly, depending upon the requirements of the level of management to which it is directed.

FURTHER POINTS OF INTEREST

In a paper of this type, an explanation of a system such as is typified by the Librascope Operational Control System must necessarily be abbreviated. It has been possible to give only a thumbnail sketch of what is really only one phase of the system. In so doing, many important points which should be emphasized before this paper is concluded have been brushed over.

LOCS is designed to work with partial or incomplete release of engineering drawings or specifications. Because of the nature of Librascope's operations, the release of a project from Engineering usually occurs in stages, as designs are finalized. Only those who have had experience with such a condition can fully appreciate how this can complicate the design of an operational control system.

Although Phase I of LOCS encompasses the operation from Engineering release through Shipping, the LOC system when complete is designed to provide control of an entire industrial complex. Just as a company like Librascope can control its operations with LOCS, so can multicompany operations be controlled from one operations center; or, similarly, several subcontractors working on the vast and complex military contracts typical of today's missile age can be tied together by an on-line, real-time control system.

The LOC system has been designed to be, whenever possible, fail-safe. Failure to transmit information where information should be transmitted is noted and reported by the computer.

If the transmission of the quantity of items passing Receiving Inspection exceeds the numbers received, or if the quantity of items completed in Operation No. 2 exceeds the number completed in Operation No. 1, the discrepancy will be reported by the computer. If the opposite of these conditions occurs, some adjustment may be required; but, as can be seen, a fail-safe condition exists. These are just a few of the many ways in which the system operation is protected.

By taking the control center off-line, it is possible to simulate plant operation. This provides management with a valuable tool for judging the effect on plant activity of various schedule changes, increased or decreased production loads, changing product mix, and so forth, without affecting the operating system. This ability may be one of the most important characteristics of LOCS.

A final point of interest, and one that is of particular importance, should be presented here. The Librascope Operational Control System is not a decision-making system. It is our opinion that systems of this type will never replace experienced management in making business decisions. LOCS can and does compare information and indicate that a decision must be made, but it does not make decisions. It prepares management reports which are practically concurrent with the conditions they relate to so that management's decisions can be made in time to be effective.

CONCLUSION

It is an interesting exercise at this time to look back with 20-20 hindsight over two years' experience with the design and implementation of LOCS in order to see what its effect has been and what has been learned.

First, and most positively, LOCS has increased management's control over company operations. The advent of accurate, on-time reports has provided the information necessary for purposeful decision making. Management's control will increase in scope as further phases of the system are implemented.

LOCS, even in Phase I, will be an economic success. The operation of the system will pass the breakeven point in the not-too-distant future.

Although the system has gained acceptance throughout the company, there were times when the going was pretty "rough." As stated earlier, the system concept was explained to all personnel, and it won their interest and acceptance. The problems which occurred in the LOCS activity were operational in nature. Healthy differences of opinion existed between the systems engineers and operating personnel as to the manner in which the system would operate and as to its effect on the areas under their control. The LOCS personnel feel that these problems could very well have been minimized by using the approach that the operating personnel were part of the design team and were responsible for changes in their departments. Man is an animal who will resist change simply because it is change, and none are more aware of this than the LOCS designers.

The industrial engineers who designed LOCS initially viewed the system function as a computation problem. Their view has changed, however; and they now realize that the system function is essentially one of mass information storage and retrieval, with computation exercising an essential, but subordinate, role.

The LOCS design approach was to develop an integrated system which would provide control of the entire industrial complex, and then implement the design in phases. This approach has proven its value as the system implementation proceeds into further phases. Problems of incompatibility in data, information, and method have been designed out of the system. Industrial engineers are perhaps more aware, from their training and experience, of the dangers and pitfalls of the "adding-on" approach than any other group. The industrial engineers who

tackled the LOCS design problem were determined from the beginning that they would design a completely compatible total system. Fortunately, they had management backing; therefore, as additional phases are implemented the system remains integrated.

Putting aside the subject at hand, we might ask ourselves, in the words of the popular song, "What will the future bring?" One thing we can be sure it will bring is more and more systems similar to the Librascope Operational Control System. Management is all too aware that manual or even unit-record systems cannot keep pace with the demands of today. With automated manufacturing processes, tape-controlled machine tools, and automatic warehouses all making greater demands, anything less than real-time operational control will be useless.

Such systems as are designed must be completely integrated. The add-on approach is economically and functionally unsound. We would not tolerate such an approach in a modern weapons system; why should we tolerate it in an operational system?

The course of events will not be without its problems. As we are facing a situation of technological unemployment today due to automation in the factory, so shall we face white-collar unemployment due to automation in the office.

Must we all re-invent the wheel as we attempt to develop integrated systems for our own use? The answer to that question is, of course, no! We can and should draw heavily on two sources for information and assistance: the electronic data processing machine manufacturers and the universities. Many EDP machine manufacturers are developing systems teams, such as the LOCS team, who are especially well qualified to render expert assistance. The universities are developing graduate programs of industrial engineering, business administration, mathematics, and economics whose graduates will provide leadership in this new era.

The future in this era promises to be exciting, challenging, and rewarding. Whether we are rewarded depends upon whether we accept the challenge.

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SIMPLIFYING "IMPROVEMENT CURVE" APPLICATION

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In almost all production processes, the per-unit costs decline with experience; that is, the tenth unit costs less than the first, the one-hundredth unit costs less than the tenth, and so on. This decline or improvement is often sufficiently regular to be predictable with considerable accuracy. The trend of this reduction has been variously called the "improvement curve," "learning curve," "cost curve," and other names.

I. TOTAL COST CURVES

It is fundamental that the improvement curve is usually applicable to all recurring costs of producing successive units of a product. Speaking generally, most costs are recurring; therefore the curve is usually applicable to the total cost.

The cost of producing a product, when reduced to the simplest of terms, can be said to consist of two basic elements, viz., labor and material. We also know that most manufacturers accumulate and record the costs of their products by production releases or "lots" rather than "by unit."

Let us look at an example demonstrating the application of the improvement curve to total costs. The cost records of a company that has produced 350 units of a product over a five year span reveals actual costs "by lot" for labor and material as shown in Table I. Table I also shows how this product

would probably be contracted for and delivered under successive contracts with the government.

When plotted on plain graph paper the total average cost per lot develops a curve as shown in Figure 1 below.

When plotted on log-log graph paper the same total average cost per lot as well as the average cost for the two basic elements yield curves as shown in Figure 2 below.

These curves show that the reductions that occur in the total cost are the result of reductions in both the labor and material elements.

It will be noted that there are two plottings for Lot No. 1 covering the costs for producing the first ten units procured on the first government contract. In government procurement, the initial engineering and tooling usually is bought in the first contract. These are costs which are non-recurring and not subject to improvement curve phenomena, so curves excluding these costs are shown also. All other costs ordinarily are subject to the improvement effect. Let us now examine the latter curves and note certain aspects.

When plotted on arithmetic graph paper, the data develop a strong curvilinear trend. However, when the same data is plotted on log-log graph paper, the trend is relatively straight. Because it is easier to project straight lines, logarithmic graph paper is usually used in working with the improvement curve. Notice, however, that in this instance the trends on log-log graph are also slightly curved.

TABLE I

LOT COST TOTALS - PRODUCT A
PLUS
CONTRACT AND DELIVERY DATA

Lot No.	1	2	3	4	5	6	7	8	9
No. Per Lot	10	20	30	40	50	50	50	50	50
Units Cum	10	30	60	100	150	200	250	300	350
Labor Cost	54,850	16,800	12,750	10,800	9,570	9,170	8,150	8,090	7,700
Mat. Cost	17,400	11,450	9,550	8,500	7,750	7,450	7,150	6,900	6,690
Total	72,250	28,250	22,300	19,300	17,320	16,620	15,300	14,990	14,390
Contract No.	1st	2nd	3rd	4th	5th				
Contract Date	Nov 1954	Dec 1955	Jan 1957	Feb 1958	Feb 1959				
Delivery Dates	Jul-Dec 1954	Jan-Dec 1957	Jan-Dec 1958	Jan-Dec 1959	Jan-Dec 1960				

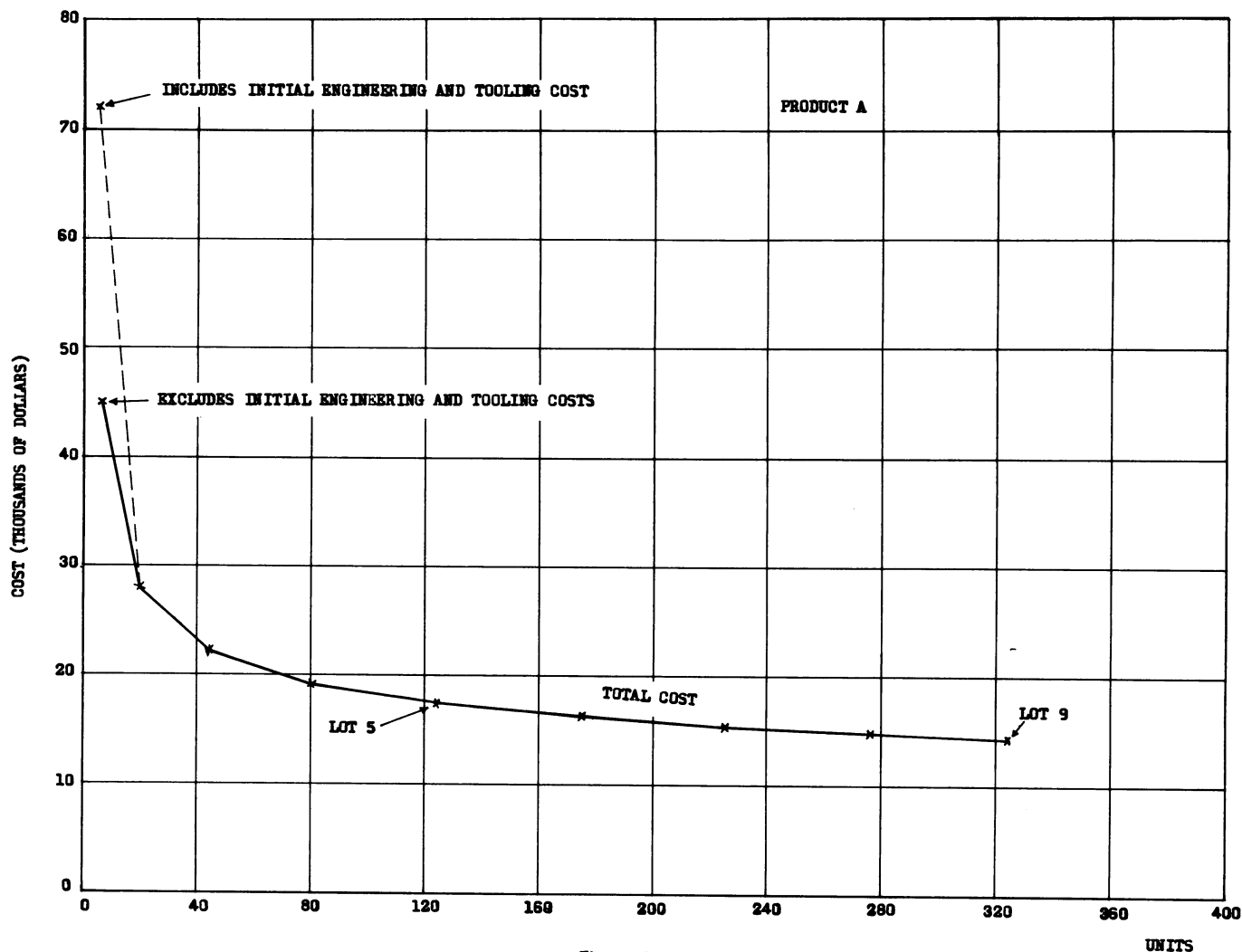


Figure 1

II. ELEMENTAL COST CURVES

A further breakdown of the cost of producing the product is shown in Table II. This elemental breakdown, as well as the descriptive terminology, is a fairly close approximation of the detail that would be available on airframe contractor's books, but may differ considerably from that available in the cost records of other industries.

If a separate improvement curve is plotted for each elemental cost, all but the subcontract cost curve would be very close to "straight" lines on log-log graph paper. Thus, the slightly curved total cost curve of Figure 2 (excluding the initial engineering and tooling) is actually a combination of improvement curves which are with one exception straight lines.

Detailed Analysis of Direct Manhours

Let us take a closer look at "direct manufacturing manhours" to see how the improvement curve can be applied to specific problems. We all know that most

jobs are performed more efficiently as experience is gained. Workers accrue individual manipulative skills and increased familiarity with the details of their tasks. Management and workers improve the process layout and tooling. As time goes by, raw materials, parts, and sub-assembly items are purchased in more suitable designs, sizes and shapes. Shop organization and control practices are improved. These and other factors increase effectiveness and reduce costs.

Why Does the Trend of These Reductions, When Plotted on Log-Log Graph Paper, Produce A Relatively Straight Line?

The answer to this question demonstrates the "phenomenon" of the improvement curve. The improvements that normally occur are of a uniform or regular type so that they yield a constant percentage reduction over doubled quantities. This uniformity is shown in Figure 3 which graphically presents the following data.

PRODUCT A

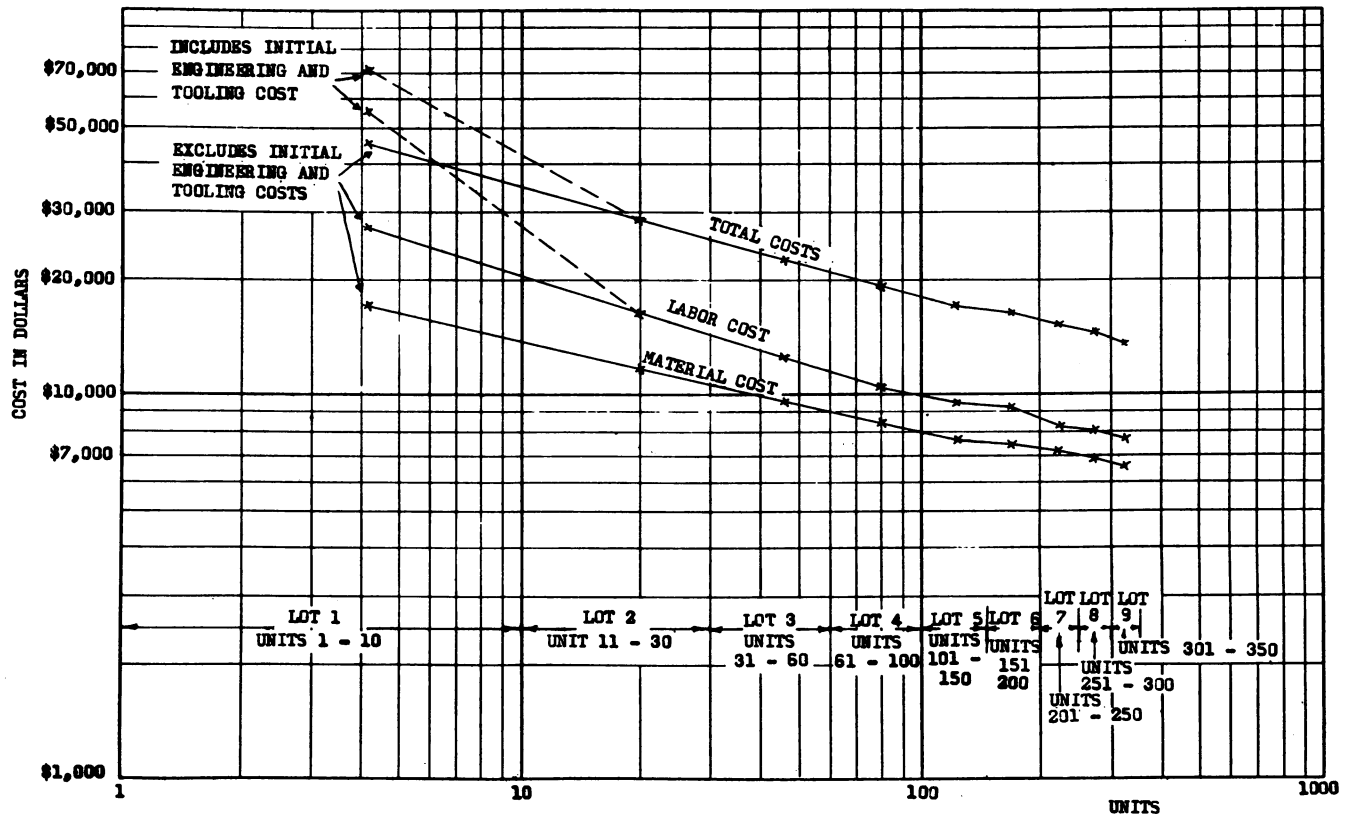


Figure 2

TABLE II
ELEMENTAL LOT COSTS - PRODUCT A

Lot No.	1	2	3	4	5	6	7	8	9
No. Per lot	10	20	30	40	50	50	50	50	50
Units Cum	10	30	60	100	150	200	250	300	350
LABOR HOURS									
Eng. D/L	3.110	45	31	25	21	18	16	14	13
Tool	2.160	78	62	50	44	40	36	34	33
Prod	5.250	2.950	2.230	1.360	1.590	1.440	1.315	1.245	1.195
LABOR DOLLARS									
Eng. D/L	8.397	126	91	75	63	56	50	46	43
Eng. O'hd	7.557	107	82	71	62	56	51	49	44
Tool. D/L	4.752	179	145	120	108	101	92	88	88
Tool. O'hd	7.365	287	229	186	172	172	142	138	134
Prod. D/L	10.500	6.195	4.728	4.054	3.561	3.254	3.064	2.988	2.880
Prod. O'hd	16.275	9.912	7.470	6.284	5.602	5.530	4.747	4.781	4.517
TOTALS	54.846	16.806	12.745	10.790	9.568	9.169	8.146	8.090	7.776
MATERIAL									
Raw Mat.	2.300	1.950	1.850	1.750	1.600	1.600	1.550	1.500	1.490
Purch Parts	4.100	3.100	2.800	2.550	2.350	2.250	2.200	2.100	2.000
Subcontract	11.000	6.400	4.900	4.200	3.800	3.600	3.400	3.300	3.200
TOTALS	17.400	11.450	9.550	8.500	7.750	7.450	7.150	6.900	6.690
GRAND TOTAL	72.246	28.256	22.295	19.290	17.318	16.619	15.296	14.990	14.396
RATES									
Eng. D/L	2.70	2.80	2.95	3.00	3.02	3.12	3.15	3.32	3.33
Tool D/L	2.20	2.30	2.34	2.40	2.45	2.53	2.55	2.60	2.63
Prod D/L	2.00	2.10	2.12	2.18	2.24	2.26	2.33	2.40	2.41
Eng O'hd	2.43 (90%)	2.38 (85%)	2.65 (90%)	2.85 (90%)	2.90 (98%)	3.12 (100%)	3.21 (102%)	3.48 (105%)	3.40 (102%)
Tool O'hd	3.41 (155%)	3.68 (160%)	3.70 (158%)	3.72 (155%)	3.92 (160%)	4.30 (170%)	3.95 (155%)	4.16 (160%)	4.03 (157%)
Prod O'hd	3.10 (155%)	3.36 (160%)	3.35 (158%)	3.38 (155%)	3.58 (160%)	3.84 (170%)	3.61 (155%)	3.84 (160%)	3.78 (157%)

UNIT #	READING	READING	UNIT #
1	8,300 x 79%	6,656 =	2
2	6,656 x 79%	5,180 =	4
4	5,180 x 79%	4,092 =	8
8	4,092 x 79%	3,233 =	16
16	3,233 x 79%	2,534 =	32
50	2,200 x 79%	1,738 =	100
250	1,280 x 79%	1,011 =	500

As we have seen earlier, log-log graph paper possesses scales in which distances between doubled readings are equal on both the horizontal and vertical axes. Therefore, plotting the above type data on such scales produces a straight line.

How Are These Improvement Curve Trends Measured and Described?

Figure 3 is described as a "79% curve." This means that when one doubles the quantity on the horizontal axis, the cost element measured along the vertical axis is reduced to 79% of its former value.

Is the Underlying Trend for the Above Manhour Expenditures Actually A Straight Line?

No, it is not; it is slightly concave. To clarify this point, let us break the production manhour data down further into its (1) fabrication, (2) subassembly, and (3) final assembly components. Table III and Figure 4 show this refinement.

The three activities have three different trends (70 per cent, 88 per cent, 78 per cent) and in each instance the plot appears to be a straight line. The total production manhour expenditures shown in Figure 3 are actually composites of the expenditures in these three curves.

Curve D in Figure 4 has been developed by combining the precise readings from the linear trend lines A, B, and C. It is actually a slightly curved line. This, theoretically, is the true underlying trend for the plots in Figure 3. It follows, that the underlying trend shown in Figure 3 would have been slightly curved had it been precisely plotted.

Because of the small curvature, one commonly assumes that the "total direct labor trend" will be a straight line for estimating and projecting purposes. However, one must be cognizant of the fact that it is a composite of a number of individual trends that possess differing slopes. A precise projection will probably generate a trend with some slight curvature. Additional breakdowns of the fabrication, subassembly, and final assembly component would yield curves with differing slopes. Accordingly, it really is not proper to show perfect "straight line" trends for these either.

What Slopes Can Usually be Expected in the Production Direct Manhour Element?

The answer to this question can only be a qualified generalization. For the airframe and allied industries, the following factors are representative:

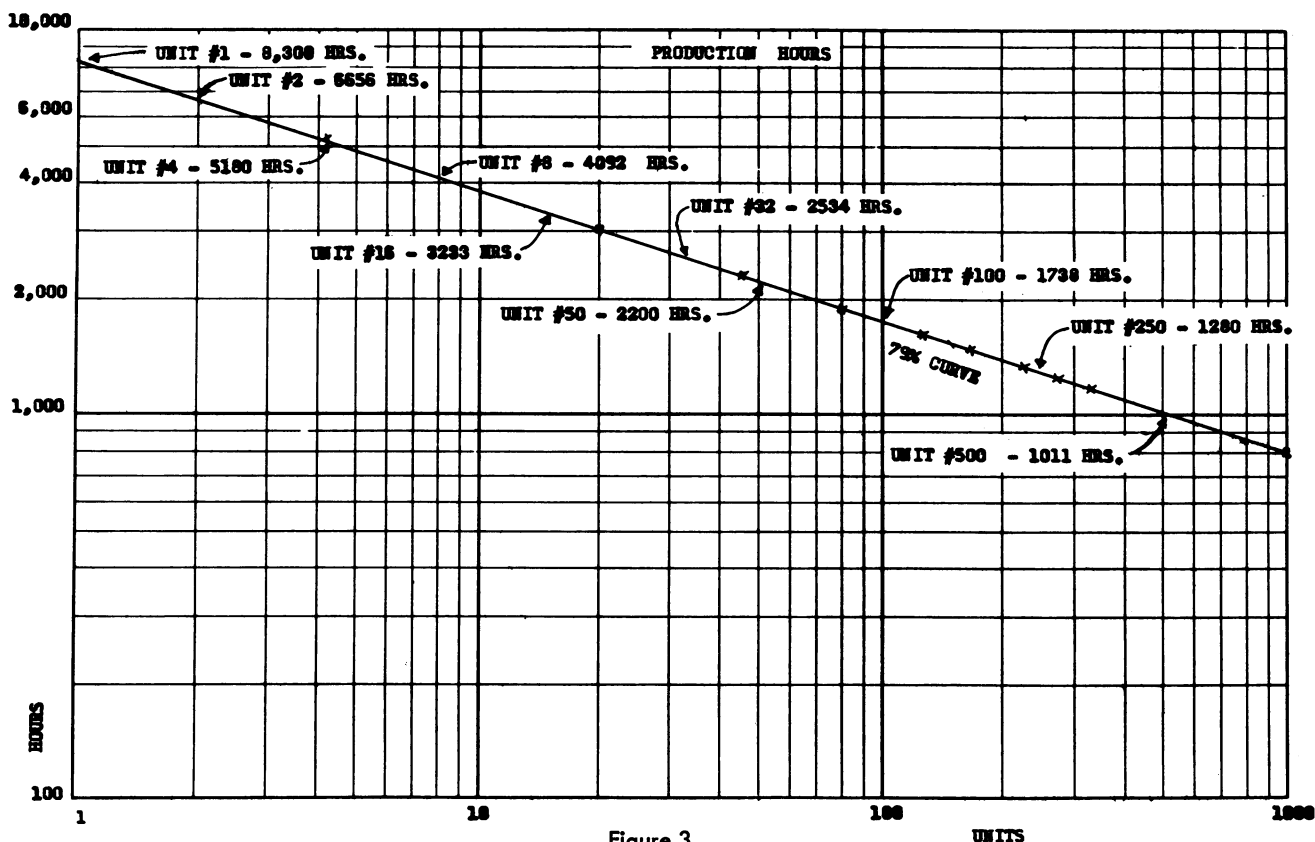


Figure 3

TABLE III
PRODUCTION MANHOUR BREAKDOWN
PRODUCT A

Lot No.	1	2	3	4	5	6	7	8	9
Quan. Units	10	20	30	40	50	50	50	50	50
Fab. Hrs.	1,500	1,150	1,000	920	840	790	740	720	700
Sub-Assy. Hrs.	900	525	390	320	270	240	215	205	195
Fin-Assy. Hrs.	<u>2,850</u>	<u>1,275</u>	<u>840</u>	<u>620</u>	<u>480</u>	<u>410</u>	<u>360</u>	<u>320</u>	<u>300</u>
TOTAL	5,250	2,950	2,230	1,860	1,590	1,440	1,315	1,245	1,195

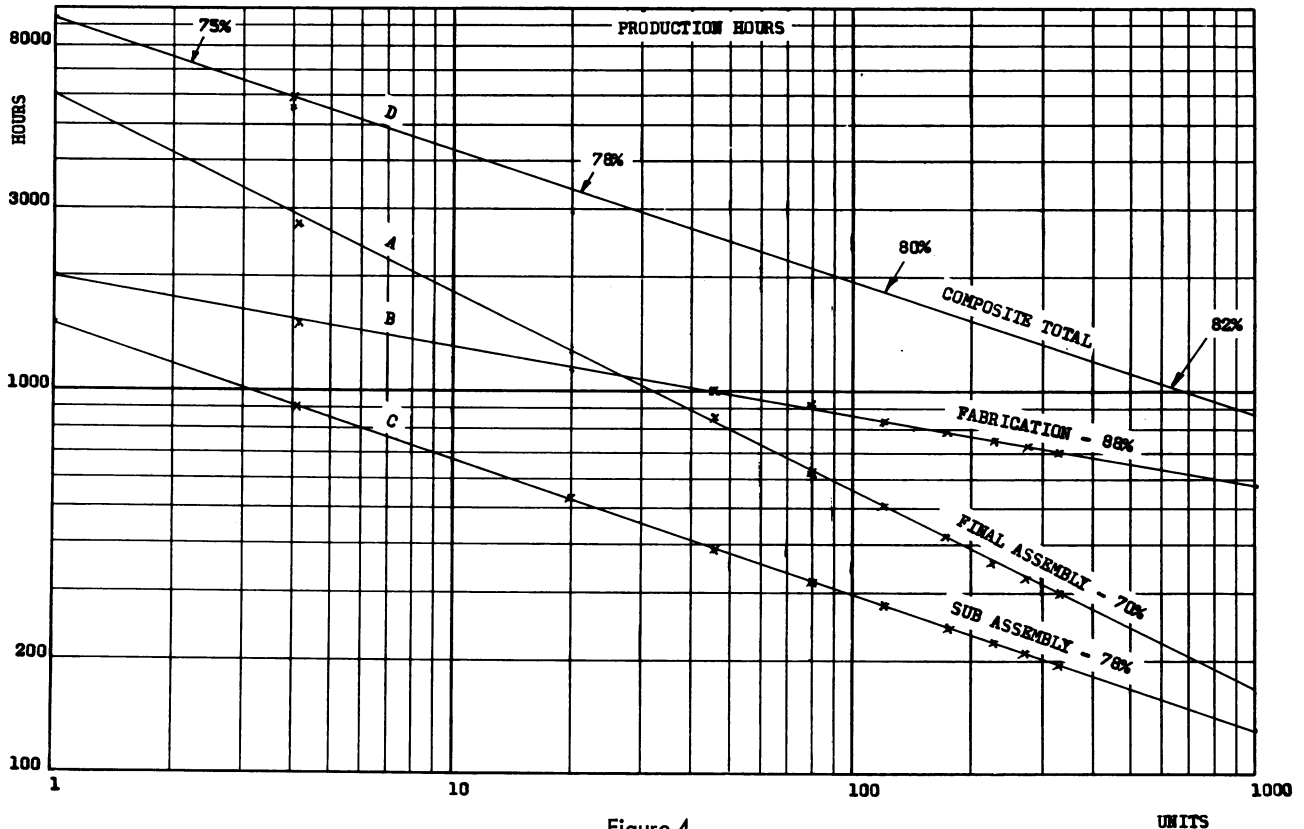


Figure 4

Fabrication labor	80% to 90%
Subassembly labor	75% to 85%
Final Assembly labor	65% to 75%
Overall labor	70% to 80%

Engineering and Tooling Manhour Curves

As previously stated, the manhours required for what is commonly referred to as the "initial engineering" and "initial tooling" effort is of a non-recurring type and is not, therefore, subject to the improvement curve phenomenon. During most production programs there are, however, engineering activities which are of a continuing or repetitive nature. These are commonly referred to as "sustaining engineering" and "sustaining tooling" tasks. The engineering and tooling manhours charged to Lots 2 through 9 in this production program are

intended, in this simplified example, to be solely of this "sustaining" type. To make all plottings, including Lot 1, comparable, only the "sustaining" portion of Lot 1 manhours is plotted.

Frequently, this sustaining effort appears to be subject to improvement curve application. For this reason, the successive per unit manhour requirements will often possess slopes very similar to the production slope. However, there are also programs in which inputs of these elements do not appear to possess improvement curve characteristics and other techniques must be used in the estimating process.

Manhour Dollar Cost Curves

Normally, in government procurement, when we are estimating the dollar cost of the direct labor, we

will usually first estimate the manhours required, using improvement curve techniques where applicable. Then, second, to these manhour estimates we apply a "labor rate" and "overhead rate" in dollars using other tools which we estimate separately.

Assume that, in February 1959, we are estimating the production labor cost for units No. 250 through No. 350 of the Product A program. On this date, we would have historical manhour information through Lot No. 5 and could predict production man-hour requirements as portrayed in Figure 5.

Normally we would also have "labor rate" and "overhead rate" history available from the Product A manufacturer, so that we could make separate projections to develop estimates for these factors. Assuming that the labor rate projection for the midpoint of the projected run is \$2.42 per hour and overhead is 160 per cent of direct labor. The production labor dollar cost would be estimated as follows:

1,180 hrs x \$2.42	=	\$2,856
O'hd @160%	=	4,569
Total (Composite)	=	\$7,425

The labor dollars cost can also be estimated from an improvement curve projection of direct labor and overhead costs. Utilization of both techniques will provide an accuracy check. If the results differed significantly, this should be a warning that would prompt a thorough recheck of the validity of both approaches.

Raw Materials

Reductions in the raw materials element for successive units and/or lots are caused by some, if not all, of the factors which generate reductions in production manhours. In addition, scrap losses are reduced and rejects become less frequent. There are probably other causes. As we get into the purchased parts and subcontract elements, we will find that reduced prices for successive buys is another cause for reductions. Generally, this is not the case for raw materials, since this element usually consists of items which are "off the shelf" type procurements in which reduced prices for follow-on buys are seldom realized. As a matter of fact, under our inflationary economy of the last few years, it has been a "fact of life" that prices for raw materials have often increased in successive buys. These increases have, of course, tended to "flatten" the curve for this element. It appears that, generally, a slope of around 95 per cent is quite prevalent. However, other slopes between 92 per cent and 98 per cent are also experienced.

Purchased Parts or "Vendor Items"

Here, again, reductions in this element for successive units and/or lots are caused by some, if not all, of the same factors that cause reductions in both the raw material and production labor elements. In addition, for many items in this element, it is often

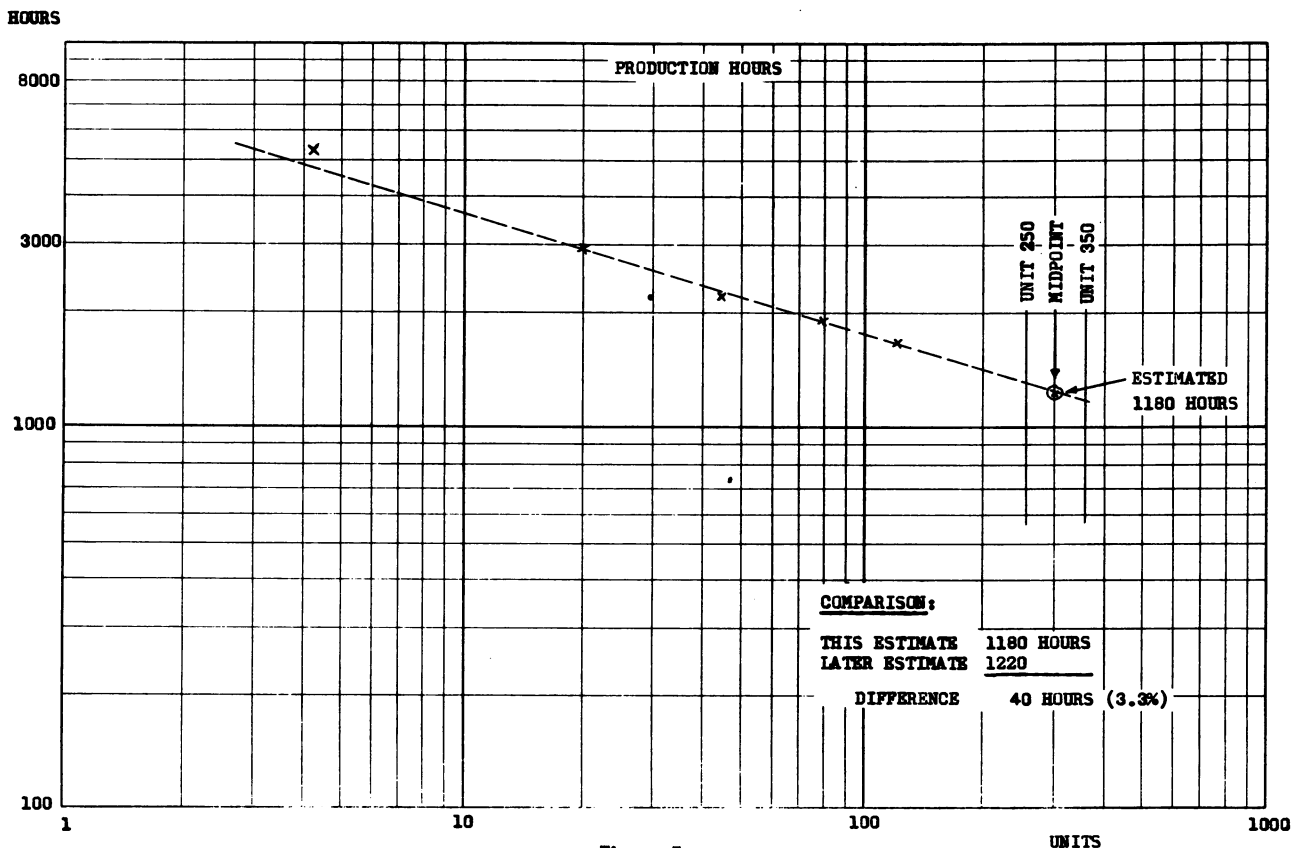


Figure 5

true that reduced prices can be obtained from the vendor for successive buys. However, some purchased parts are also of the off-the-shelf type items and are, therefore, subject to the same inflationary increases that affect raw material items. Those items that are not off-the-shelf, however, are subject to the same improvement curves for labor and material costs as we have been discussing. Therefore, as between buyer and seller, either through competitive buying or through the negotiation process, improvement curve applications and techniques by buyer and/or seller often generate reduced prices for successive buys.

Thus, the purchased parts curve is usually a combination of improvement curves for innumerable individual items which might vary in slope. The overall trend for this element will usually be a 85 per cent to 95 per cent curve.

Subcontract Curve

The production of individual subcontracted components is, of course, a process that is usually akin to the overall process of producing the end item of which the subcontracted component is a part. Therefore, the total cost to the subcontractor for producing successive subcontracted components will be a combination of improvement curve costs for most, if not all, of the same elements as are in the end item. Thus, this curve should ordinarily look like the Product A total cost curve shown in Figure 2.

In procurements made from the subcontractor by the end item producer, reduced prices for successive purchases of subcontracted components should, and usually are, established through negotiation. Thus, depending on the mix of labor and material and the improvement curves experienced for the various elements, the price (end item producer cost) curve for individual subcontracted components may vary. The overall subcontract element slope will be a composite of the curves for all subcontracted components as shown in Table II. Generally, the overall subcontract element usually generates a trend of between 80 per cent and 90 per cent.

Before leaving this subcontract element it is appropriate to say that, in government procurement of major end items such as aircraft and missiles, we usually try to acquire from our prime contractors or from our own auditors, not only the actual prices that have been paid by our prime contractors to their subcontractors for major subcontracted items, but also the subcontractor's actual costs to date. Then to determine what a prime contractor's cost will be, we project his subcontractor's cost and add a profit estimate. The resulting subcontract price becomes the estimate of the prime contractor's cost for the subcontracted item.

Some Additional Estimating Situations

Now that we have reviewed the improvement curve characteristics for the various elements in Product

A, let's take a little closer look at the process of using this phenomenon in developing cost estimates or predictions. This process is, fairly simple and accurate if we have considerable cost history and trends available. However, when the amount of history diminishes the process of prediction becomes progressively more difficult and estimates are likely to be less accurate.

In Figure 5 we developed an estimate that was fairly accurate. We had historical data and trends for the first 150 units, in five lots, and we estimated the cost of follow-on units No. 251 through No. 350. By what you might call a "sight of eye" projection of the trends experienced in these first five lots, we developed an estimate of 1,180 manhours per unit, which differed from the actual of 1,220 manhours per unit by only 3.3 per cent.

Now let us take a look at some additional estimating situations where we have less to go on. For this purpose, we shall again use our Product A production manhour data.

Assume that, in December 1956, when only the data from the first lot is available, we want to estimate the production manhours for units No. 61 through No. 150, to be procured on the third contract. There is only one plotting and hence no indication of the trend. In the aircraft and allied industries, we most likely would have manhour histories on other comparable products, which could be used as a guide in estimating the improvement curve slope. Thus, as shown in Figure 6, we could use the available manhour history for products B, C, and D. From this information, product A manhours would be projected at a 76 per cent curve. It will be noted that, for this purpose, the product B, C, and D histories are shown in terms of manhours per airframe lb. per unit. Because aircraft vary considerably in weight, and also because the amount of effort that is subcontracted varies considerably from program to program, it has been found to be advantageous to convert all in-plant manhour data into "manhour per airframe lb." data. The resulting figure is the manhours per lb. that would have been required had the production been "100% in-plant." Products B, C, and D are assumed to weigh 300, 500, and 1,000 lbs. respectively. The 5,250 manhour average for the first lot is converted into an assumed and, of course, fictitious 10 manhours per lb. figure for the assumed 750 lb. weight of product A. The additional 2,250 manhours used to develop this figure are assumed to be the manhours required for the subcontract efforts. Thus $5,250 + 2,250 = 7,500 \text{ hrs.} \div 750 \text{ lbs} = 10 \text{ manhours per lb.}$

In this example we find that the 76 per cent slope that was developed led to an estimate of 1,450 hrs. per unit. When compared with the actual figure of 1,925 hours, this is about a 16 per cent underestimate.

Thus far all estimates for product A have been developed after some cost history for *that* product existed. What do we do when we have no such history? The answer is that we seek out every bit of

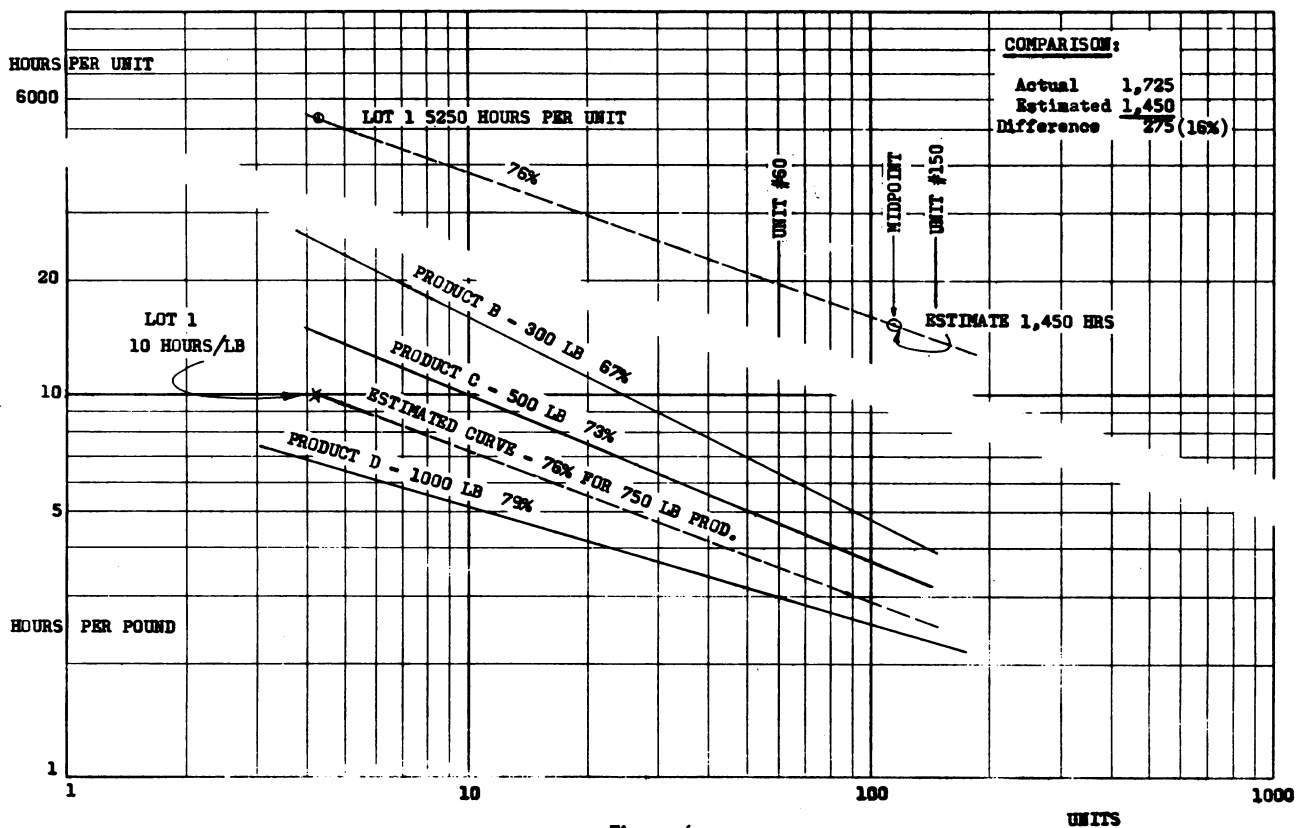


Figure 6

information that is available on other programs of a similar or comparable type and, using this data and our best judgment, do the best we can. In actual situations it will be found that companies possess considerable history on other production programs. All, or portions of, that history will be useful in developing an initial estimate.

III. EFFECT OF "CHANGES" ON THE CURVE

Now we come to an aspect of using the improvement curve which has been very troublesome and frustrating to many. It is the effect of "changes" in a production program. Before getting into this problem let it be stated emphatically that the curves examined so far *have been "free" of changes*. They have been clean, smooth curves, a kind seldom seen in production programs. Now we will turn to some curves with the disruptive effect of "changes" in them.

Let it be noted at this time that "changes" in production programs usually fall into the classification of "engineering (or design) changes." However, there are other types, such as changes in (1) delivery schedule (2) amount of work subcontracted (3) rates of production, etc. These latter types usually occur much less frequently. All changes have a disruptive effect on the curve, for when the change is major the disruptive effect is very pronounced. The following discussions will be confined to design

changes; however, the principles involved are equally applicable to the other changes.

To illustrate how a change affects the improvement curve, we will again use a very simple example of a production manhour curve. Let us assume that 250 aircraft, model M, have been produced. After a few flights of the first two or three aircraft, and wind tunnel tests, it is determined that the aircraft is unstable. To correct this defect it is necessary to redesign and change the entire tail assembly.

The redesigned tail is first installed on the 101st aircraft. Although the new tail is similar in complexity, weight, and size to the old tail, differences in configuration prevent any interchangeability of parts.

Manhour expenditures to produce all 250 aircraft are shown in Table IV and Figure 7.

Note the very pronounced hump caused by the change and the steep concave trend in the curve right after the change. To determine why this occurred it is necessary to separate the manhours required to produce the old and the new tail from the manhours required to produce the remainder of the aircraft. These manhours are shown in Table V and Figure 8.

It is immediately apparent that the manhour expenditures that caused the disruption were those for the new tail. When plotted as shown above with the first lot of five new tails positioned with the 101st through the 105th aircraft, a very concave curve is created. Now, let's reposition the manhours for the

TABLE IV

AIRCRAFT MODEL "M" PRODUCTION MANHOURS

Lot No.	Lot Quan.	Lot Total Manhours	Lot Average Manhours
1	10	2,030,000	203,000
2	15	1,650,000	110,500
3	25	1,975,000	79,000
4	25	1,550,000	62,000
5	25	1,342,500	53,700
6	5	455,000	91,000
7	20	1,220,000	61,000
8	25	1,237,500	49,500
9	25	1,112,500	44,500
10	25	1,012,500	40,500
11	25	937,500	37,500
12	25	900,000	36,500

TABLE V

SEGREGATED MANHOURS FOR A/C MODEL "M"

Lot No.	Lot Quan.	Lot Average Manhours (Tail)	Lot Average Manhours (Other)	Lot Average Manhours (Total)
1	10	66,000	137,000	203,000
2	15	37,000	73,500	110,500
3	25	28,000	51,000	79,000
4	25	23,000	39,000	62,000
5	25	20,400	33,300	53,700
6	5	60,000	31,000	91,000
7	20	31,000	30,000	61,000
8	25	23,000	26,500	49,500
9	25	19,500	25,000	44,500
10	25	18,000	22,500	40,500
11	25	16,000	21,500	37,500
12	25	15,000	21,000	36,000

new tail on the log-log graph and plot them "back to No. 1." This means that we assume that the first lot of new tails is the first lot of a new product. Also, let's compare this curve with that for the old tails. These plottings are in Figure 9.

When re-plotted in this manner it is immediately apparent that the manhours required to produce successive lots of the new tail are somewhat comparable to those required for the old tail. That is, the average for the first few units of the new tail is close to the average for the first few units of the old tail. Similarly, the average for the second lot of new tails is nearly the same as the average for the second lot of old tails, etc. The hours required for the remainder of the aircraft, which was not changed, continued their uninterrupted trend from unit No. 101 on.

We see, now, that the real reason why a hump appeared in the curve when the changed tail went on at unit No. 101 was that the first lot of changed aircraft contained manhours for both "old" and "new" work. The "old" work continued its original trend line, but the "new" work was subject to a new "improvement curve" trend that started over again with "unit No. 1" of the "new product."

Actually, changes usually involve the removal of "old" and the addition or substitution of "new" effort as shown. Thus, they can be expected to follow the general pattern of this simplified example. However, we seldom if ever possess segregated manhour cost figures for a change as shown in this example. Therefore, we usually must apply improvement curve techniques to changes without the luxury of the segregated data shown above. How do

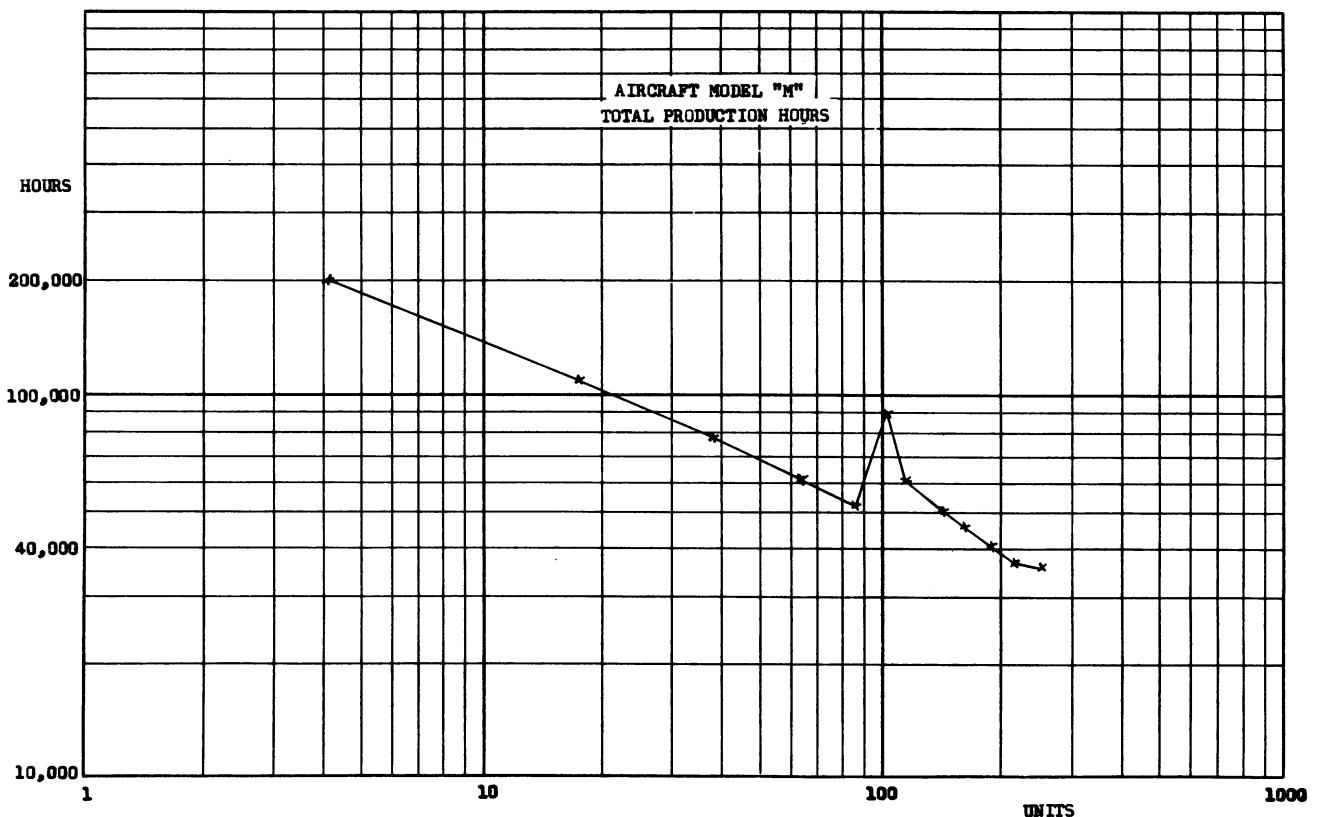


Figure 7

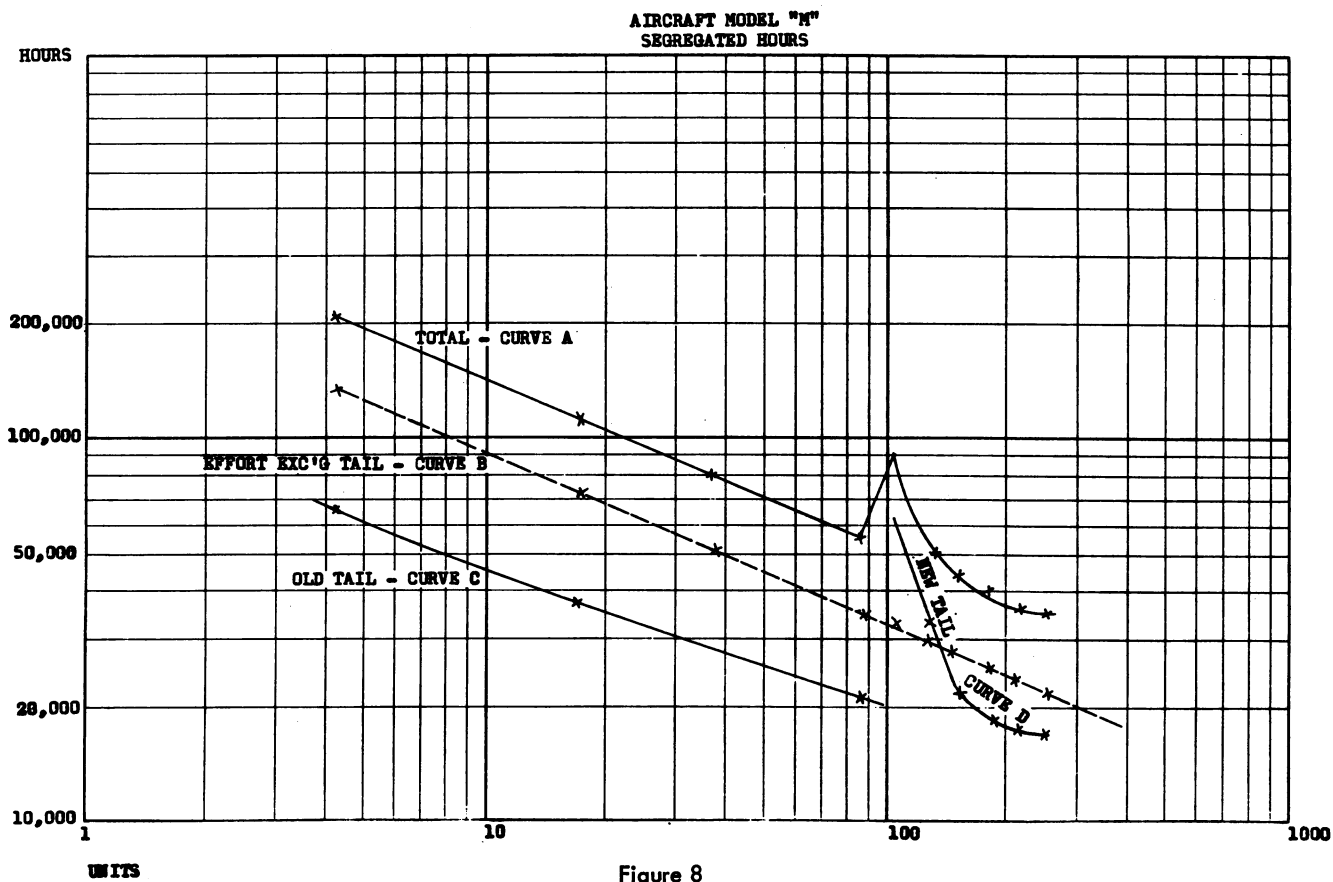


Figure 8

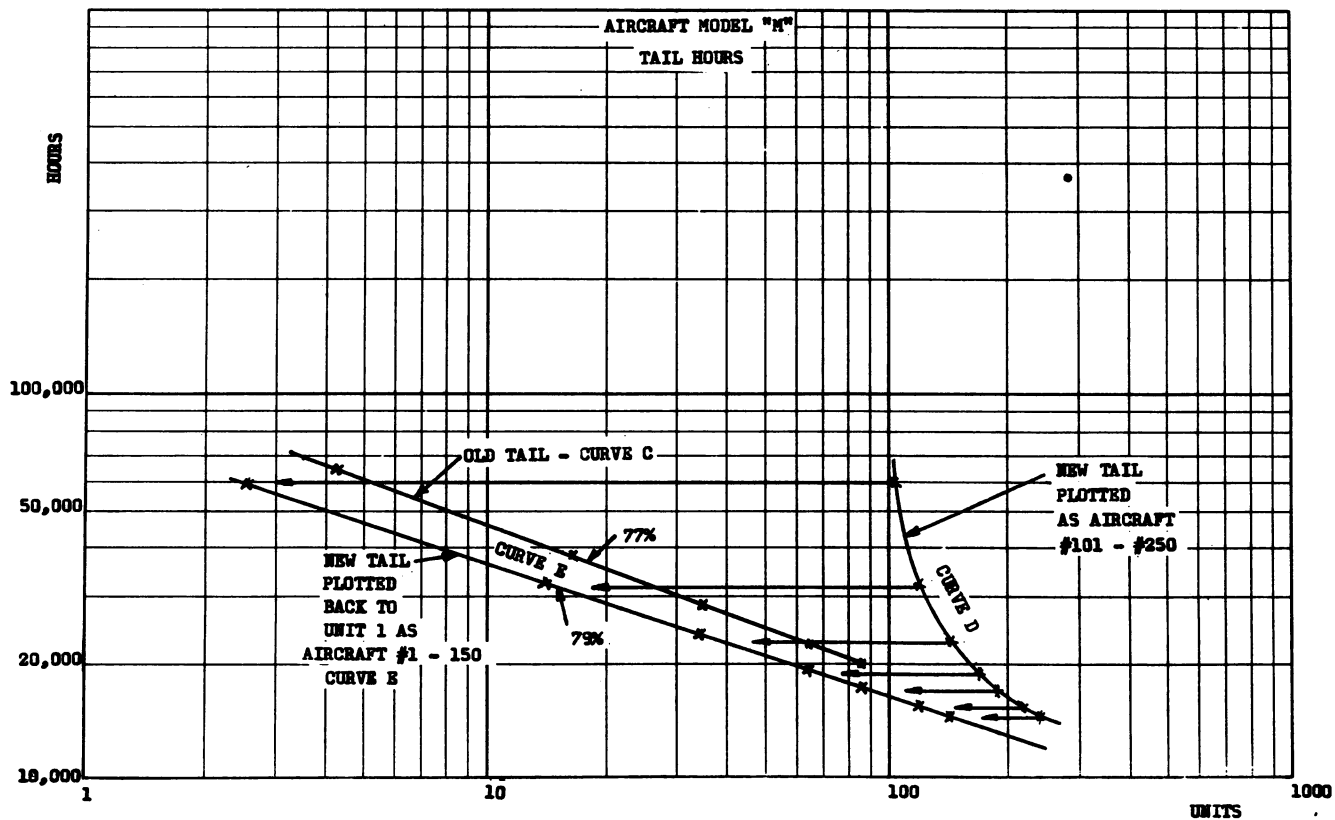


Figure 9

we do this? Well, it usually isn't simple; but once we recognize the principles and fundamentals of the makeup of changes fluctuations in curves, as demonstrated in Figures 8 and 9, we usually can find an approach to problems of change.

Let us assume that we have the actual data only through plane No. 105 and that we want to estimate what planes No. 200 through 250 will cost. The plottings in this instance are shown in Figure 10 below. We would proceed as follows.

The 91,000 hour actual for planes No. 101 through No. 105 is composed of hours for both "old" and "new" work. The portion that is "old" work is some unknown percentage of the 50,000 hours planes No. 101 through No. 105 would have required had they possessed the original tail. The portion that is "new" work is, on the other hand, some unknown percentage of the 250,000 hours that the first five planes possessing the original tail required. These unknown percentages can be determined with fair accuracy by solving the following equation:

$$250,000 X + 50,000 (100 - X) = 91,000$$

Solution: $X = 20\%$ (rounded)

Thus, in the 91,000 actual hours, 20 per cent of the effort was for new work and 80 per cent was for old work. An estimate for planes No. 201 through No. 250 can be developed in the following manner:

$$\begin{aligned} 20\% \times 45,500 \text{ hrs} &= 9,100 \text{ hrs} \\ 80\% \times 35,000 \text{ hrs} &= 28,000 \text{ hrs} \\ \text{Total estimate} &= 37,100 \text{ hrs} \end{aligned}$$

This estimate compares with the actual for planes No. 201 through No. 250 as follows:

Estimate	37,100 hrs
Actual	36,750 hrs
Difference	350 hrs (1%)
	(overestimate)

In the above problem we had actual "after the change" data. Now, let us assume that we have actual figures only through plane No. 50 and that we want to estimate what planes No. 101 through plane No. 150 are going to require. Here we have an estimating problem that is a little more difficult. By various means, we determine as accurately as possible what portion of the task is being deleted from the curve at plane No. 101. This, of course, is the "original tail" task. We will assume that this deleted portion is about 30 per cent. This means that for planes No. 101 through No. 150, the unchanged or "old" work will take about 70 per cent of a projection of the actual hours required for the first fifty aircraft (three lots) to the midpoint of planes 101 through 150, as shown in Figure 11. To this we must add what the "new" or "changed" work will require. The "new" or "changed" work is the new tail. This new work is for a product that is of the same approximate weight, size, complexity, etc., as the original tail; therefore, the manhours required should be about 30 per cent of those required for the first fifty aircraft with the original tail. Thus, as shown in Figure 11, for our "new" work

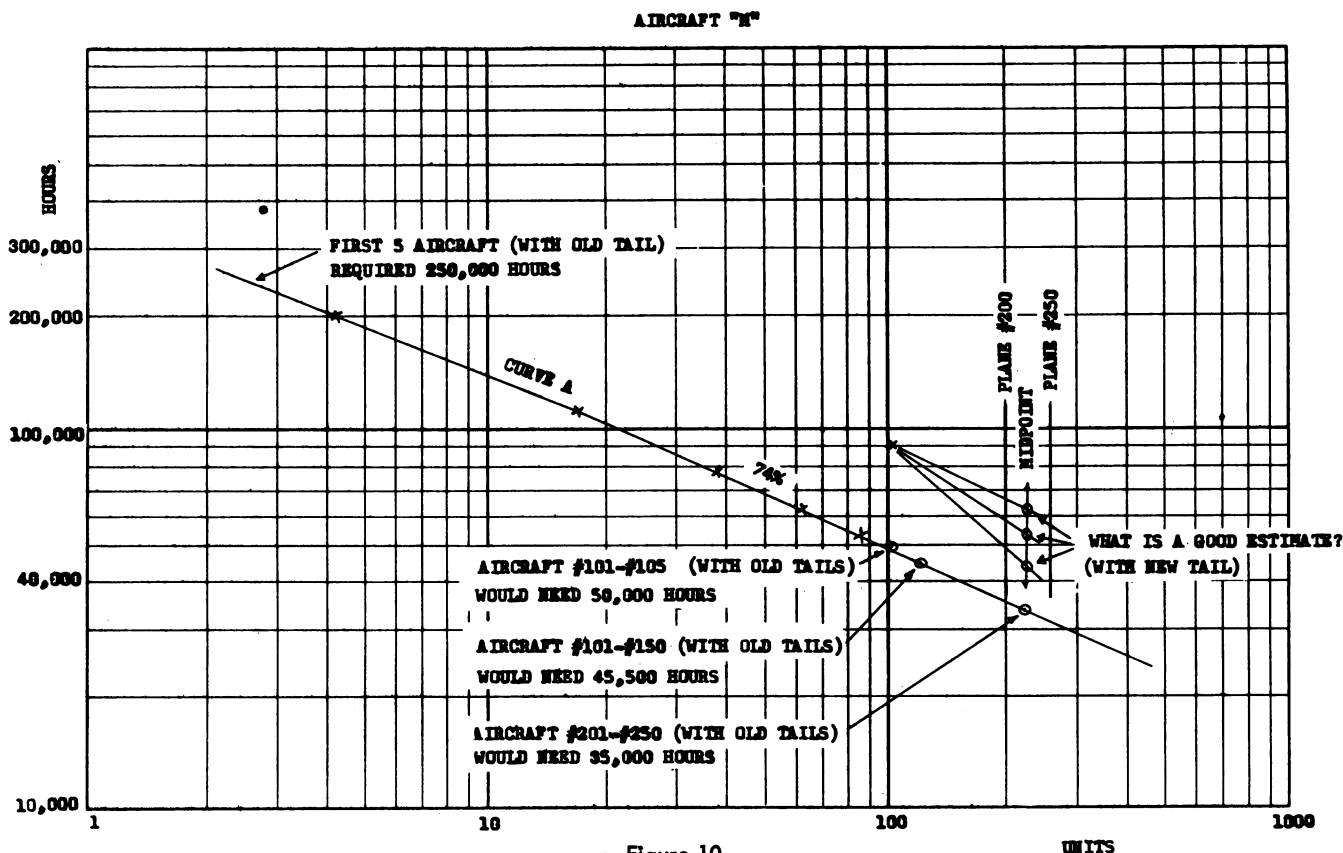


Figure 10

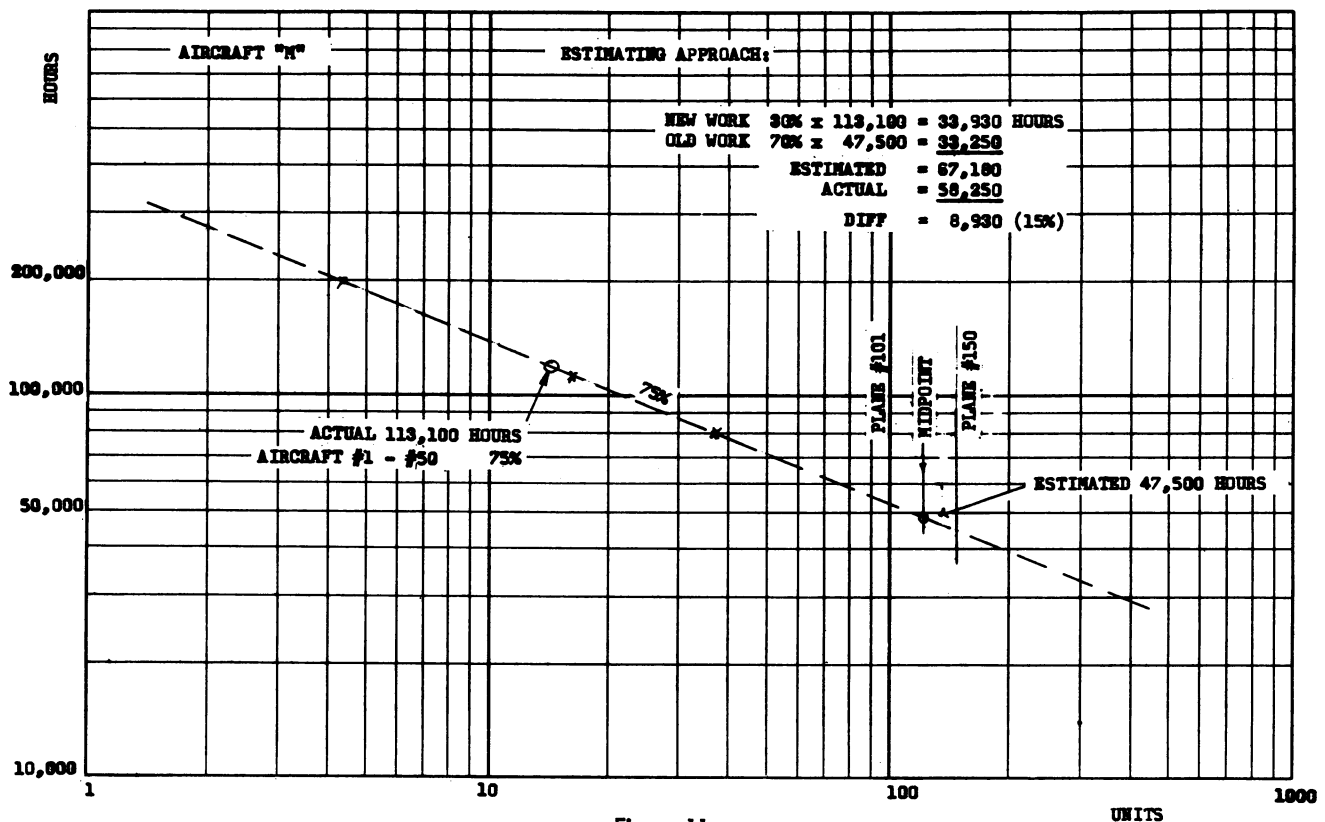


Figure 11

portion, we take 30 per cent of the average cost of the first fifty aircraft. The sum of the two estimates, i.e., 70 per cent for old work and 30 per cent for new work, gives us an estimate of 67,180 hours per plane to produce units No. 101 through No. 150 with the changed tail. As shown in Table IV the actual average manhours per aircraft for lots 6, 7 and 8 was 58,250 hours, so we missed by 8,930 hours or 15 per cent. We didn't do so well on this estimate.

The above analysis is, of course, an oversimplified approach to this estimating situation. In actual practice we would be much more thorough and precise. For instance, we would probably conclude that, although the new tail was of the same size, complexity, etc., as the old, probably some learning on the "old" tail would carry over into the "new" tail; also, probably the curve for the old tail should be assumed to be shallower or steeper than the overall plane slope, etc. However, the principles that should be applied have been demonstrated. The main principle is that the "old" and the "new" work should be estimated separately, using judgement and common sense to the maximum extent possible.

IV. DANGERS IN USING CUMULATIVE AVERAGE CURVES

Our discussion so far has dealt only with the unit curve. Another way of presenting data is the cumulative average curve. Table VI presents the man-hour data for product A in both unit and cumulative

average form. As Figure 4 showed, the total man-hours improvement curve for product A is fairly straight. In such a case the cumulative average curve would also be approximately linear and would lie above and be parallel to the unit curve. Either could be used to develop a fairly accurate estimate of a follow-on quantity.

Figure 12 shows the unit and cumulative average curves for another product.

Due to the curvature of the unit curve, the cumulative average curve will generate projections that are considerable in error. Figure 12 clearly demonstrates *the danger in using the cumulative average curve*. Practitioners with extensive experience in using improvement curves follow the rule: "Never use the cumulative average curve — use only the unit curve."

As is apparent from the above examples, the cumulative average curve is not as responsive to

TABLE VI

Product A Production Manhours

Lot No.	No. Units	Cum. Units	Lot Tot. Manhours	Lot Av. Manhours	Cum. Tot. Manhours	Cum. Av. Manhours
1	10	10	525,000	5,250	525,000	5,250
2	20	30	590,000	2,950	1,115,000	3,717
3	30	60	669,000	2,230	1,784,000	2,973
4	40	100	744,000	1,860	2,528,000	2,528
5	50	150	795,000	1,590	3,323,000	2,215
6	50	200	720,000	1,440	4,043,000	2,022
7	50	250	657,500	1,315	4,700,500	1,880
8	50	300	622,500	1,245	5,323,000	1,774
9	50	350	539,000	1,195	5,862,000	1,675

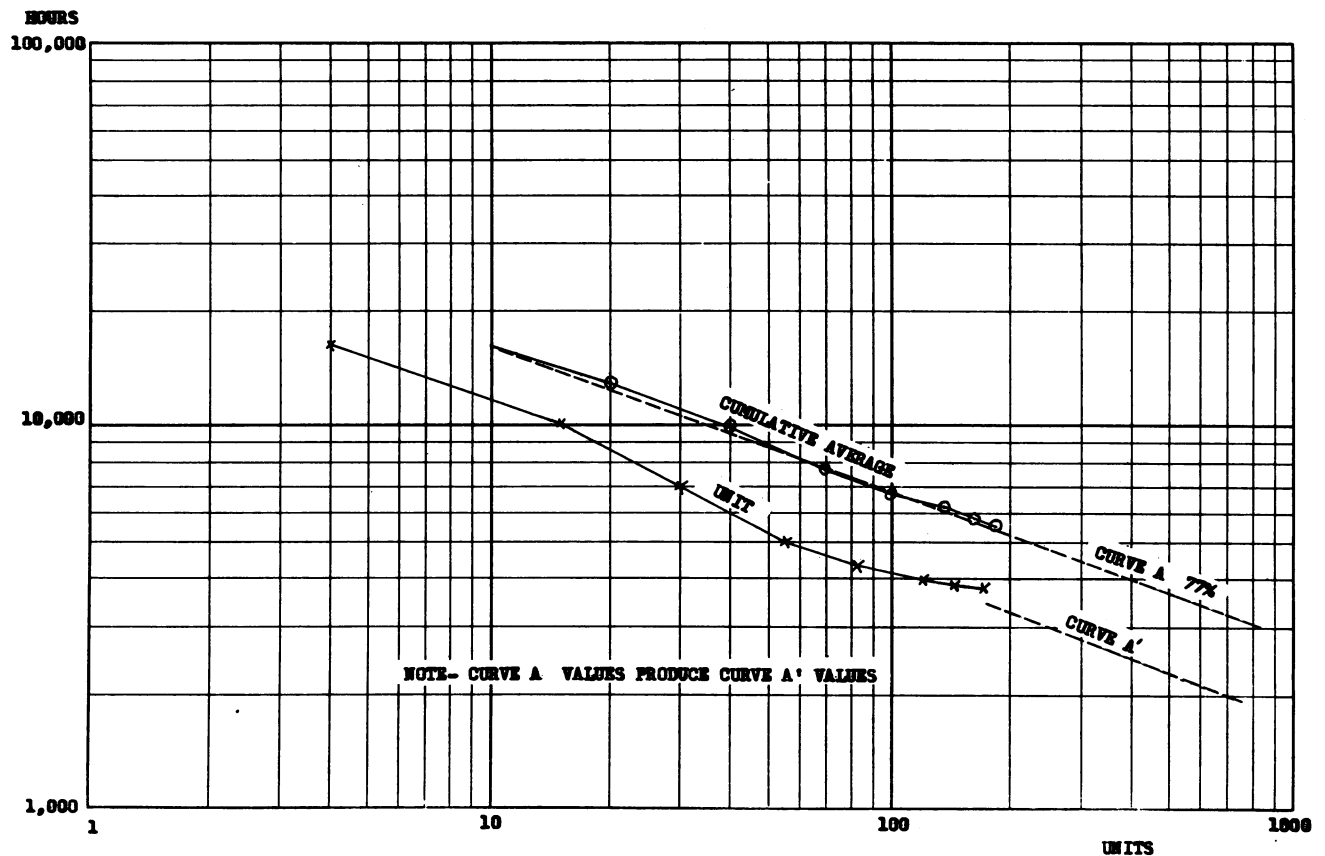


Figure 12

changes in trend as is the unit curve and, because of this aspect, it should not be used in lieu of, or in preference to, the unit curve.

V. TABLES OF IMPROVEMENT CURVE VALUES

In the process of using improvement curves, many companies have developed readings or factors for each trend line, i.e., 75 per cent, 81 per cent, 98 per

cent, etc., and have compiled "Improvement Curve Tables." The unit No. 1 reading or value for each curve is always a multiple of 1, such as 1.00000000.

Typical of the factors that one finds in these tables are the following values applicable to an 80 per cent curve. These tables which I have designated "Method 1," usually show only the "unit" and "cumulative total" factors. The "cumulative average" factors must be developed by interpolation.

METHOD 1 VALUES

<u>Unit No.</u>	<u>Unit Value</u>	<u>Cum. Tot. Value</u>	<u>Cum. Average Value</u>
1	1.00000000	1.00000000	1.00000000
2	.80000000	1.80000000	.90000000
3	.70210400	2.50210400	.83403467
4	.64000000	3.14210400	.78552600
5	.59563700	3.73774100	.74754820
10	.47651000	6.31538400	.63153840
50	.28382700	20.12172400	.40243448
100	.22706200	32.65082100	.32650821
500	.13524600	98.84725100	.19769450

When these values are put on log-log paper they form curves identified as Method 1 in Figure 13 below. It will be noted that the "unit line" for this 80 per cent curve is straight, whereas the "cumulative average" line is somewhat curved.

Now let's take a look at another set of values for an 80 per cent curve found in another table, which I will designate as Method 2. These values are as follows:

METHOD 2 VALUES

Unit No.	Unit Value	Cum. Tot. Value	Cum. Average Value
1	1.00000000	1.00000000	1.00000000
2	.60000000	1.60000000	.80000000
3	.50631200	2.10631200	.70210400
4	.45368800	2.56000000	.64000000
5	.41818500	2.97818500	.59563700
10	.32855000	4.76510000	.47651000
50	.19307900	14.19135000	.28382700
100	.15419800	22.70620000	.22706200
500	.09133400	67.62300000	.13524600

When the latter values are plotted on log-log graph they form curve identified as Method 2 in Figure 13.

It will be noted that, in this set of values, the cumulative average curve is linear and the unit line is curved.

The question that has plagued many is, "Which method is correct; which set of values is a true 80 per cent curve?" One table says that you have an 80 per cent curve when unit No. 1 takes 100 hours, unit No. 2 takes 80 hours and unit No. 4 takes 64

64 hours, etc. However, the other table says you have an 80 per cent curve when unit No. 1 takes 100 hours, unit No. 2 takes 60 hours, and unit No. 4 takes 45.37 hours, etc. The answer is, "Neither table is right or wrong."

The validity of this answer is sometimes hard to see. Two products can be produced with identical lot costs by two separate companies, one company using Method 1 and the other Method 2. Each company will describe the underlying trend as an "80 per cent curve."

IMPROVEMENT CURVE FACTORS

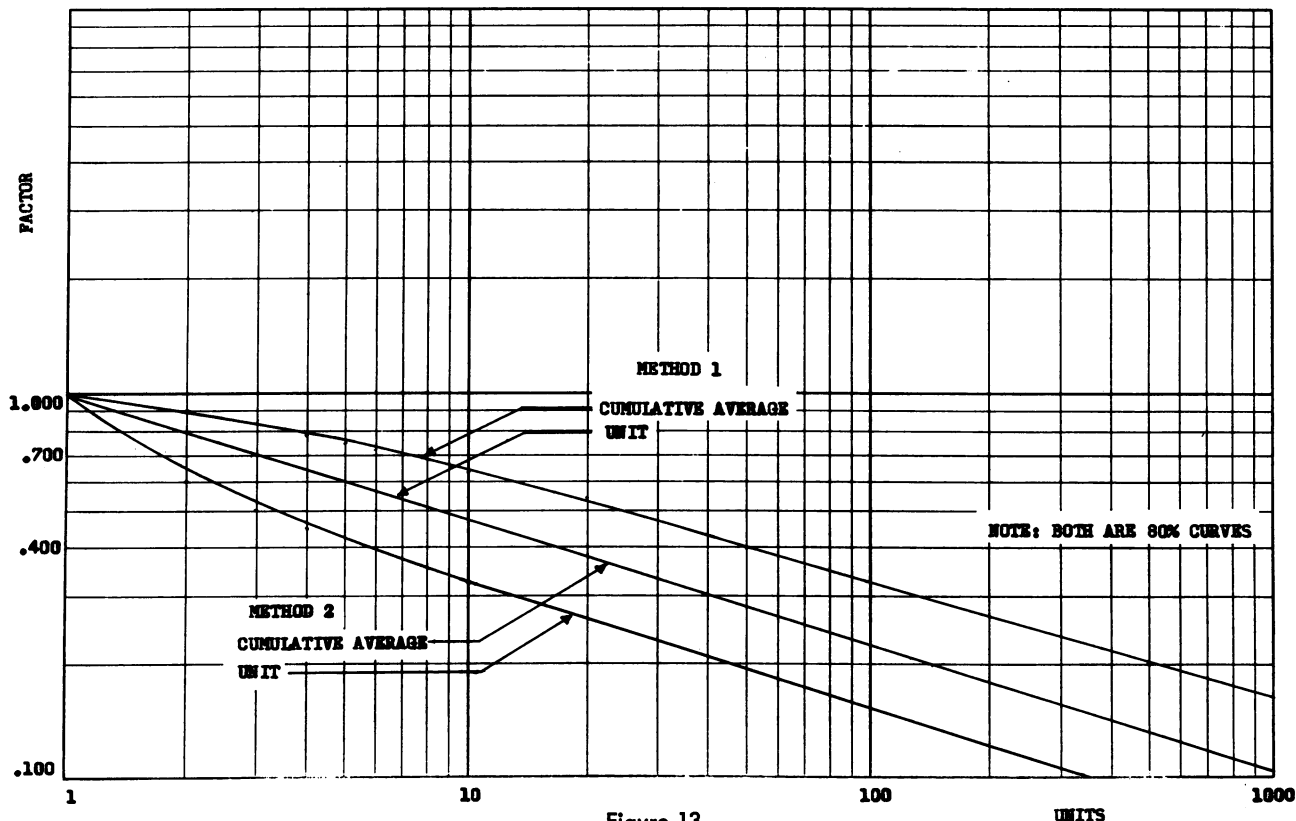


Figure 13

Figure 14 shows the plottings from which each company derived its "80 per cent" curve.

Using Method 1, unit No. 1 cost 7,800 hours and using Method 2, unit No. 1 cost 11,500 hours. This is the distinction that must be recognized and understood. The cumulative average and unit value has to be one and the same figure for unit No. 1; that is, the cumulative average and unit values had to "come together" at unit No. 1. Method 2 says the trend is an 80 per cent curve because the *cumulative average value* readings possess an 80 per cent trend for doubled quantities, whereas Method 1 says it is an 80 per cent trend because the *unit value* readings possess an 80 per cent slope for doubled unit readings.

In addition to "tables of factors" for Methods 1 and 2 above, there are other tables of factors for other types of curves, (e.g., "hump" and "Stanford" type curves). There are also tables that are merely variations of 1 and 2 above. Once the similarities and dissimilarities in Methods 1 and 2, which are the most widely used, are thoroughly understood, all other type tables should be easily discernible.

VI. CONCLUDING COMMENTS

The foregoing has demonstrated five important fundamentals that must be fully understood in order to use the improvement curve technique as an effective tool in the cost estimating process:

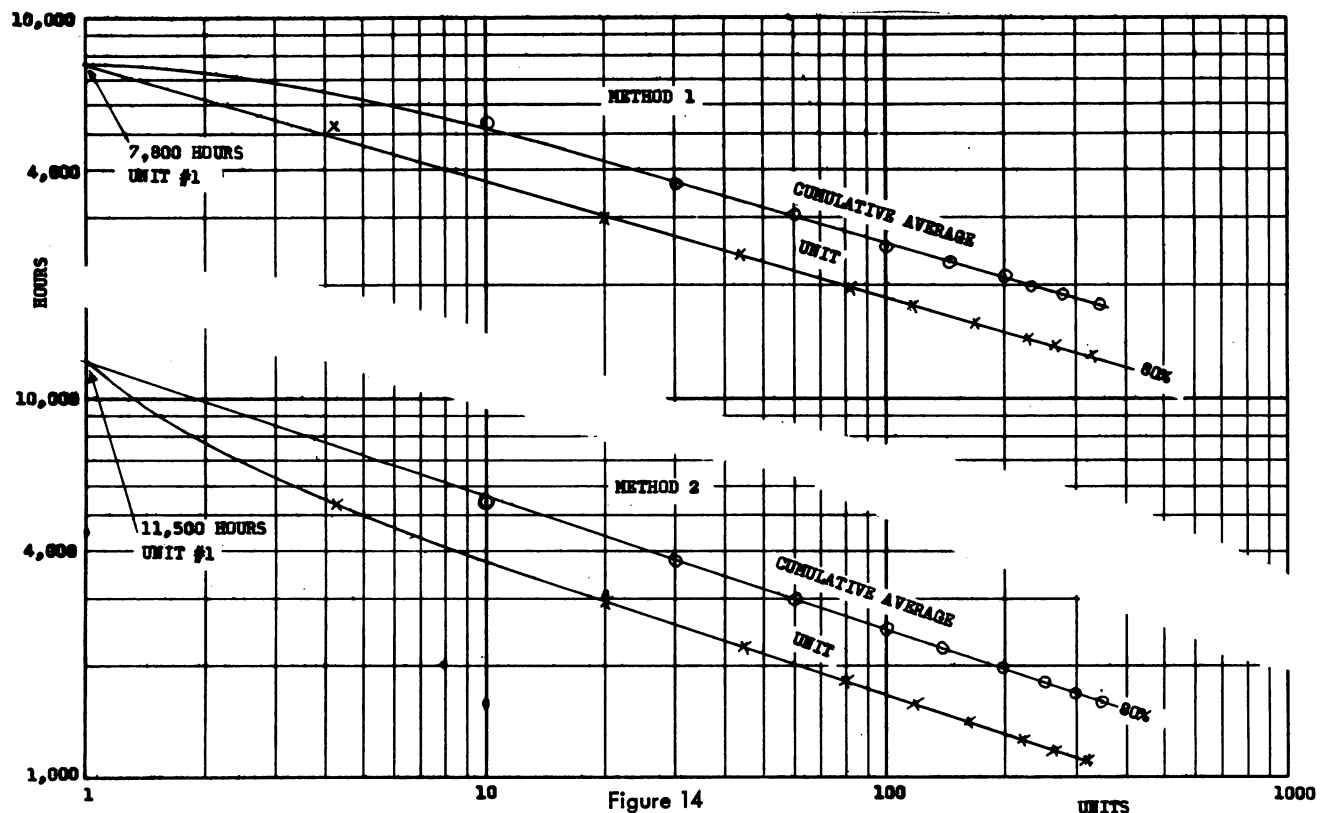
1. The improvement Curve principle is that "recurring costs decline by a uniform percentage as quantities double."

2. The improvement curve concept is usually applicable to all labor and material recurring costs.
3. Disruptions caused by "changes" must be fully understood.
4. The "unit" and not the "cumulative average" curve should be used.
5. Differences in "Tables of Improvement Curve Value" are confusing and must be fully understood.

Once a thorough knowledge of these fundamentals is acquired, proficiency in using this tool can then be attained by practicing its application. Practice can be accomplished by obtaining the past cost history on products; then, as has been done in the examples shown in this presentation, one can go back to various dates in the history in order to project what happened later. In this practice, don't cheat — don't permit later history to influence your projections. Such exercise will develop a "feel" for this valuable tool.

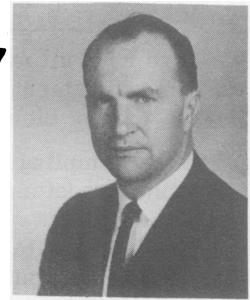
REFERENCES

- Falk, Stephen A., *Improvement Curve Analysis Techniques — A Practical Workbook with Text and Exercises*, Boston: Harbridge House, Inc., 1959.
- Cochran, E. B., "New Concepts of the Learning Curve," *Journal of Industrial Engineering*, July-August, 1960.



WORK MEASUREMENT IN A NON-MANUFACTURING COMPANY

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United California Bank
Los Angeles, California



Today's presentation covers some of the high points in the application of work measurement at United California Bank. The approaches described here can be used in manufacturing as well as non-manufacturing areas. This presentation will be generally limited to the actual situation at the Bank and will not attempt to rationalize any particular technique, nor will it endeavor to describe the technical aspects behind such approaches. Many texts are available that give excellent coverage of all phases of work measurement.

Since we are interested in the use of work measurement at United California Bank, let us take a brief look at this Bank. The Bank has over \$2.3 billion of resources; it employs more than 5,700 people, who are located in some 130 branches spread throughout the State of California from San Diego on the south to Weed on the north; and it has two major head offices, one in Los Angeles and the other in San Francisco. The salary and employee benefit expenses are over 60 per cent of the expenses of operating the bank excluding interest expenses. Employee expenses are over 40 per cent of total expenses. You can therefore see that the high percentage of salary dollars to total expenses makes it imperative that a non-manufacturing company, such as a bank, have a good work measurement program.

We currently have 3,500 employees at the branch level who are 100 per cent work measured. This is 80 per cent of the branch office personnel. The remaining 20 per cent are measured in a more limited way through the use of staffing patterns and other devices. For example, each branch must have a branch manager. The manager, of course, is measured by his performance in many areas. We are in the process of developing additional guidelines to tell us requirements for officers in a branch beyond the absolute, bare staffing pattern requirements. We have also instituted work measurement in our Head Office departments and currently have some 375 employees on measured work. This is being expanded through continuous study in additional departments. It will also be expanded by implementation into our Northern District Headquarters counterparts.

UCB Standards

United California Bank branch standards came from three sources:

1. The Southern District system, which was introduced in 1947, with work factors derived jointly by United California Bank and two other banks.
2. We inherited a system in our Northern District through a merger with another major bank.
3. These two systems were evaluated and developed through intensive study of the systems in several of our branches.

After we merged with this other large bank, it was mandatory that we adopt a centralized system which would meet the following requirements:

1. Provide an effective measure of operating performance which included:
 - a. Current comprehensive data
 - b. A sensitivity to mix changes
 - c. Flexible in accommodating procedure changes and additions.
2. Be readily understood and easily applied.
3. Provide a basis for scheduling at the branch level.
4. Be capable of economical administration and conversion to mechanical presentation.
5. Provide a basis for product cost analysis for a cost control system.

With these thoughts in mind, the systems available were carefully analyzed. Also, several other work sampling studies were used to develop a new comprehensive system. The new standards were installed system-wide in January, 1962. Even though these standards are very current, we are already in the process of revising and updating areas which are changing. We are currently in the process of putting our Southern branches onto automation, which will have a tremendous effect on the standards in that area. This will mean that we will have one group of standards for our Northern branches, which will not be on data processing for some time to come, and a different set for those operating under EDP in the South.

Work Measurement Tools Used

We have used all available techniques in establishing work measurement standards. The following is a list of some of the techniques used:

Work sampling	Historical
Basic predetermined data	Supervisory
Standard data	estimates
Stop watch data (wrist-watch and wall clock)	Effort rating
	Tab data reduction

Work sampling has been our main work horse. However, it alone is not satisfactory. We find it absolutely necessary to use all of the techniques. We find it of particular value to have a good predetermined work measurement system. I shall talk a little bit about this later. As stated before, I will not be discussing the merits of any of the techniques since such data is readily available in many textbooks.

However, I would like to bring forward two warnings regarding the use of work sampling:

1. Do not be fooled by the purported "simplicity" for setting standards through work sampling. It requires the use of a *well trained analyst*. We see much literature and we hear many people talking about the tremendous, wonderful new way to set standards. If you listen to these people and put the untrained into the field of *setting standards* by work sampling, you are only getting ready for a host of troubles — so prepare yourself.
2. Make sure you have adequate quality control before you start setting standards by work sampling. Many of you who have been involved in manufacturing have never faced the problem of quality control. Those of you who have worked only with a stop watch have not faced this problem either. But when you start doing work measurement via the work sampling approach and when you are not in a factory which has a quality control system, you have some real problems that you must face up to. When you do work sampling, for example, of a person preparing invoices, you do not know whether these invoices were accurate, you do not know how many of these items were thrown in the trash, nor how many of these had strikeovers; in fact, you know nothing about them unless you establish your own quality control measurement. We in the Bank have adopted the following approach for the present time, although it is not completely satisfactory. We ask each supervisor at the onset of every survey if the quality of his work is satisfactory. If not, why not? And what must be done to make it satisfactory? Assuming that his department's work is satisfactory, we establish standards based on this particular level of productivity and quality standards. It is absolutely essential that you

get this agreement in advance. I have experienced occasions where this agreement was not gotten in advance, and I can assure you that it can lead to many problems.

Setting Standards

The following steps outline the procedure used at UCB in establishing standards. Immediately following this sequence of steps you will find a discussion of pertinent items affecting our program at United California Bank:

1. Schedule departments.
2. Obtain top management approval.
3. Select analyst.
4. Obtain available data about department, such as organization charts, procedures, history.
5. Interview department head.
6. Present plan to entire department — use flip chart. (We measure the department or group and not the individual during the initial survey. The standards may be used for individual measurement after they have been installed.)
7. Interview all supervisors and selected personnel.
8. Prepare standard data sheets — no work improvement usually.
9. Start work measurement, which is usually work sampling in our case; however, we do use PMD and other predetermined type data.
10. Start count.
11. Forward raw data to the Tabulating Department daily.
12. Obtain and evaluate daily runs, including ratings, from Tab.
13. Complete full cycle of work — normally twenty days to one month. This will give about 20,000 to 30,000 observations.
14. Compute standards.
15. Check with supervisor for reasonableness of standards.
16. Easel presentation of results to department head, supervisors, and one level above department head.
17. Presentation to the entire group measured, along with Dr. Barnes' film on work measurement.
18. Start measuring.

Now that we have reviewed how UCB goes about setting standards, let's look at some of the details behind these.

Why No Work Improvement

The work measurement program at UCB is divided into two distinct phases. First, a program to establish standards throughout the Bank with the idea of setting ceilings so that management will know how many people should be required to perform current and future work with the present procedures. When setting standards using current procedures, obviously all avoidable delays are eliminated and observations leveled for pace-effort rating. This alone can give management a substantial initial saving. It also enables management to evaluate what the costs of expanding a program in a certain area will be and then keep it within these costs. Our second phase is to go back after all standards have been established and do work improvement and re-establish the standards. I should point out that if an analyst observes an area that can obviously be improved without a great deal of work during phase one, he points out these items to the department head in the work measurement report.

Control Charts Not Required

Control charts are not required when setting standards by work sampling. Control charts are needed when doing a "Go, No-Go" study by work sampling techniques. Why is there a difference? When you are setting standards by work sampling, you are measuring the amount of time that people are working. You are also measuring the number of units which they produce. These two factors equated together, along with pace rating, gives you a standard. Even if there is a major catastrophe such as a fire in an adjoining room, this will not destroy the validity of the standard. Why is this the case? Let us assume the workers do not work for half of the day, and during the remainder of the day they only work about half pace. The observer would note this. He would delete half of the time, rate the remaining half of the time at a 50 per cent level, and count the units produced. Thus, this time would be good in setting acceptable standards.

Activity Time Standard Sheet

One of the major ingredients in setting standards at our Bank is to get a good, clear definition of what work is being performed, who is doing the work, and where it is being done. In order to simplify this matter, we have developed an Activity Time Standard Sheet (Exhibit I below). When reviewing this form please observe the following points:

1. The activity is clearly identified at the top of the sheet along with the pertinent data as to who was doing it, including the grade level and the number of employees performing this task.
2. The center of the sheet provides space for an active description of what is going on.

3. The remarks space is used for unusual observations.
4. The bottom of the sheet tells who did the study and shows the calculations involved in establishing the standard.

Exhibit I

ACTIVITY TIME STANDARD										P. NO. 122	
ACTIVITY											
DEPOSIT - COMMERCIAL - Accept - With Cash											
OPERATOR'S NAME AND TITLE		GRADE		PER. OF		START DATE (MO., D. YR.)		ACTIVITY CODE NUMBER			
Deputy-In-Teller		J2A		1		Feb/Mar. 1961		J2A			
						DEPARTMENT NAME & NUMBER					
						Covina Office - 173					
						SECTION					
						Teller				SHIFT	
ACTIVITY CONTENT (DEFINE START & END POINTS) - USE ACTIVE VERBS											
<ol style="list-style-type: none"> 1. Greet customer - use microphone. 2. Accept cash and/or check together with deposit slip - operate sliding drawer. 3. Verify that deposit slip is filled in correctly and that the transaction is in order. 4. Verify endorsements where checks are being deposited. 5. Where cash is being deposited, count and verify the cash. 6. Where cash is being put, have customer sign for cash and count out the requisite amount - operate sliding drawer and use microphone. 7. Enter amount of deposit in teller machine; print date on deposit slip and cash slip. 8. Hand receipt and other appropriate documents to customer - operate drawer and use microphone. 											
FINISH:											
ANALYST											
S. I. Rastall				Work Sampling				TIMING			
DEPOSIT SAMPLE SIZE PER HOUR		5		TOTAL		A		20,479		ACTIVITY TIME WITH ALLOWANCES - MINUTES	(a) (a) = f
OBSERVATIONS FOR THIS ACTIVITY		b		172		B		172		PERCENT COUNT	g
DETERMINES		(1/10) = c		.00840		C		1/10 = h		1.375	h
TOTAL COUNT TIME - MINUTES		d		245,748		D		DEGREE OF RELATIVE ACCURACY, AT 90% CONFIDENCE LEVEL		15.2	i
d (1/10) = .15 (ALLOWANCE) = e		e		282,610		E		PERFORMANCE RATING FACTOR		105	j
BANK COUNT TIME OBSERVATION		f		282,610		F		TOTAL STANDARD TIME PER UNIT - MINUTES		1.43	k
Number of Cash Deposits		g		282,610		G		UNIT RATES		1.43	l

1020 0-01

DIAGRAM OF WORKPLACE ON REVERSE SIDE

Work Sampling Observation Card

We use IBM mark-sense cards for collecting data for work sampling surveys. A copy of one of our work sampling observation cards is shown on Exhibit II. I urge you to carefully study the various columns on the card. You will note the immense amount of detail that is available to us.

Exhibit II

WORK SAMPLING OBSERVATION CARD

[illegible]

The following items are prepunched into the deck and have a one time cost only at the start of the study:

Department	Pay Grade
Shift	Job Code
Employee's Name (1)	Work Center
Male or Female	

Now, before we go on, let us discuss just a little bit about one factor that may be disturbing you. That is the employee's name. We have found that it is necessary to identify the employee by name and not by some mystical number. We explain this to the employee at the beginning of the study. We inform him that the data is not accumulated against his name. Certainly there are those who do not believe this, but through practice we believe that we are building up an understanding in the Bank so that people eventually realize that when we say that data is collected by activity only and not against an employee, we are being understood. We even give a copy of this card to the employee so that he can see exactly what we are using. We have had no trouble with this procedure.

Now, let us take a look at the rest of the card. The first three columns for mark-sensing are marked "Activity Code." This is where the analyst records the code number of the activity which the employee is participating in at the time of the observation. This may be either a work category or a non-work category. The next two columns are for rating. We rate in units of 10 per cent. We find this quite adequate. This is discussed at a later point in this presentation. The next column is "Tour Number." The tour number is a number that identifies the time of the day that the study is taken. The tour number is marked only on the top card of each deck for each tour made. The two bubbles at the top of the card marked "Tour Card" are also mark-sensed, indicating it to be a master card. In this way, when the deck is run, all of the cards following this master card are punched with the tour number.

At the end of the day the analyst takes all of the cards that he has used during that particular day, wraps them, places them in a box, and shows the day number on a separate slip of paper. This number is then gang punched in all the cards for that day. Through this procedure each card is provided with the day and the tour number.

The mark-sensed data on the card is the responsibility of the analyst. The analyst must personally take his cards to the Tab Room each day and pick up the previous day's cards which were unsatisfactorily marked, correct them, and return them to the Tab Room. In this way, we have found we have very little trouble with our analysts properly marking the cards.

By having a great deal of data punched into the card at practically no cost, we are able to have a myriad of data available for scheduling and planning. For example:

1. Activity by: male or female, day, time of day, pay grade.
2. Ratings by: total, activity, male or female, group, time of day, pay grade.
3. Combinations are limited only by expense, time and need.

Clip Boards

We have designed a special clip board for use in mark sensing cards. You saw this board at the conference. The board holds approximately fifty cards and also provides a place for notes and a clip where the analyst may put his sheets identifying the work activities. We have both left-handed and right-handed boards. The board is also provided with a place for a stop watch.

Ratings

We originally established standards without pace rating. However, it soon became evident that it would be necessary for us to do pace rating in the office if we were to have standards with which we could be satisfied. Now, just how do we go about pace rating in our establishment of standards by work sampling? First of all, the analyst must be trained. He must see a work situation in the same light as the other analysts in the department. We have accomplished this by a concentrated effort rating training, using the SAM films. Each analyst observes these films. His results are plotted against the times provided by SAM, and these are discussed with the analyst. We have found that it is best not to show the analyst his actual ratings. We merely discuss his trends and his problems. After the analyst is out making actual studies, he reviews at least one film each week. In addition, we get a Tab run of the actual rating he produces on the job. These are reviewed and then discussed with the analyst if necessary. Our ratings are set so that the average qualified worker may obtain 100 per cent performance without incentive or 125 per cent with incentive.

Allowances

We add 15 per cent onto the raw standards for the following items:

1. Coffee — 20 minutes.
2. Personal time and fatigue — 20 minutes.
3. Supervision received by or given by a non-supervisory employee, machine-down time, normal make ready, normal put away, normal unavoidable delay — 22.6 minutes.

The Need for A Pre-D System

It is absolutely necessary to use a pre-D system in connection with work sampling if your program is to

operate smoothly. We use a system called PMD. PMD stands for "Predetermined Methods Time Data." We find it desirable to use PMD for establishing costs for new products, for validating work sampling, and to pick up small items missed by work sampling.

Accuracy List

We have each analyst prepare a cumulative accuracy list of all his standards when we use work sampling. He starts with the standard that is least accurate, records the standard and its accuracy in one column and in the next column the cumulative accuracy. He then records the next standard and proceeds to total these in the cumulative column until all the standards are listed. In this way we can observe what percentage of our total time is covered by standards of a certain degree of accuracy. We endeavor to have 80 per cent of our standards within a + 10 per cent accuracy at the 95 per cent confidence level.

Earned Staff Calculation Sheet

After the standards have been developed, it is necessary to install these standards. We have the department send in their activity counts to us at specified times. These counts may be either daily on a continuous basis or taken at random periods over the measured cycle. These work counts are then recorded on the Earned Staff Calculation Sheet (Exhibit III).

Exhibit III

EARNED STAFF CALCULATION SHEET

WORK MEASUREMENT - PERSONNEL RELATIONS

PAYROLL SECTION

ACTIVITY	REF. NO.	TOTAL COUNT	PERIOD	AVG. DAILY X FACTOR	STANDARD MINUTES
NEW EMPLOYEES PROCESSED	900-1				
SAVINGS BONDS ISSUED	900-2				
NAME CHANGES PROCESSED	900-3				
SHORT-HOURS DEDUCTIONS PROCESSED	900-4				
TRANSFERS AND CLASSIFICATION CHANGES PROCESSED	900-5				
TERMINATING EMPLOYEES PROCESSED	900-6				
PAY RAISES PROCESSED	900-7				
OVERTIME PAYMENTS PROCESSED	900-8				
A.I.D. ENROLLMENTS PROCESSED	900-9				
PART-TIME EMPLOYEES PAID	900-10				
ATTENDANCE CARDS POSTED	900-11				
EMPLOYEE PAY STUBS DISTRIBUTED	900-12				
SEMI-MONTHLY PAYROLL PROCEDURE	900-13				
Miscellaneous:					
MISCELLANEOUS PAYROLL ACTIVITIES - VARIABLE TIME	900-24				
MISCELLANEOUS PAYROLL ACTIVITIES - FIXED TIME	900-15				
SUB-TOTAL (ROW A)					

Supervision and Administration:

PAYROLL SUPERVISOR (900-16)

PAYROLL ADMINISTRATION (900-17)

TOTAL STANDARD MINUTES

EARNED STAFF CONVERSION FACTOR 0.0021

TOTAL PAYROLL SECTION EARNED STAFF

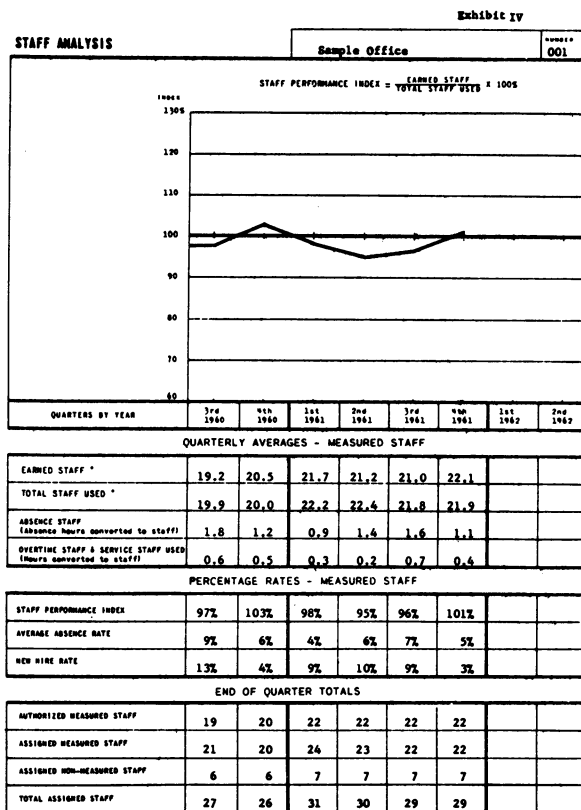
NOTES:

1. For definitions of the work counts to be reported see the "Final Activity Time Standards" Sheets in the Supervisor's Work Measurement Manual.

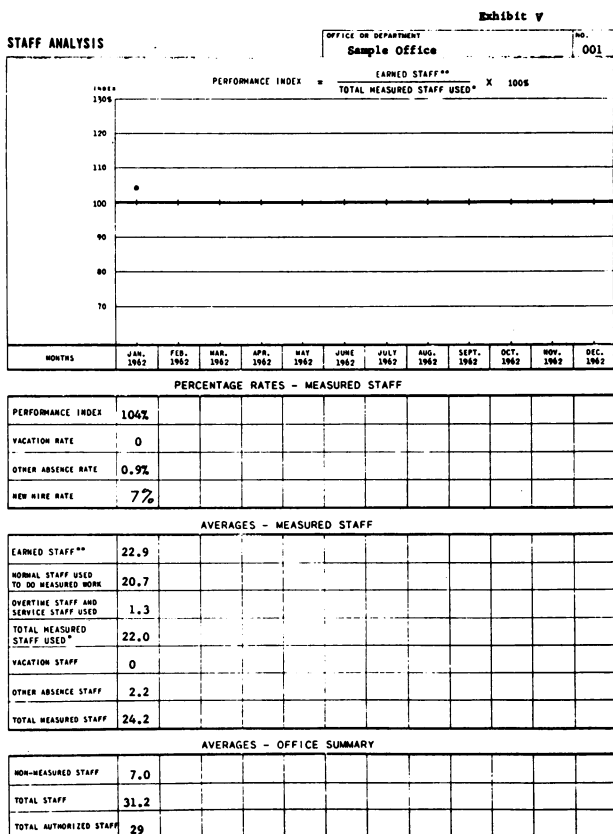
This sheet is almost self-explanatory and only needs a couple of points of explanation. The conversion factor is used to convert the number of standard minutes into the number of earned staff. We use earned staff instead of earned hours or earned minutes because it is more comprehensible. The conversion factor used on these sheets is the reciprocal of 480 minutes.

Staff Analysis

After the earned staff has been calculated, as shown on Exhibit III, it is transferred to Exhibit IV, Staff Analysis, which is a report that goes to management. Exhibit III, the Earned Staff Calculation Sheet, is retained by the Industrial Engineering Services group with a copy returned to the working supervisor for his use in scheduling and planning his work. The Staff Analysis Sheet (Exhibit IV) is the old sheet used at United California Bank. Exhibit V is the new sheet installed at UCB in January, 1962. Exhibit VI, at the end of the report, is the definition of terms used in Exhibit V. We have not yet developed for publication the new definitions for the terms in Exhibit V. However, I felt that you would like to see the more advanced sheet in our program. The Staff Analysis Sheet (Exhibit IV) is self-explanatory. The plotted line shows the performance, the earned staff line shows the work load expressed in man hours, the total staff used shows the number of people used in performing work. The absence staff shows the



number of people absent, and the overtime staff shows the number of people that were either on overtime or service staff used. The percentages are merely reflections of the other items shown in the chart. It will be of particular interest to note one item, that is, the New Hire Rate. The particular significance of this is that we do not use the learning curve in the application of our standards. We try to plot our results against the theoretical ideal. Thus, we do not give any consideration for the learning curve. We assume that the branches all have the average qualified worker. The new hire rate reflects the amount of new staff used in an activity during the reporting cycle. Should the performance drop, this *may* be one of the items which explains the drop in performance. The bottom half of Exhibit IV shows end of the quarter totals, while the remainder of the data are averages. Therefore, we are dropping this from our report as you will see in Exhibit V because most people tended to confuse end of the quarter and average figures.



Use of Standards

We use our standards for many items; namely, staff control, staff planning, scheduling, product costing, work load trends, cost accounting, and incentives.

Top Management Support

This is one item which I stressed over and over again at the Seminar. I did not do it here; I saved it

for the last. Top management support is *absolutely necessary* if you are going to have an effective work measurement program.

Exhibit VI

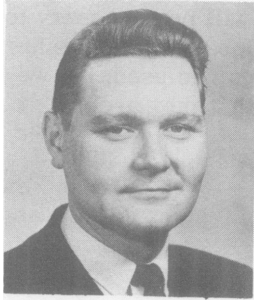
DEFINITION OF TERMS USED IN THE STAFF ANALYSIS

- STANDARD TIME FACTOR** - the average time required by an experienced employee to perform a given task.
- MEASURED WORK** - the work activities covered by standard time factors.
- MEASURED STAFF** - the staff performing measured work.
- EARNED STAFF** - the average daily staff required for the measured work. The earned staff is determined by multiplying the average daily measured work by the standard time factors and converting to staff. The average daily measured work is determined from the work performed on the regular activity count days.
- TOTAL STAFF USED** - the average daily staff used to perform the measured work. The total staff used is determined by adding the total paid hours (less absences) for measured staff personnel to the total hours worked by service staff personnel during the quarter, and converting to staff.
- ABSENCE STAFF** - the average number of measured staff personnel absent each day (including vacations). The absence staff should be added to the earned staff in determining the number of measured personnel required to staff the office. The absence staff is determined by dividing the total number of absence hours during the quarter (from the weekly time reports) by the available work hours per person per quarter (normally 520).
- OVERTIME STAFF AND SERVICE STAFF USED** - the daily staff equivalent of overtime hours and service staff hours worked by measured staff personnel. The overtime staff and service staff is included in the total staff used, and is determined by dividing the total number of overtime and service staff hours during the quarter by the available work hours per person per quarter.
- STAFF PERFORMANCE INDEX** - the measure of staff efficiency. The staff performance index is determined by dividing the earned staff by the total staff used. 100% is standard and indicates that the total staff used exactly equalled the earned staff. Less than 100% is below standard and more than 100% is above standard.
- AVERAGE ABSENCE RATE** - the per cent of the measured staff absent each day. The average absence rate applies only to the measured staff and is determined by dividing the absence staff by the average assigned measured staff.
- AVERAGE ASSIGNED MEASURED STAFF** - the base figure for the average absence rate and the new hire rate. The average assigned measured staff is determined from the total staff used, minus overtime staff and service staff used, plus absence staff.
- NEW HIRE RATE** - the per cent of the average assigned measured staff hired during the quarter. The new hire rate is useful in interpreting staff performance, as new hires customarily require a period of orientation and training before becoming fully proficient in their work. The new hire rate is determined by dividing the number of measured staff personnel hired during the quarter by the average assigned measured staff.
- AUTHORIZED MEASURED STAFF** - the number of measured staff personnel authorized by Branch Operations at the end of the quarter.
- ASSIGNED MEASURED STAFF** - the number of measured staff personnel assigned to the office at the end of the quarter. The assigned measured staff is determined from the total assigned staff, minus the assigned non-measured staff.
- ASSIGNED NON-MEASURED STAFF** - the assigned office staff performing non-measured work (officers and miscellaneous personnel).
- TOTAL ASSIGNED STAFF** - the total number of persons assigned to the office at the end of the quarter. The total assigned staff includes all officers and miscellaneous personnel, and is determined from the Table of Staff Distribution.

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1. Employees' names must be put in the sequence in which we intend to observe the employees before the list is given to Tabulating. If it is desirable to random these observations in

addition to the random time, it will be necessary to rearrange the cards before the observer starts his tour. Certain Tab procedures can be used, but we have found through experience that they are not practical.



COMPUTER SIMULATION AND SYSTEMS DESIGN

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Computer simulation of operational systems has been employed with considerable success in many different firms and for an extensive number of situations: production planning and control, inventory systems, maintenance, reliability studies, waiting-line and servicing networks of various kinds, materials-handling analyses, evaluation of plant layout, and so on. We are concerned here only with the use of this tool in the study of complex industrial, business, and military systems, not with their use in the simulation of another computer, or a biological process, or a "learning" organism. (1) The use of computer simulation as a tool for management and as a technique for systems analysis is relatively new; only recently has meaningful information concerning this technique been available. (2) These restrictions are usually based either on national security or on company proprietary regulations. Perhaps surprisingly, papers reporting computer simulations of complex military and other governmental-oriented complex systems seem to be more common than those dealing with business and industrial systems. For whatever reasons, a valuable tool for increasing efficiency has not been in such general use as its potential requires.

PURPOSE AND SCOPE

Hence, it is the purpose here to present to those who manage individual enterprises (and to those who help them) an exposition of an important development, *computer simulation*, which can be a most useful technique to improve the operation and the design of business and industrial operations. (3) While certain recent advances discussed later may increase the possibility that small enterprises will find this technique useful, it is primarily intended for the study of large-scale, complex systems. So it would seem that relatively large enterprises would be most interested at present; indeed, for such concerns, knowledge and use of computer simulation appears vital. (4)

In this presentation, very little of the history of simulation on computer simulations is given; theory is given only a cursory examination; and the use of computer simulators as training devices is virtually ignored. (5), (6) No one can begin to simulate a system by using this material alone, since both the systems to be modelled and the technology of this kind

of modelling require considerable knowledge, data, and experience. However, guidance for the future acquisition of that knowledge, data, and experience should emerge. The intent is to be practical, to develop an enthusiasm concerning the subject and its possible use, to warn of certain dangers and disadvantages, and to create a desire to learn more.

Pitfalls. Indeed, the great enthusiasm for computer simulation of business systems now current is in a way a warning of possible pitfalls. Such simulations usually produce great masses of output, apparently quite realistic and invariably quite convincing, that sometimes lead the unwary to believe that he is examining the *real* operation and not an *artificial* representation. The realistic appearance of the output and the dramatic compression of time ("ten years of operations in an hour on the computer") often weaken the innate skepticism of even the most cautious. In addition, computer simulation usually involves much time and considerable cost. Data are needed that never were needed before — more time and more cost. An electronic digital computer is almost always needed as well; it must be programmed and debugged — more time and cost.

A Versatile and Powerful Tool. These are warnings, however, not stops. Industrial engineers and their managements now have available a most versatile and powerful tool for the study of current operations and for the design of new installations. This tool is probably best called computer simulation, a technique in which an electronic digital computer is used to "simulate" both actual and hypothetical systems.

THE CONCEPT OF "COMPUTER SIMULATION"

The word "simulation" can be used in a broad sense to mean any model, any abstraction of reality, expressed in symbolic form. (7) The simulation, the model (usually less complex than the reality it supposedly represents) can be studied itself in order to predict what the consequences in the real world might be. In engineering, there is a well-established acceptance of the concept of model construction and study. The simulator need not have all the characteristics of the object system, but it must have the characteristics of the original which are essential

to asking pertinent questions and getting specific answers.

We are here restricting the meaning further, however. Much of the progress of engineering and of science in general may well be said to be the result of the development of increasingly sophisticated, usually mathematical, models of particular systems and the solution of these models for conditions of optimality. But what if the system is so complex that no analytical solution is yet known? Or suppose the reality under study is so little understood that no meaningful model is as yet possible? Can this process of modelling, of simulation, still be of use?

Suppose we manipulate the model: feed it input and observe the reactions of its components and its output. We might then test whether the result of this "model manipulation" is a useful prediction of the behavior of the object system. If so, a uniquely valuable tool would become available. Here we limit ourselves to "digital computer simulation": the numerical manipulation of models programmed for electronic digital computers for the purpose of studying large-scale systems and their performance.

Almost any of the technical industrial engineering functions can be so simulated. Many have already been. Some examples are:

1. Traffic scheduling.
2. Study of plant layout.
3. Determination of maintenance crew size.
4. Utilization of limited-capacity facilities.
5. Analysis of manufacturing operations, for both job and flow-shops.

The technique is particularly suitable for such difficult problems as waiting-line networks having many service points and non-deterministic arrival and service rates, for complex production lines with feedback, and for very complex multi-echelon inventory systems. Possible applications appear to be limited only by the inventiveness and ingenuity of users.

Fundamentals. In a computer simulation such as is under discussion here, a computer model that represents the process or system under study is developed. It is necessary that the analyst understand clearly the objectives of the simulation because such understanding is essential to the proper definition of system elements, the relationships between and among the elements, and the rules used to process the flow through the representation. Thus, an explicit *quantitative* description of the system is developed which can be used, in effect, as "a laboratory," to be driven and manipulated as if it were "the real system." The outputs and dynamic responses over time in some sense represent the outputs and dynamic responses of the real system. This manipulation is accomplished by converting the explicit and quantitative description or model to a computer program. (8) Different inputs, different elements,

different relationships, different decision rules could be tried in order to discover the effect of the change on system performance.

It must be said that much of this work to date, especially in the study of actual operational situations, appears to be relatively unsophisticated. However, rigor now is becoming more common; the danger of gross misuse has much lessened. Indeed, work now in progress indicates a broad range of invaluable (and unique) roles in the future for the technique of computer simulation.

Certain Technical Matters. Since we are particularly concerned with possible present and future applications of this technique in industrial engineering, we will not devote much time to nice questions of definition or of theory. In a computer simulation intended to help the management of an existing system, a clear statement of the purpose of the analysis is essential. We may draw attention to such various purposes as the following:

1. Ordinarily the behavior of the individual elements and the relationships among the elements are known; what is not known is the behavior of the overall system. However, the analyst may merely be interested in discovering whether or not he has any meaningful representation in his simulator at all. He manipulates the simulator to discover whether he understands the object system at all and whether the significant factors have been considered.
2. On other occasions, the question is one of rule testing. Every element in the model must have a clearly defined and definite way of handling multiple and simultaneous demands on the resources of the system. We may keep the configuration of the simulator constant but test various rules to discover those which seem reasonable and appropriate.
3. If two or more rules appear to be reasonable, we may wish to test which one is "best" according to some specific criteria.
4. For a given system configuration and set of rules, we may wish to use the computer simulator to train the personnel who operate the system or to justify a new design by operating it as if it were already installed.
5. On occasion, several of these ends (and others) may be desired at the same time.

There is reason to believe that the computer simulation (and certainly its definition) which should be used in each of these cases may well differ from the others. Note the following:

"...simulation as a technique in training aircraft pilots is quite different from simulation used in computer models to determine the queuing characteristics of automobiles at a

traffic light. These two applications and uses of the term have little in common, and a definition which tries to incorporate the characteristics of both is so broad as to be meaningless." (9)

There are probably a number of possible simulators that could be developed for a given system. Such a situation is not necessarily, as has been sometimes suggested, a result of confusion about the subject matter, but merely a reflection of complexity of analysis. Further, it is imperative that the modeller know what is *not* to be simulated as well as what *is* and for what purpose. The fact that such considerations are now generally understood suggests the increasing maturity of computer simulation.

Computer simulation, however, is far from a rigorous and well-established intellectual discipline. Understanding of purpose and the development of a logical, rational, systematic computer model of some system is far from a complete theory. Some of the many methodological questions that still need to be answered are:

1. What are appropriate criteria to judge a simulator?
2. How is validity to be evaluated?
3. Is fidelity of representation important? If so, how is it to be evaluated?
4. If the functions in a simulator are non-linear, which of the great number of possibilities should be used?
5. What method or methods should be used to estimate the values of the parameters?

In existing simulators, these questions have usually been answered without complete understanding or assumptions have been made that led to ignoring the questions. For many problems, these rather loose methods can be completely erroneous.

Steps in Simulation. The steps needed in developing a simulator of an operating unit in a business enterprise (such as a job-type machine shop) can be listed as follows:

1. Discovery and specification of the problem to be considered.
2. Data collection for the purpose of discovering relationships and for the development of the model.
3. Model construction. There are two approaches:
 - a. Represent the real system in a flow diagram. (Avoid useless detail; remember a good "simulator" is one which answers the specific problem posed and is not necessarily one which describes reality well.)
 - b. Design a logical flow diagram around the questions to be answered.

4. Modify the model based on "field tests," deduction, and the results of simulation runs.
5. Test the model by manual methods if possible.
6. Convert flow diagram to computer code.
7. Debug. See Step d.
8. Experiment with the simulator. See Step d. Attempt to design experiments with sufficient replication so that meaningful conclusions can be drawn from the output. Decide whether you are interested in transient or steady-state answers. Conduct runs accordingly.
9. Evaluate the results.

CURRENT ENTHUSIASM: JUSTIFIED OR FADDISM?

There is undoubtedly a considerable amount of misdirected enthusiasm in the recent interest in computer simulation. Some simulations have been done even when analytical methods existed. Without question, some computer simulations have been started because they provided a good way to use available computer time, available because of poor estimates of utilization. Some simulations have probably been begun merely because it was fashionable to do so, even though no problem required it.

Such distortions do not destroy the usefulness of this technique however, when it is properly used. It is important to understand that almost always the essential element in computer simulation is the rapidity with which results are made available. In some cases, unfortunately, this method is selected even though it is most inappropriate because of the time required to obtain answers. Data collection is almost always required; rarely are data available in the form and the detail needed. The design, programming, debugging, operation, and analysis of a computer simulator inevitably take considerable time. Costs are often higher than expected. But in many, many cases computer simulation is the only relatively sophisticated technique available and its answers are, by any test, cheaper, faster, and better than any other answers possible.

At the present time, computer simulation is more attractive and more useful than ever before because of the accumulated knowledge provided by the time and effort of those who have already experimented with it. Many persons now have considerable technical skill and experience in the use of this technique. In addition, equipment now available at present has substantially greater computation power and storage capacity, making it much more useful for such work.

Yet, in the solution of operational problems by the use of conventional methods, engineers (and their managements) have too often taken one of two courses, both of which are seldom satisfactory. Sometimes the analyst is so rushed or is so overwhelmed by the apparent complexity of the system

under study that he oversimplifies the model. This simplification gives answers and does so with dispatch; however, too many times such "answers" are wrong because, if put into effect, they could produce chaos in the real system. On the other hand, engineers and others have been known to develop such complicated mathematical models that no method of solution is known. When traditional mathematical models are designed for analytical solution, they must be made less complex, less real, if they are to be solved at all. Computer simulation does not encounter these problems because, no matter how complicated, the consequences inherent in the computer model can be discovered. Notice that, in general, a simulation cannot be "solved" in the sense of finding an optimum. But, in many instances, optimization is not as important as the discovery of significant improvement in system performance. Where gross oversimplification results from speed or where distortion arises from an attempt to give an analytical solution, computer simulation is clearly called for.

DEVELOPMENTS IN DIGITAL COMPUTER SIMULATION

The increasing interest in, and use of, digital computer simulation has brought some welcome developments both in concepts and in hardware. For example, modellers now realize that data collection almost always takes as much time as all the other steps in the design of a simulator. Rarely does information exist in sufficient detail or in proper form. It appears that little can be done about this problem, but with its recognition the difficulties have to some extent been minimized. The speed and increased storage capacity of the newer digital computers, as has been pointed out, has made it possible to construct simulators of quite large and complex systems without the inefficient use of the slow storage. In terms of computation power, the very large machines have a lower cost of use or rental. Some of the instruments promise both an ease of programming and a flexibility of computer logic that should be of great help in simulator programming.

Modelling. Early computer simulators often used a method of internal timing in which the entire model is updated in fixed time intervals. In many cases, such a timing scheme is extremely inefficient. Asynchronous updating (or even combined methods) is now usual.

Many simulators appear to have assumed that all the elements of the system are stochastically independent. This simplification is now being abandoned when appropriate.

Simulation of human participants in a man-machine system has always been a problem. There are two approaches now being used: the incorporation of an element with fully specified decision rules or the use of actual human beings as an integral part

of the simulator (so-called "manned simulation").

Experimental Design. The manipulation of the computer simulation models and the great amounts of output produced by such manipulation soon made it clear to analysts that it would be necessary to design the runs in order to get the most information possible at lowest cost. Brute force simulation runs also had to be avoided because, in general, digital computer simulation models are now almost invariably probabilistic models, since such models are particularly appropriate for business man-machine systems. Considerable work has been done on variance-reducing techniques and on other methods for designing the simulation runs efficiently. (10) Validation procedures are also becoming considerably more sophisticated. (11)

Computer Programming. It is perhaps in the programming of digital computers that the most useful developments in computer simulation are coming about. Most simulators are now being written in modular form as closed subroutines so that the program can be changed easily. Automatic programming methods now enable the analyst to write the program in symbolic form, not in machine code. IBM's FORTRAN II is particularly interesting because it provides for segmenting of the program in a relatively simple way. While no existing symbolic compiler is as rich in logic flexibility as the technique of computer simulation seems to need, the importance of these developments is not to be underestimated. Work is now in progress on methods of providing easily changeable input/output formats as well. The editing of input and output can be most tedious and time-consuming and is usually of relatively little worth to the ultimate use of a simulator.

The General Purpose Simulators. A number of programming methods are now available to speed up the translation of flow charts to digital computer programs. Apparently, a number of these so-called "general purpose simulators" exist, but company security regulations have kept them unavailable generally. The "Job Shop Simulator" of the General Electric Company and the International Business Machines shows what the possibilities are. (12) It is reported that Harry Markowitz at the RAND Corporation has developed a "Systems Programming System." Geoffrey Gordon of IBM has made available a most exciting computer program: "A General Purpose Systems Simulator":

1. "...a general-purpose simulation program designed to aid system study work."
2. "The system to be simulated must be described in terms of a block diagram...."
3. "[The GPSS develops a computer program from the block diagram directly in which the model operates by]...following the flow of

traffic through the system and observing the effects of blocking caused by the need to time-share parts of the system or by limiting the capacity of parts of the system." (13), (14)

Simulation and Managerial Control. Perhaps the most exciting news regarding computer simulation is the possibility of combining a computer simulation model and the managerial control system of an enterprise. Such a combination would enable us to use the control system as a predictive device and make computer simulation an *on-line, continuous* managerial control mechanism rather than an off-line, intermittent study technique. Once again, there is some evidence that this combination of computer simulation and control system may already be in use, but this has been little publicized.

SYSTEM ANALYSIS, COMPUTER SIMULATION, AND THE INDUSTRIAL ENGINEER

Any process or system, no matter how complex, can be simulated if it can be broken down into a set of components or elements for which operating rules can be specified. In engineering science, the use of analog devices is well established to study operational system performance, both of actual systems and for proposed systems. In many situations, the inherent problems of accuracy and lack of flexibility suggest a digital device as the proper simulation device. Frankly, it is possible to predict that almost all of industrial engineering which involves a complex system of any kind will use digital computer simulation. Indeed, the industrial engineer who remains unfamiliar with computer simulation will soon be so crippled intellectually that most of his usefulness will be gone. It is difficult to conceive of another way in which —

1. old assumptions about a system can be re-examined,
2. new parameters can be determined,
3. new relationships between components can be discovered,
4. the "significant" variables can be identified, and
5. any number of possible "solutions" for proper system operation and design can be tested.

As experienced analysts know, in the study or design of complex systems, most of these results are usually impossible to obtain.

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5. For a discussion of the theory of computer simulation, see: Morgenthaler, George W., *loc. cit.*, pp. 376.
6. For an extensive study of the use of computer simulation in training, see: Bogdanoff, E. and others, *Simulation: An Introduction to a New Technology*, TM-499, Santa Monica, California:

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NEW PATTERNS FOR MANAGEMENT

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I was reminded while talking with Professor Barnes a moment ago of something a friend of both of us used to say. The friend was Professor Kurt Lewin, who was at the University of Iowa when Professor Barnes was there. Kurt Lewin would frequently say in a somewhat puzzled fashion that stupid people must have more brain power than intelligent people, because, he said, being stupid, they get themselves into the kind of mess that the most intelligent person couldn't find his way out of. I felt somewhat in this situation today because I had accepted this invitation without noting that it was tied in with the Engineering Institute; and of all the people who really scare me, the engineering profession does the most thorough job. They can be so precise, and those of us in the social sciences are always having to apologize so much for our shortcomings in this respect that I suspect, if I had known or read more carefully the invitation, I might have been a bit more reluctant to be here today. But now that I am here I hope that I can tell you some of the things that I as a company president and as a social psychologist have found of help in the management of people, and yet do it without arousing any anxieties in you that I will move into an area with which I am not too familiar.

I am reminded here of a story told me by a fellow psychologist several days ago about a young lad who announced that he was going to marry a girl just like mother. He hunted and he finally found a girl who cooked like mother, who spoke like mother, who dressed like mother, but he said: "I didn't marry her because my father hated her." I hope you won't hate me for some of the things I say today, because really we are all talking about much the same thing. We are talking about production and productivity. We are talking about profits — and to me as a company president, you would, I am sure, understand that profit is not a subversive word. We're talking about turnover and profit control and all the common problems that plague those of us who are in industry, whether we are active in management and engineering or whether we are simply clipping coupons as stockholders.

In an article that I wrote recently I took issue with a popular phrase: "Don't be an amateur psychologist." I took issue with it because I felt that it implies something very wrong in our social relationships. A serious reconsideration of this sentiment would readily change it. I would propose that

we say instead: "By all means be an amateur psychologist, but get some training and be a good one." And it is along these lines that I would like to talk to you today. To support my thesis that in management and in the handling of people — and handling them effectively so as to get the maximum potential from them, not by coercion but through willing cooperation — each of us has to act the role of the psychologist; not, of course, in the highly technical and professional sense, but rather in the same way that every parent is a therapist as he educates his child. Every teacher is a therapist. And if we look upon growing up, growing older, and growing wiser as coming about through the efforts of others to guide and counsel us, then I think that we can be good amateur psychologists by knowing what we are doing and what others are seeking in the way of need fulfillment. As a result we may possibly build our companies into much more effective organizations than the ones we are operating with today.

Within this frame of reference let us look at the matter of basing our actions upon psychology. Could any of us grow up successfully without learning to interpret the actions of others, without being sensitive to their needs and wants? In the process of becoming an executive, especially, haven't we had to be adept at predicting how people will react in a given situation; haven't we had to learn to understand why they react as they do? These are essential techniques of living and form part of the basic subject matter of psychology, which simply aims to prove the validity of our common sense assumptions and principles about people. These problems that interest the psychologist also form part of the daily life of every manager. The problem that the executive faces today is, in part, one of staying abreast of the many new discoveries that are coming out of the social science institutes and research centers. It is even more difficult to find the time and the means for routinely applying these new findings to our own organizations. I think, though, that we must face up to the fact that large stockpiles of information and data already exist which would be of great help to us in the management of our organizations — but the data are largely unused.

Just how to bridge the gap between the findings of the research centers and their practical application on the production floor is a problem that troubles a great many of us. It is easy enough to say that the professionals write in their own language —

one difficult to understand — but this is not a sound excuse. The physicists write in their own language too, and so do all other scientists. It is too easy to blame the people at the universities, to ask why they don't send us their findings, or sell them to us, or persuade us that we should try out some of the new techniques. Here again the assumption that the responsibility belongs to others creates controversy but not any real action. Ultimately, I think, it has to be people like yourselves, people like myself, who will join and communicate with one another about problems that exist in all of our companies and thus bring to one another the combined thinking and wisdom of our respective disciplines.

Everyone knows that in the early days of American industry the owner-manager dominated his business. He made the decisions, he told everybody what to do. Like Louis XIV whose assertion, "I am the State," epitomized absolute monarchy, so the old-time industrialist was himself "the management." Today, for the most part, management is distinct from ownership. The approach to business problems must be professional. The typical executive reaches his position on merit, not by family connections; and he holds it only so long as he brings about results in higher output, lower costs, and better products. The problems that we as managers must face today are far more varied and complex than those of the owner-manager of fifty years ago. It is no longer possible for us to hire workers who will do as we say without question. Moreover, our workers today demand much more of us than merely better pay. They want recognition, power, and a sense of personal worth. If they don't get it, they are not going to react helplessly. They are going to do something about it, and we will find it hidden in restricted output, absenteeism, product waste. We must consider, too, the needs of our workers because we recognize, as they do, that capacity to produce now depends less upon their muscles or their dexterity and much more upon their motivation and morale.

In the past, too, there was a strange tendency, as we look upon it today, to think about an organization in mechanical terms. Formerly, we used such phrases as a smoothly-operating or smoothly-running machine. We talked of organization charts as blueprints. From our point of view, the analogy was always a bad one. The conventional textbook outline of an organization or organizational structure looked very pretty. It followed the classical military model — with army-like unity of command, table of organization, span of control, centralized authority. These principles were borrowed from the organizational models of the military, and the church, but they ignored one significant difference. Industrial organizations do not have the power of court martial nor excommunication. Industry is not backed with any authority to enforce its regulations, unless it is prepared to lose its manpower; and our concern is with salvaging its human resources and bringing them up to its highest potential. We cannot

accept the defeat of losing our people but must rely upon persuasion. And this persuasion is the kind that resolves and reconciles differences in face to face meetings, not the kind available to former generations in other places which functioned on battlefields or against picket lines.

I think that a great deal is known about human nature — far more than social scientists admit and far less than most people in other sciences recognize. We know something about the conditions under which changes in relationships between people take place, when they become more cooperative, when they become more hostile, and why. We know something about how to measure human capacities, how to analyze personality and character, how to interpret perceptions; and we have a considerable body of knowledge on human motivation. But so little of this knowledge is being used in any of our large companies today. Part of the cause, I believe, is that the men in management — and now I talk not merely about middle management, who have been exposed to far more study and training than any other management group — I talk now as well about top management; and here I can speak as an equal to those presidents attending or to those who will read these proceedings. I believe that it is of paramount importance that all executives, from the president through middle management, must have a broad understanding and knowledge of human nature, and particularly of their own.

In his role as supervisor or manager, each individual is constantly observing and evaluating the actions of others but he is rarely, or too infrequently, aware that his reactions are founded on what he believes his subordinates are feeling, thinking, or perceiving. As one psychologist put it, we are constantly seeing things not as *they* are but as *we* are. A man sees what he wants to see or expects to see in people. The old adage, "Seeing is believing," is entirely wrong. It doesn't make psychological sense. It does if you reverse it: believing is seeing. We believe the way we do about other people's motives for acting, and then we find the evidence to support our beliefs. Many studies prove beyond doubt that most of our attitudes are established without the facts, that there need not be any correlation between how much you know about a subject and how strongly you defend your attitude. But apparently we do accept beliefs about people through many quite unconscious cues: and then, with similar unawareness, proceed to build up evidence to prove the belief. Hence, I feel that it is important, most important, for anyone in a managerial position to get some help in achieving better self-understanding. If we are to understand others, we have to understand ourselves first; for, otherwise, we are never really sure whether the decisions we have made are based on the fulfillment of our personal needs rather than on company needs, or whether they are genuinely based on the welfare of the company.

Invariably, when we talk about getting greater cooperation within the organization and about the

need to make changes — whether they be technological changes, or personnel changes, or changes in the way people act toward their subordinates or their superiors — the answer to the question of who is to be changed is invariably others, not me. Yet, it is my belief that each executive must be ready to change himself when, through improved self-understanding, he understands his customary reactions more clearly, and understands also why people acted toward him as they did. There is a readiness to change others. The others may be the world, the government, the union, our colleagues, our children, our wife. Rarely does anyone propose some self-analysis before he seeks to change others. Let's look into our own mirrors and see *ourselves*, not the image that we'd like to see and often kid ourselves into seeing. Many of you who look into the mirror each day when you shave hardly recognize any difference in your appearance over the last twenty years — the self-image remains relatively unchanged; others, however, may see rather major changes. And so self-understanding with guidance, with help, can assist us in squaring reality with our attitude. Of course, it is not only people like ourselves who need to change; but, if we can arrive at a better perception of how our subordinates see us, if we can perceive that we have been guilty of the common error of looking at the other fellow from our own point of view, I believe that we will be able to straighten out many of the conflict situations that may have troubled us for long periods of time.

We need to know something too about our own frustration tolerance. So many men who are table pounders or decision postponers, or who preach dedication and never practice it, are completely unaware of the contradiction between their stated belief and their actual practice. And who is there to tell them? Who will risk telling them in the face of retaliation, defensiveness, and hard feelings. I have often asked groups of top executives to write answers to the two questions: What kind of person do you think you are? and, What kind of person are you, really? This is an interesting assignment, and if some of you feel intrigued by it, try to write out the answers for yourselves. You may find it a worthwhile experience.

At times, I have asked the subordinates of these executives to answer these questions for their superiors. The discrepancy between the manager's self-image and image seen by his subordinates makes crystal clear the reasons for misunderstanding reported by the executives. Naturally, subordinates do not always see their superiors correctly. Very often subordinates will see the boss in the light of their own past experience and future expectations. Thus, an employee who sees the company president as a father figure, and who resents his authority because of unhappy experiences with his own father, will react critically to *any* act of his boss. This conduct, the executive may learn, need not be taken seriously, since the reaction of defiance is directed against the father himself, not against

the father figure — though such persons are irritants, undoubtedly, in any organization.

Along with self-understanding, I think we need to get more understanding of the values that others bring to the work situation. For example, let's talk about one of the things we do know about — work. Why do people work at all? What makes some work hard and others work only indifferently. All of us know people to whom work is not penance but pleasure. Many of us in this room, I dare say, feel that way about the professions we have followed. What is it that those who find fulfillment in their work get from it? Many studies have confirmed what many of you, no doubt, have assumed intuitively: Those who derive the greatest satisfaction from their work do so as a result, first, of sharing responsibility; second, participating in decision making; and third, obtaining recognition for good performance and judgment.

What do we mean by participation? This is a word that we hear a lot about nowadays. Well, I would define participation quantitatively. I would say that participation is likely to be low when an employee is given scanty information about policies that directly affect him. Participation would be heightened if the employee were not only informed that a new company policy exists, but also about *why* we have made the policy. He should also be encouraged to ask questions about it. Participation, however, begins to be most meaningful when we invite our employees to make suggestions on how to cure a troublesome situation. Now he contributes toward clarifying issues, facing problems, and making decisions. In none of these situations, and I might add, since this is a luncheon talk, that I am going to refer to any of the specific experimental studies which validate the principles I am describing; but the literature contains detailed analyses of these studies which I believe you may find valuable in re-thinking this problem of participation, in determining how far it goes, and whether or not — this is a question that is asked of me frequently — participation is an abdication by management of its responsibilities. Obviously, we don't think so, and, moreover, we ask people to participate only in those areas in which they have an immediate concern and about which they have information that is useful to the company. Participation must be genuine, it cannot be a pretense. It is not the sort of thing that elementary schools indulge in when they set up pupil self-government and allow the youngsters to decide on important matters — as long as they decide the way the principal wants them to. By participation we mean that the decisions have not been made, that there is a free exchange of opinion between management and the employees involved (and this may be at the worker level as well as at any other management level), and that no decision is made until both parties have had a chance to talk out their respective points of view. Now, if management believes that a man is selfish, is self-seeking, will do as little as possible, does not want responsibilities,

then the recommendation to add participative management to company policy is unlikely to be accepted. If, on the other hand, management believes that men are very much alike whether they be workers or executives, that all people seek a sense of achievement, that they want recognition for individual creativity; if management genuinely believes that it can increase employee freedom and decision-making, that it can reduce the amount of supervision, the amount of pressure, and the amount of authority from above, then it will encourage greater participation within the organization, with what I believe will be most beneficial results.

Industry is going to be forced to broaden participation at every level of the company. It is going to have to do this because our schools and our homes have set a precedent in this respect. Youngsters today enter industry after they have been guided by parents and teachers in a process that has tended constantly toward wider participation by the youngsters in family decisions. As you well know, children today are involved in far more family decisions. They are permitted to express dissatisfaction with many proposals, and frequently win out because we have gone along with the concept that growth means greater independence, greater interdependence, less of a blind obedience and more of an opportunity to talk things over and work out solutions. With this greater freedom and this encouragement to exercise more initiative, we are raising a generation of kids who, as a result of their participation in the Cub Scouts, the "Y" or the school government, have had a greater opportunity to express themselves; and they have expectations of experiencing a similar opportunity when they go into their first job in industry. Too often they are disappointed. They find that in industry they are expected to be subordinate, passive, dependent. They are not consulted even about the matters that directly concern them, unless it sometime be through a union representative — who doesn't talk to them either.

When people who have attained psychological maturity are compelled to act in an immature manner, the inner feelings of resentment are deep. Hostility invariably arises in the personality of anyone who is compelled to act dependently in an issue that he feels he should be allowed to decide for himself. Which features of the company make men act like children, keep them from standing on their own two feet, compel them to be subordinate members who can never make decisions and who suffer consequently from perpetual feelings of powerlessness? There are three organizational features that make this dependence. The first is a highly formal organization or structure of the company, the second is the immediate supervisor, and a third is the automatic controls, budgets, systems, policies, which limit the freedom of the individual. Moreover, in addition to these controls, there are other internal controls that most of us have set up in our companies. As they work out, many of these controls

are brakes on the intelligence and responsibility of very able employees. They parallel the dependency controls that the young individual finally grew away from at home.

I find that these controls bring about much the same reaction in our employees as government controls do on many of us who are constantly exposed to the limits and controls on our own activities by bureaucratic regulations. We object loudly to many of these controls imposed by government because we see their smothering effect and their interference with free initiative. But the same executives who protest most loudly at executive meetings about government controls have set up similar bureaucratic controls in their own companies. Such controls are fundamentally born of distrust. They are marks of a lack of faith in others. Participation offers one answer to the apparent dilemma. Participation gives all of our employees the kind of involvement in problem solving that encourages them to feel they are not being controlled to the point where their intelligence and responsibility must be considered worthless. In participation we respect their ability and maturity by giving them freedom — freedom to discuss with each other and freedom to discuss with top management the problems that bother them or the company. We seek their counsel. Sometimes their recommendations will be followed, sometimes they won't. In either case, because they have been treated as adults, because they have had an opportunity to present their ideas, they will not resent the times when their advice is not taken. In these situations they will recognize that the decision properly rests with others. With genuine participation we will have motivated people to work with us instead of permitting their repressed hostility to get in the way of cooperation.

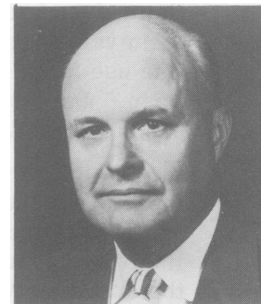
Many executives, particularly those at the vice-presidency and presidency level, have seen the impressive results of sensitivity training in improving their subordinates' executive performance in interpersonal relations. In my judgment sensitivity training is essential to supplement even the most skilled common sense understanding of the needs of others. Yet, thus far, too few top executives who have recommended sensitivity training for their middle management people have had the courage or the curiosity to try it themselves. But I can't see how we can expect greater sensitivity on the part of our managers when top management itself still fails to understand some of its own motivations and the reasons for its own practices. Top management, moreover, are the persons most deprived of a frank personality feedback from their associates. Consequently, I think they would gain tremendously from the confrontation of fellow members in a sensitivity group — members who would not be awed by their prestige and status and would truly help them gain the insight they need into their practices as president or E. V. P. Such confrontation would bring out the greatest potential of their human resources, much of which may be as yet untapped.

It may be difficult for some in management to accept the idea that they need help, that they are not experts in psychology and in self understanding, that anyone can tell them anything about management which they have not acquired in a lifetime of experience. Yet, as a company president, as a manager, and as a psychologist who has met with

and probably taught more company presidents than any other American, I feel very safe in saying that the greatest opportunity for channeling the tremendous potential that exists within our organizations lies to a large extent with broadening the understanding and insight of the people on top.

VALUE ANALYSIS IN ENGINEERING

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Isn't Value Analysis another name for Industrial Engineering? This question is so often asked by industrial engineers that we will start with it today.

OBJECTIVES ARE THE SAME

The basic objectives of both might be approximated as, "To prevent or eliminate unnecessary costs." For comparison, the objective in transportation might be a transport substance between Los Angeles and San Francisco. The means used might be an airplane, a freight train, an automobile, or a bicycle. But the results would be very different. Similarly, for the objective, "To prevent or eliminate unnecessary costs," different means will exist. Success will result from choosing the most appropriate means for each specific situation. A similarity of objective does not in the slightest degree indicate similarity of approach, of technique, of emphasis, of resources used, or of results accomplished in specific situations.

MANY OF THE "TOOLS" ARE THE SAME

Wheels are found on the airplane, train, automobile, bicycle; engines in the airplane, train, and automobile; and steel, copper, aluminum, fabric in all. Still, they are entirely different products. They do not accomplish the same results in any given situation, nor is any one best for all situations. Similarly, in Industrial Engineering and Value Analysis common parts will be found, sometimes used identically, sometimes used differently, sometimes providing different emphasis.

BUT THERE ARE MANY DIFFERENCES

Together, let us clearly see that different technologies, like different products, have much in common. The automobile and the airplane have wheels, engines, generators; yet, the airplane also has wings, emphasizes lightness, emphasizes streamlining, and so forth. As a result, it is a totally different product, worthless as a substitute for the automobile in some situations, far exceeding its performance in others.

Similarly, radar equipment and television equipment have much in common — electric components, oscillator circuits, filter circuits, antennas, and so on. Still, each has the addition to its system of a vital few *differing* parts so that the over-all is a different product bringing about very different end results.

The difference in products and in product capabilities in specific situations is created by the difference in *some* of the parts included in the product system. The difference in technologies and in technology capabilities in specific situations is created by the difference in some of the parts — techniques and special knowledge — included in the technology.

DIFFERENT PRODUCTS OR TECHNOLOGIES ARE IDENTIFIED BY THEIR DIFFERENCES

To be most helpful, I would like to discuss:

1. Areas of "newness."
2. The approach of value analysis and engineering.
3. The techniques.
4. The emphasis.

1. Areas of Newness

- a. Dividing all expenditures into costs of: *use values, esteem values, no values.*
- b. Using function as the only true base for the determination of appropriate costs.
- c. Evaluating functions in dollars and cents.

2. The Approach

- a. The basic approach is entirely from the customer's viewpoint. What does the customer want? He wants: suitable performance and suitable cost.

Suitable performance includes two classes of items: suitable use values — which include quality, life, safety factors, etc; and suitable esteem values — which include attractiveness, shapes, colors, features.

When translated into the manufacturer's language, these "values" become "functions."

Use values become product use functions; esteem values become product esteem functions. The use functions cause the product to "perform," and the esteem functions cause the product to sell.

- b. With *functions only* as basic considerations, the approach and techniques promote good answers to the question of how to provide reliably and at lowest cost the functions which the customer wants.

Work does not start with such self-oriented considerations as: How do we want to design it? What tooling do we have in place? What in-place know-how should be used? What materials do we want to use? Do we want to buy it or make it?

These and similar considerations limit original thinking, prevent the creation of the best value alternatives, and often result in lost business and closed factories. These considerations are important *after* appropriate values of functions have been determined and are factored into decision making in the implementation of value alternatives.

- c. The evaluation of groups of functions and of individual functions in dollars and cents saves large amounts of design time and expense. Such evaluation at once rules out many design and manufacturing approaches as being too costly, so that effort is at once channeled into approaches which have the potential not only of achieving suitable performance but suitable costs as well.

3. The Techniques

Three basic steps are carried out by the aid of a job plan and thirteen special techniques. The basic steps are: identify the function; evaluate it by comparison in terms of dollars; cause value alternatives to be developed.

Step 1: Identify the Function. Any useful product or service has a prime function. That function can usually be described by a two-word definition, such as, provide light, pump water, indicate time, exclude dust, support handle.

In addition, there may be secondary functions involved. A light source may be required to resist shock, a pump for domestic use to operate at a low noise level, a clock or watch to provide attractiveness, an umbrella to be useful as a cane, a dust enclosure to allow access to interiors, and a handle support to provide for locking.

Step 2: Evaluate the Function by Comparison. To minimize unproductive or disappointing design time and expense, manufacturing methods time and expense, and purchasing time and expense, establish the value in dollars for each group of functions collectively, then each function individually by comparison.

"Value" used in this sense is the "lowest cost to accomplish reliably a function or a group of functions." This will be determined by a creative search for engineering, manufacturing, and other value alternatives which would reliably accomplish the total function together with the over-all costs involved. Obviously, this evaluation will be just as good as the skill and knowledge and effectiveness of the evaluator.

For example, for the function of containing 200 gallons of gasoline in a landing craft which has a useful life of eight years, what is the value? Four 50-gallon drums would cost a total of \$28, but they wouldn't stand the environment. They need environmental coating. Estimate that the coatings would about double the cost. Function value is estimated at \$60. The specification called for specially-fabricated, special alloy tanks costing \$520 each. But alternatives were developed in harmony with the value of the function. The result was that in this procurement of tanks for 1000 ships, the cost to the taxpayers, instead of being the expected \$520,000, was \$80,000.

The fact that the function had been evaluated in dollars adds a new valuable dimension. Had this been done before the original design work and previous procurements, the savings would have been: large amounts of design time saved; large quantity of special alloy steel critical during emergencies — not needed; special cutting and welding equipment — not needed; five-sixths of the cost available for other needed weapons.

The importance of the technique of evaluating the function cannot be over-estimated.

Step 3: Cause Practical Alternatives to be Developed.

The value analysis and engineering technology utilizes a seven-phase job plan, thirteen special techniques, and a system of special knowledge to promote the evaluations of the function, the development of practical alternatives, and the overcoming of "stoppers" or roadblocks which always exist to impede both the development of and implementation of practical alternatives.

The job plan contains the following phases which will be listed but not here expanded to include procedures:

1. Orientation
2. Information
3. Speculation
4. Analysis
5. Program planning
6. Program execution
7. Appropriate Summarizing

Of the thirteen special techniques in the technology, two will be listed and expanded by explanation and example. Some of the techniques have for their principal objective the development of new and better

alternatives, while others have been found essential to overcome to a reasonable degree the "roadblocks" which exist.

One technique designed basically for the formation of alternatives is:

BLAST – CREATE – THEN REFINE

In this technique – after the creation of the function "value" by comparison – the value engineer mentally very "cruelly" blasts or "dismembers" previous approaches. His thinking now starts with simple and different solutions – which would *not* perform the function but which have something in common – and which are very economical to accomplish. This is followed by intense practical creativity, then by refinement to produce totally functional alternatives. An example will best illustrate.

A spacer stud is required to fasten a timer to an appliance. Naturally, quantities are large. Steel is acceptable. Cost – automatically produced on screw machines – is 8¢.

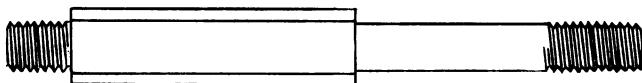


Figure 1

What is the function which the part must perform?

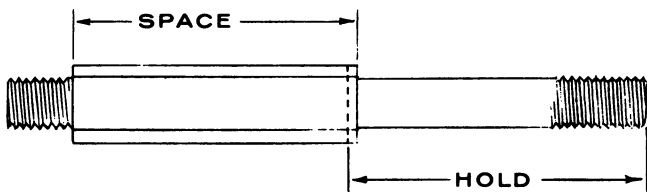


Figure 2

There are two functions – to hold, and to space.

By comparison, what is the appropriate cost (value) for the holding function? what is the appropriate cost (value) for the spacing function?

Value is now determined for each function separately by comparison. The holding function could be reliably accomplished by a steel screw, for example, which costs 1/2¢. Therefore, the value of the holding function is not over 1/2¢

The spacing function could in general be accomplished by a cut-off length of tubing or a rolled spacer which would cost about 1/4¢

Value for the two functions 3/4¢

But, how to get a practical alternative? The technique:

BLAST – CREATE – REFINE

The screw machine approach cannot be used because costs 1/10 must result. Help in getting started is sought from every source. Thinking starts with an eight-penny nail of approximately the appropriate size, containing a head, and costing 1/10¢.

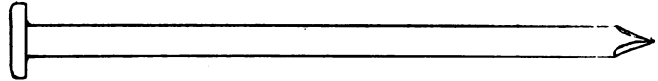


Figure 3

Creating and refining, the answers are developed to the question: what must be done to the nail so that it will accomplish both functions reliably, and what will be the added cost of each added operation?

The head must be moved down slightly on the shank, it must be made a hexagon, another head must be made in the middle of the nail to provide the necessary spacing action, then threads must be rolled on each end of the modified nail.

Suppliers in this type of business said they could do it and, in fact, *did* so – the *cost* becoming .8¢ – about the 3/4¢ indicated by the function evaluation. The practical alternative was created by the step-by-step use of the blast – create – refine technique.

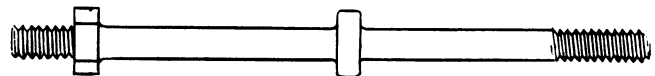


Figure 4

A technique basically oriented toward the ever-present "overabundance" of roadblocks is:

AVOID GENERALITIES – GET DOWN TO SPECIFICS

Nearly every generality is a force for perpetuating the *status quo*. An early step must be the elimination of the generality by insisting that all decision criteria come precisely from the situation being studied – none from generalities. Generalities act to stop action very much as fog stops traffic. Although there are not necessarily obstructions in the fog, there is likewise no assurance of the absence of them.

Some such generalities might be: Black plastics are brittle; stainless steel is ductile; dies for that part are too costly.

Precisely what plastic? and what application? and what cost? Precisely what stainless steel? what treatment? what applications? what cost? Precisely what is the part? where is the best know-how? what does dies cost?

An example of eliminating the roadblock in this last case was: 3000 per year rather heavy, small, simple stampings, were to be produced. The tooling manager said, "Parts too heavy; quantities too low; dies cannot be liquidated." Cost — \$1.41 each.

After the "roadblock" was overcome and quotations secured from a small lot vendor, the dies cost \$75, the parts 39¢ each. For an expenditure of \$75 a return of \$3000 per year was secured — but only after some technique had dealt with the roadblock.

4. The Emphasis

These points should be especially noted here: greatly increased emphasis on function; much increased emphasis on practical creativity; increased emphasis on promptly utilizing a special function/cost related knowledge for the creation of better, more practical alternatives.

Also, there must be an extreme emphasis on (1) identifying the "stoppers" or roadblocks which prevent value information development, and (2) the use of special techniques to deal with them. The technique "Avoid Generalities — Get down to Specifics" is an example of one of several in this class.

SUMMARY

The technology of Value Analysis and Engineering consists of a system of techniques and of special knowledge which are used in the design concept stage, the design stage, the purchasing stage, and the manufacturing stage to efficiently identify unnecessary costs so that they may be prevented or removed.

This technology is function-based and operates first, to establish appropriate cost, or value, of the functions; then, to create alternative means for reliably accomplishing them. It includes specific techniques for dealing with roadblocks which stop or impede the process of idea development, information gathering, or alternative implementation. By providing better answers, not only costs but also quality and reliability are improved.

Industrial engineers readily appreciate the magnitude of opportunity to identify and prevent or remove unnecessary costs. Those who are able to secure training in the techniques of Value Analysis and Value Engineering will find great assistance in this set of techniques and procedures which will assist them in applying their technologies efficiently and effectively.

WHY HAVE MEASURED DAYWORK?

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PRELIMINARIES

Measured Daywork Defined

Measured Daywork is a form of managerial control involving (a) the application of time standards to productive operations; (b) hourly earnings not affected by the level of performance; and (c) regular reports and evaluation of elapsed hours, in comparison with standard hours, as an aid to control by various levels of management.

This definition does not appear in Industrial Engineering handbooks and textbooks, as they define measured daywork as a type of incentive plan of the 1920's. Measured Daywork as used today in many plants is as defined in this paper and has no form of wage incentive payment whatsoever. This paper will first explain the details of Measured Daywork as defined above and then will consider why it is being used in many new plants. A familiarity with measured daywork can be obtained by comparing it briefly with unmeasured daywork and incentives with regard to worker earnings and management controls.

Characteristics of Daywork (Unmeasured)

In daywork form of wage payment, worker income is not dependent on worker output. This feature of daywork certainly eliminates a source of potential labor problems relating to questions concerning wages that is present in incentive plans.

A second characteristic of daywork is that the level of worker performance and the costs being incurred in a shop section are literally unknown. It is true that with a job order cost system one can compare actual costs on a job with a similar job, but only long after the job has been shipped and if there has been a similar job. Daywork leaves much to be desired because of this lack of control. This is evident in the present interest by management in many companies to obtain control over traditional daywork operations, particularly maintenance operations and office operations, through the use of work standards.

Characteristics of Incentives

A wage incentive system differs from a daywork system in the areas of earnings and control. First,

the income of a worker is dependent on his output. Thus there is an area of "discussion" with the worker concerning standards because they directly affect his earnings. The second characteristic is that performance in a shop section is known because there are standards to measure the worker performance and to control costs.

The May 1960 issue of the U. S. Department of Labor's *Monthly Labor Review* reported that only 27 per cent of productive workers in manufacturing industries were paid on an incentive basis.

DESCRIPTION OF MEASURED DAYWORK

Measured Daywork has the identical characteristic of daywork regarding worker income in that worker income is not dependent on output. It has the identical characteristic of an incentive system regarding management control in that standards are used to measure the performance of each shop section. To further explain the Measured Daywork plan, consider the plan as it affects productive employees, foremen, and industrial engineers, and note how the control element is included in the plan.

Productive Employees

The productive employee in a Measured Daywork plant receives a certain constant dollars-per-hour for every hour worked regardless of his output. This hourly rate of pay should be fair for the job performed relative to all other jobs in the plant when a proper job evaluation structure is in effect. If the rates established are at least equal to the average area rates paid for comparable jobs, the worker should not have legitimate grievances concerning the fairness of hourly pay.

In return for this rate of pay the employee is expected to produce a fair output. There is no time incentive which permits an employee to stop work after reaching a production quota. The employee is expected to apply a normal effort, work continuously for the specified work period less reasonable personal time, use prescribed methods and facilities, and meet quality requirements. He is given a standard on all jobs so that he knows what management expects as a fair output.

Foremen

The foreman in a Measured Daywork plant is expected to directly supervise about 25 employes. This number varies with the geographical area to be covered and the complexity of the jobs being performed. There are no group leaders to present a barrier to effective communication between the individual foreman and worker. The foreman is expected to truly manage his section in all respects. He must see that the employes are properly selected and placed on the job. He should also see that they apply normal effort, work continuously for the specified work period less reasonable personal time, use prescribed methods and facilities, and meet quality requirements. The foreman is also responsible for job instruction, tool and equipment availability, material availability and utilization, control of indirect expenses, manufacturing methods, approval of standards, good housekeeping and, most important, employee relations.

The foreman is responsible for correcting situations where an employe fails to meet the standard. First, he should determine the reasons for not meeting standards. The reasons may point to delays beyond the control of the operator, such as material not available when it is needed, material abnormally defective, tools or equipment in poor condition, or balance lacking between operations. These are representative of the conditions beyond the control of the operator that prevent him from meeting standards. The foreman is responsible for correcting this type of occurrence.

However, at other times the operator may be at fault. Improper handling or operating methods, including wrong machine cutting speeds or feeds, will cause sub-standard performance. Training and closer supervision by the foreman are called for in such cases. When delays or incorrect methods are ruled out as causes of poor performance, a foreman may determine through observation that specific operators are failing to work effectively. The foreman will be expected to follow up such situations until they are corrected. In Measured Daywork all should understand that a fair day's work will be a condition of continued employment.

Industrial Engineers

The first major function of the industrial engineer is to establish how a job is to be performed. He does this by consulting with line foremen, manufacturing planners, and others as required to determine in advance the necessary manufacturing operations. This determination will include the designation of machines, budget sections, operation sequence, speeds, feeds, tool numbers, jigs or fixtures, and other details.

The next major function for the industrial engineer is to establish standards, as, for example, in an incentive system, with appropriate allowances

for personal needs, using stop watch, standard data, or predetermined time systems such as M T M.

The final major area of the industrial engineer is current workplace methods. He should spend a great deal of his time working in a shop section and assisting the foreman to be certain that proper workplace methods are being used by the employes. The industrial engineer should be continuously trying to improve these workplace methods.

Control with Measured Daywork

The control in a Measured Daywork plant is obtained by having standards to measure the foreman's effectiveness. This indirectly measures the effectiveness of the employes. Thus the performance standards are used by the foreman to help them supervise operators. Periodic performance reports to management, either daily or weekly, show the level of productivity for each foreman's section. These reports indicate the effectiveness with which the work has been handled within a foreman's section, thus permitting the foreman to chart his own progress, to determine where improvement should be made, and to know how he stands with respect to established goals. They furnish higher management with the same information for a larger section of the plant and give an evaluation of individual foremen. They provide a basis for questioning sub-standard performance so that reasons can be determined and corrected. These performance reports also provide the staff departments such as industrial engineering with information to show where increased activity on their part is needed to assist the foremen.

The summary-of-performance report used in Westinghouse plants stresses the performance ratio for unit management. This ratio is determined by obtaining the actual output of standard hours production which was planned and determining the ratio of this to the total elapsed hours minus any hours for planned work without standards (Figure 1). In practice it is almost a ratio of the actual hours produced which can be sold to the customer to the total hours worked. The performance reports also have an objective performance ratio for each foreman.

Figure 1

WEEKLY PERFORMANCE REPORT FOR MEASURED DAYWORK PLANTS

UNIT SUPERVISOR AND UNIT NO.	NO. OF OPERATORS ON REG. TIME	ELAPSED HOURS				STANDARD HOURS		PERFORMANCE RATIOS		
		TOTAL (B+C+D)	WITHOUT STANDARDS PLANNED	WITHOUT STANDARDS UNPLANNED	WITH STANDARDS	PLANNED	UNPLANNED	OPERATORS B+C+D	UNIT MANAGEMENT C/A-B	OVERALL
		A	B	C	D	E	F	J	K	L
ME - JUNE JONES	25	1170	30	50	390	3005	50	96.5	88.5	90.5

INCREASED PRODUCTIVITY WITH MEASURED DAYWORK

With this brief explanation about Measured Daywork procedures, consider the reasons for having this form of wage payment. The major reason is to increase the productivity per employe through the years.

New Methods Increase Productivity

To see how Measured Daywork aids in increasing productivity, let us note that productivity may be increased either by increased worker effort or by new methods and equipment. One can question whether any increase in productivity is going to come or should come from increased effort above normal on the part of the individual. Most manufacturing people will agree that they cannot expect employees who exceed standard to work harder each succeeding year. Even industrial engineers preach: "Work smarter — not harder." Increased productivity in each succeeding year is therefore going to come from improved equipment and methods, and not from increased worker effort.

Incentives Emphasize Effort

The well-received second edition of the *Production Handbook* edited by Professor Carson states, "Probably the most important and fundamental principle of wage incentives is that wage incentive bonuses are additional rewards for extra performance above a standard which requires 'normal' level of effective operator effort and for which a properly evaluated hourly 'base rate' is a suitable and typical remuneration."

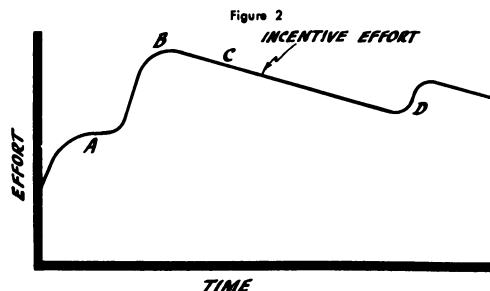
Opportunity for Extra Effort Diminishing

Note the fundamental concept that the worker is expected to exert extra effort above normal. In the 1920's and 30's, the opportunity for extra worker effort was present in the plants. Times have changed, and the degree of mechanization in the plants of the 1960's is quite different. The same opportunity does not exist for increased worker effort above normal because of the numerous machine- or process-controlled operations. An individual who wants to exert extra effort cannot do so on automatic equipment where the cycle is controlled or where there are paced conveyors. The output from machine or process-controlled operations is not dependent on worker effort, but on the equipment itself.

Incentive Makeout Determines Productivity

The use of incentives in attempting to obtain greater worker effort in order to increase productivity in the succeeding years will be a failure. Incentives are not satisfactory for attaining increased productivity even on operations that are completely worker controlled. Compare output and effort through the years on an individual operation completely worker controlled as to pace. First consider an incentive plan by referring to the curve of worker effort vs. time (Figure 2).

The effort of the worker will increase to some low plateau indicated by A in the curve. The effort will be at this plateau until a standard is set for the job. Once the standard is set, the effort will increase



rapidly to B on the curve. The worker then becomes quite proficient on the job and discovers many minor methods changes and short-cuts which management did not make a part of the original job method. As these worker-initiated methods changes and improvements are made, the effort level diminishes as indicated by C on the curve. Next, management may do a new methods study on the job and install some new methods, as well as discover some of the improvements the operator has been using. This means the worker effort level will increase as indicated at D on the curve.

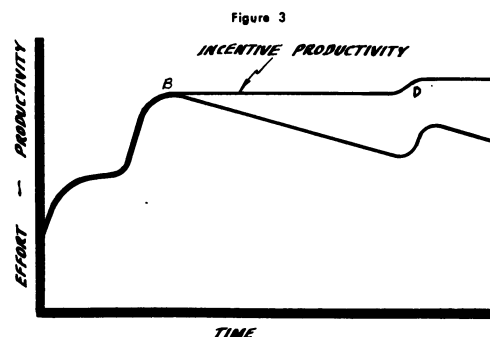


Figure 3 adds a curve of productivity or output to that of effort. The productivity follows the effort to about point B. Point B is the output level that gives the worker incentive earnings which he thinks management will accept as being a reasonable earnings level. The productivity remains constant at this level until management institutes methods changes at point D. There is now a slightly increased output level which is determined by the worker to keep his incentive earnings at the prior level.

Incentives Retard Methods Changes

Certainly, in an incentive plan, new methods and equipment can be installed, but consider what is often involved. Any change in methods and equipment can affect the earnings of the employee. It very seldom does, but workers feel this danger is always present. There is often worker pressure to prevent new methods from being installed. However, this doesn't stop progress and eventually they are installed. Depending on past practices in the plant, all of the improvements brought about by this new method may not actually be reflected in greater

output because there may have been some compromise on standards or on wage payment in order to make the methods change. The output is not based on effort but on accepted "makeout" for the job.

Industrial Engineering Effort Not Fully Effective in Incentive Plan

If full return from methods improvements cannot be obtained in an incentive plan, the solution might be to have new methods installed more often. New methods are introduced by industrial engineers and are proportional in some manner to hours expended by industrial engineers on methods improvements. They can develop these new methods when they are not involved in arguing with the workers about standards. Every minute an industrial engineer spends debating a time standard or being involved in grievances over time standards is a loss as far as improved workplace methods are concerned. Therefore, the slow improvement in productivity indicated on the previous curve is probably fair and representative.

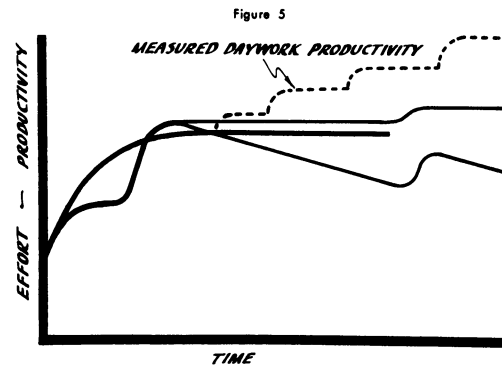
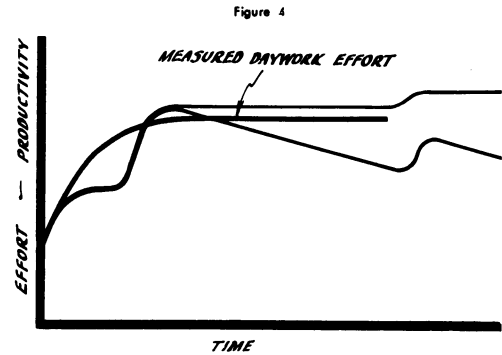
Poor Methods and Pace Create Fatigue

The previous curves are representative of a single worker doing a single operation. The worker is working at some arbitrary effort level which is determined by the acceptable rate of incentive earnings allowed, instead of by the natural pace of the operation. Practicing industrial engineers realize that there actually can be more fatigue to a worker from working at an unnatural effort level rather than working at the normal rhythmic pace called for by the work sequence. This might be paraphrased by saying: "It is harder to look busy than it is to be busy."

Measured Daywork Productivity

In a Measured Daywork plant, the curve of effort is different. Figure 4 shows the effort curve in comparison with an incentive plan. The effort reaches a normal effort level at a faster rate than in an incentive plan. This is realistic, as there is no need for the worker to hold back his output by awaiting the establishment of a standard. Regardless of the exact value of the Measured Daywork standard, his income is not affected, and therefore he does not hold back on production initially. The effort remains at a normal rhythmic level for the correct method of performing the operation. With methods changes there is no change in effort level.

Figure 5 shows the productivity in a Measured Daywork plant that will accompany the effort shown in Figure 4. The productivity increases quite rapidly through the year's relative to an incentive plan.



Reasons for Increased Productivity

The first reason for this rapid increase is that methods changes are easier to put into operation than in an incentive plan. There is always a natural resistance to change, but this resistance on the part of operators is substantially reduced when their earnings are in no way affected by the change.

The second reason that productivity increases much more rapidly than it does in an incentive plan is that the full result of the methods change is in the form of additional productivity. With worker effort constant, all changes in methods result in additional productivity. A 30 per cent improvement in method, a 30 per cent increase in productivity.

The third reason is that the industrial engineers can devote more time to workplace methods instead of being burdened with the administration and grievance problems present in an incentive system. The result is more frequent changes in methods than in an incentive system because of the additional industrial engineering hours that can be put into these improvements.

The fourth reason is that there is an additional source of improvements which aid in increasing productivity, and these are suggestions from the workers themselves. Their ability to earn extra compensation beyond their hourly guaranteed rate is dependent upon their submitting worthwhile suggestions in the suggestion system.

Measured Daywork Superior to Daywork

A daywork plan provides the same atmosphere for increasing productivity through new equipment and methods as does a Measured Daywork Plan. However, the productivity will not be as great with daywork because the vital control element is lacking. With daywork, the foreman's effectiveness in properly managing his sections suffers because standards are not available to guide his actions.

ADDITIONAL ADVANTAGES OF MEASURED DAYWORK

Aids Technological Progress

In this age of massive engineering and numerous product innovations, our manufacturing technology is increasing at a rapid rate. Processes used in many of the newer industries, such as semiconductor and atomic reactor component manufacturing, were unknown a few years ago. The change of technology is at a much greater rate than it has been at any time in the past. Frequent changes in methods and equipment are required simply to build new products that use these new processes, to say nothing of increasing the productivity of each employee. These changes in methods and equipment *must* be made in order to make an acceptable, reliable product.

Provides Sound Basis For Supervision

Measured Daywork helps to control operations because it provides a sound basis for supervisors. They have to use supervisory "know how" to govern their section as they cannot stand back thinking that incentive for additional dollars will provide the stimulus for a good operating section. Surveys indicate that the attitude of the foreman to the worker, and the worker's being treated properly by his foreman, are more important in achieving good morale and motivation in the plant than earnings.

Aids Indirect Labor Control

Measured Daywork also gives a more practical basis for control of indirect work. There is less difference between the approaches taken by management to control the cost of direct and indirect operations. In neither case are operators paid on an incentive basis. Also, both types of work can be covered by some form of performance evaluation in that standards can be applied to indirect workers as well as to the direct workers.

Stimulates Effort Toward Automation

In Measured Daywork there is also a stimulus to make technological changes in order to have paced operations. Such pacing of operators aids the

foreman in keeping operators on the job and producing a fair day's work. The foreman desires this and stimulates changes to paced operations.

Creates Interest in Productivity

There is an emphasis on over-all productivity in a Measured Daywork plant. The reporting technique that was previously mentioned is directed toward evaluating and improving the over-all productivity. This approach stresses the operator's effort level, and it also places appropriate emphasis on minimizing the delays, unplanned work, and other factors that lower productivity.

Improves Labor Relations

Labor relations are greatly improved under Measured Daywork. The performance standards in Measured Daywork do not serve as a basis for incentive earnings. Also, failure to meet standards is not normally a direct cause for disciplinary action. For these reasons operators do not have impelling motives to question standards or to argue about them. This tends to remove one of the handicaps to good labor relations. Not only are fewer questions likely to be raised on the troublesome subjects of standards, bonus earnings, and similar topics, but the foreman is in a better position to resolve the inevitable questions that are raised on other subjects. The foreman has the time available for these other problems because he is not subject to involvement in incentive disputes.

Promotes Operator Flexibility

Measured Daywork provides the climate which is conducive to flexibility of operators. Operator assignments are flexible due to the absence of the incentive plan within a foreman's section, and due to the daywork rate, which prevents any lowering of income caused by transfers within the same job classifications or labor grade. When a worker is to be transferred to a job in the same labor grade, the earnings are not affected in any manner. Since experienced operators can be assigned where they are needed within classifications or labor grades, there is a tendency toward better equipment utilization.

Corrects Standards

Standards can be revised most easily under the Measured Daywork form of wage payment. This revision is always necessary where methods are altered, but the effects of creeping methods changes are sometimes overlooked. In Measured Daywork, any mistakes made in standards do not become cumulative. While any changes of standard should be made concurrently with methods changes wherever possible, the ability to revise the standards and not affect earnings is a definite advantage.

Performance standards can be revised by management whenever warranted.

Industrial engineers will not rush into setting permanent standards before new installations are past the development stage. This is more than just a convenience or a way to improve the accuracy of performance standards. It also means that the tendency is lessened for operators to slow down on new jobs prior to the setting of permanent standards.

Simplifies Paper Work

Under a Measured Daywork plan of wage payment there is simplified accounting and less paper work. It is obvious that payroll accounting becomes simpler and less costly when employees are all paid a day-work rate, as less complicated records are required. This saves time on the part of the foremen, time clerks, and industrial engineers.

Measured Daywork Overcomes Problems

All of the prior references to an incentive system

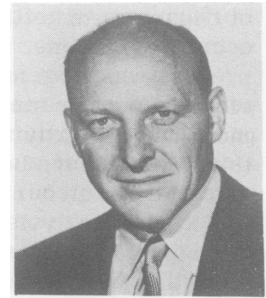
have been made on the basis that the incentive system is properly conceived and administered. Without getting into a discussion of how incentive systems can deteriorate after initial application, it can be said that any difficulties experienced with an incentive system which make the system less than ideal are in themselves reasons for using Measured Daywork.

SUMMARY

The use of Measured Daywork should increase in the future as the use of incentive systems diminishes. Because of its superior control element, Measured Daywork will replace daywork. It is a method of wage payment which will increase productivity more rapidly than an incentive system; it is also compatible with our rapidly advancing technology and need for new production methods and equipment, as it establishes a favorable climate for the introduction of such novelty.

A MORE EFFECTIVE USE OF TIME

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A number of years of experience in manager counseling and development have served to convince me that an effective use of time is the number one problem facing most people who try to accomplish things. The time available for total living is, of course, exactly the same for every person; yet, within that equal allotment, some are able to accomplish and create much more than most of the rest of us. It soon becomes apparent to anyone who attempts to advise other people on their time use, or who seeks to improve his own use of time, that one's total life is really under consideration. Thus, although we are primarily concerned with occupational or professional time, the major time-disrupting influences may stem from disorganized and anxiety-producing personal or off-the-job situations. Contrariwise, those who are in the business of counseling and advising people with home and family problems are aware that some of these pressures have their genesis in the very nature of the individual's occupational or professional life. In other words, it is virtually impossible for one to expect to have a calm, full, and balanced personal life if one's occupational life is helter-skelter and disorganized, and the reverse of this appears to be equally true.

In this presentation, obviously, we are primarily concerned with a more effective use of the time available to one's job or profession. This can be a useful bit of self-analysis, just so long as we keep in mind the fact that the total life is really involved. Likewise, as part of this preamble statement, it is well to remember that time utilization is a personal matter. Thus, each of us is quite efficient in certain areas of our time use, in comparison with many of our fellow men; and, on the other hand, almost every other person has some areas of his time utilization in which he is more effective than we are. Thus, the material in this presentation must be adapted by you to fit your particular needs. Each of you must do this personally, as I am currently in no position to direct my statements to your special needs. I fully recognize, as do most advisors in this field, that all of these recommendations are not equally pertinent or useful. They do represent, however, a collection of approaches and techniques culled from a wide variety of sources, and each of these suggestions has proved of value to some individual with a time problem.

I should like to approach this overall problem from the standpoint of five specific recommendations:

- I. Find out what now uses your time, and seek ways to simplify and organize your present use factors.
- II. Control some of your time environment. All busy people must make continuing efforts to control their time environment.
- III. Reserve "blocks of time" for definite purposes — practice time planning.
- IV. Check up on your work methods and see which of these can be improved.
- V. Take time to live — including time for home and family, relaxation, recreation, and cultural activities.

Let us now consider each of these items in a little more detail.

I. FIND OUT WHAT NOW TAKES YOUR TIME

Most people are not really aware of what occupies their time. Therefore, one little exercise which I have frequently suggested is that the individual simply make a list of the different things which he does, as he does them. I don't know how long this list should be nor the period which it should cover — certainly it should cover an entire work cycle, and it should represent the different matters that come up to take one's time, literally in the order in which they arise.

Most business executives will readily admit that most of the things they do are important, and all of the things they do are urgent. It seems to be these two bugaboos, *urgency* and *importance*, which harass many top-level people. It is generally conceded, I think, that the higher one is in the scale of affairs, and the more one has a *bona fide* problem of adequate time, the more one should really limit one's activities to those things which are genuinely urgent or really important. When Dwight Eisenhower was President, he was reported to have said that he had finally so-organized his activities that only those things crossed his desk which were deemed to be really urgent or genuinely important, but he had found, upon further comparison, that those things which were truly urgent were usually not to important, and those things which were highly important frequently were not very urgent.

These two appellations, however, give us a point

of departure in getting a perspective on what now occupies our time. I liken this procedure to the process which we must go through, periodically, in cleaning out our study or our garage or our basement, and literally throwing or giving away those things which have been cluttering up the place. The same is true in our time use. Therefore, to foster this kind of analysis and simplification, I should like to suggest to you a three-step approach, working from the basic list of activities which you have already completed.

Step 1: Using the activity analysis sheet No. 1, "Intrinsic Importance," the items from your basic list should now be transferred to this analysis sheet.

ACTIVITY ANALYSIS			
1. Intrinsic Importance			
VERY IMPORTANT Absolutely Must Be Done	IMPORTANT Should be done	NOT SO IMPORTANT May Not Be Necessary, But May Be Useful	UNIMPORTANT Can Be Eliminated Entirely

Figure 1

Here, the columns range from "Very Important" to "Unimportant," and the experience of putting one's activities on this analysis sheet can provide a certain perspective as to the relative importance of the items occupying one's time.

Step 2: Working again from the basic list of activities, now put these items onto Analysis Sheet No. 2, "Urgency."

ACTIVITY ANALYSIS			
2. Urgency			
VERY URGENT Must Be Done Now	URGENT Should Be Done Soon Short-term	NOT URGENT Long-range	TIME NOT A FACTOR

Figure 2

Here, the columns range from "Very Urgent" to "No Urgency"; once more, a certain perspective is gained by the very exercise of transferring the items from the basic list.

Step 3: Working still from the basic list of activities, the third analysis sheet "Delegation" is used. This step, of course, is pertinent only if one has subordinates to whom activities can and should be delegated. In my work with individual business executives, I have found this to be one of the most interesting, and yet most touchy, areas of personal analysis. To list the activity in the left-hand column,

ACTIVITY ANALYSIS					
3. Delegation					
WHY BE DONE BY ME I am The Only Person Who Can Do This	Can Be Delegated or Assigned to A	Can Be Delegated or Assigned to B	Can Be Delegated or Assigned to C	Can Be Delegated or Assigned to D	Can Be Delegated or Assigned to E

Figure 3

you must admit to yourself (and to me, if I am present) that you are the only person who can do the particular job. If anyone else can do it, his name is put in an appropriate column and the item is listed in that column (even though you still decide to keep the particular activity).

Once this three-step analysis is complete, it should then be possible to create a list of "ideal" activities, i.e., what should take up your time. Theoretically, this would be those items which occupy the left-hand columns on the three analysis sheets.

At this juncture, I usually recommend that the individual concerned have a heart-to-heart talk with his own organizational superior. It is of small moment for you to decide that certain of your present activities are unimportant if your boss thinks they are highly important; or for you to decide, blithely, that certain things you have been doing hurriedly are really not very urgent — if the boss thinks they must be done and *now!* This kind of a discussion proves quite useful, however, and may further help to simplify your entire outlook regarding your job responsibilities (of course, it could so clarify your job assignments that you would decide to obtain a simpler job in another organization).

II. CONTROL YOUR OWN TIME ENVIRONMENT

For many people, the major time problem is concerned with the frequent interruptions that occur throughout the day. The interruptions, for many of us, come from two main sources: from personal visitors and from the telephone.

In some offices, the problem of inside and outside visitation is serious. This problem is particularly endemic to the man in business and is not nearly so serious in many comparable professions. Thus, nobody expects the physician to be available to casual visitors during his working day (unless one expects to be billed for the visit), and likewise, no one expects to "just drop in" on an attorney friend. Yet, in almost every business organization, there are those who "make the rounds," visiting from office to office. Many offices are readily accessible to the casual, external visitor who may be "making a call" or merely maintaining a personal contact.

A parallel problem is posed by the telephone. Certainly, we could not conduct modern business operations without some means of direct communication. We rely on the telephone for this, and it is an indispensable facet of modern life. Here again, however, we can draw a parallel with other professions: no one expects a physician or surgeon to answer the telephone during an examination or an operation; no jurist is expected to answer the telephone while he is in court; no professor is expected to answer his telephone while he is practicing his profession of teaching. Why, then, should an important business executive expect to be always "on tap" and available to his telephone? Individuals who would not think of bursting into an office to interrupt a personal conversation can make their interruption just as effective by calling from across the hall or down the street. How many times have you been in an important conversation in an executive office only to have that conversation interrupted a number of times by telephone calls, which obviously had no bearing on your conversation and which, at least to you, seemed relatively less important. After every interruption you have to attempt to piece together your conversation or presentation and carry it to its conclusion.

After many discussions and investigations relative to interruptions, I have come to the conclusion that there should be established periods in the lives of each important person (if he has a time problem) during which he should not be subject to interruptions by telephones or by people. This is what I mean by controlling one's time environment. It has not proved unreasonable in many cases for an executive to get a general agreement among his colleagues, subordinates, and superiors that there will be certain hours, during the day or during the week, in which he will not be available either for personal discussion or for telephone conversation, except in dire emergencies! There are, in my opinion, certain additional specific occasions when one should not be available to any interruption. These would include: 1. When a person is doing work requiring creative thinking or serious concentration; 2. When a person is meeting with a subordinate or a group of subordinates; 3. When a person is in any kind of a serious discussion with another individual or with a group, if the interruption would not foster or help such discussion; 4. When the individual is involved in any aspect of his work wherein the interruption would decrease the effectiveness of his performance; 5. Whenever the interruption would be discourteous or rude to another person in his office.

III. RESERVE "BLOCKS OF TIME" FOR CONCENTRATED PERIODS

I have known many men who go through most of their occupational lives without ever having, in a working day, any sizable periods of time during which they can do creative thinking, long range planning, or just

plain contemplation. Many men arrive at the office an hour or two early in the morning, "before the telephones begin and people arrive," or stay an hour or two in the evening, "after the telephones and the people quiet down," in order to find just such periods of time. This is, of course, an unfortunate and unnecessary aspect of the executive life. It has become useful, therefore, to recommend to such people that they do a better job of time planning. Time planning begins with a consideration of the total month; perhaps, even the total year. For this I use a simple calendar sheet such as has become quite common today.

MONTHLY TIME PLANNER
Month of _____

MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY/SUNDAY

Figure 4

The Monthly Time Planner merely permits the person to record, ahead of time, those important reservations and incidents around which the rest of his activities should be planned. It is helpful, in this connection, if one's wife and one's secretary have similar calendars, and if these are periodically "synchronized."

A closer approach to the problem faced by many busy people is approached, however, when one comes to weekly time-planning. For this, the Weekly Time Planner has been developed.

WEEKLY TIME PLANNER

NO.	MON. _____	TUE. _____	WED. _____	THURS. _____	FRI. _____	SAT. _____
8						
9						
10						
11						
12						
1						
2						
3						
4						

* - Reserved Time; B - Available Time; D - Designated Time

Figure 5

This is merely a layout of the working hours during the week, with certain symbols used to indicate

various uses of the total available time. The first consideration is to determine what large "blocks of time" you will require during that particular week. Thus, in the example shown, the individual decided that from 12:00 until 3:00 p.m. on Wednesdays was a three-hour period which he needed for some particular, concentrated effort. A similar two-hour period was proposed for Friday, 2:00 to 4:00 p.m. You next consider what hours during the week you should be available to associates, subordinates, and others without appointment, almost on a "catch-as-catch-can" basis. In the example shown as Exhibit E, such "available" periods were determined to be the first two hours in the morning, Monday through Friday. The remaining hours are here-called "designated time" — the total time available, minus blocked time, minus available time equals designated time. This means that the hours are designated for particular purposes and are, therefore, available to others "by appointment only." Thus, of the total weekly time, those hours which are entirely open and those hours which are entirely closed are so indicated, with the remaining time being designated for specific purposes: staff meetings, committee meetings, meetings and appointments with subordinates, and so forth. This planning, of course, can be carried to any degree of refinement — some busy executives have literally designated every hour except those which are determined to be completely free or available or blocked out entirely.

IV. EXAMINE YOUR WORK METHODS PERIODICALLY

Most of us develop slip-shod work habits, and it takes a certain amount of personal discipline and periodic re-examination to keep our techniques efficient. The following suggestions have been found useful in this connection and are presented in this general way:

1. Try To Do But One Thing At A Time. A problem of most men as they go up the management ladder is that they become victims of diversification. All of us have had to learn to "keep several balls in the air" simultaneously, without dropping any of them, at least not too often. One way in which we can offset some of this diversification is to be sure that we concentrate on one job at a time and do not spend our working day doing a little bit of this, a little bit of that, and a little bit of something else. One way to offset this is to be sure we try to concentrate on but one act or problem at a time and try to carry it as near to completion as possible. A little practice in this kind of concentrated effort will pay big dividends in actual time utilization.

2. Complete Each Action. Bruce Barton has been quoted as saying that we all tend to become paper shufflers. He says "It is a temptation, as we grow older, to pick up a letter or memo, to lay it down,

to pick up another letter, etc." He continues, "I try to fight against this. When I pick up a paper from my desk, my intention is not to lay it down until I have dealt with it and got it off my desk for good." This is, indeed, a meaningful quotation, and I have personally seen it pay real time-dividends for many executives. Therefore, when going through a stack of mail or a pile of other papers, it is well to keep in mind that one should not lay a piece of paper down, however neatly one is able to make one's little piles of papers, until one has taken some action on the particular piece at hand. There are only a few things which one can do with a piece of paper once one has picked it up — my categorizations are as follows:

- a. You can read it (or scan it) and throw it in the wastebasket. This is obviously the action which should be taken regarding many pieces of paper which come to our desks.
- b. You can read the paper and mark it for filing — here it goes into an "out box" and is going on its way for possible future reference.
- c. You can assign it to someone else's attention, for him to review and discuss with you, to call you, etc. In this case, it goes also into your "out box" with the recipient's name or initials on it.
- d. You can turn immediately to a mechanical dictating device and answer the request or comment on it, either in final form or, for that matter, in preliminary draft. Even a tentative answer keeps the process moving and permits the piece of paper to go into the "dictation folder" and not be lying on the desk in an anxiety-producing pile.
- e. You can postpone or designate action at some future time. For this I use a "hold" or "tickler" file, which will permit you to plan the time when you want further to consider the request. Merely by putting a date in the upper corner and dropping it in your "out box," you can be sure that it will return to you from the "tickler file" on the date you have pre-planned. This means that you do not have to have a pile of forthcoming work on your desk, but that you have decided when you want to take the next step or action. This is the very antithesis of the old adage "Never put off till tomorrow . . ." You will find that such intentional postponement often precludes the need to take any action. In fact, one of the best bits of advice that can be given to a hurried and harried manager is often to teach him to "put off until tomorrow what he doesn't have to do today."

3. Your Office Layout Should Fit Your Needs. Be sure that your office is laid out to best serve your

particular needs. If your office is intended to be a museum or a showplace, it is all right so to arrange it. If your office is to serve the purposes of a throne room or a court room, then it should be laid out accordingly. If your office, however, is primarily a work room, or a meeting or conference room, then it should be arranged with these purposes in mind. In the latter case, your desk is primarily a work bench and, as in the case of most work benches, should be placed in a suitable corner where you can keep the material on which you are working at the moment on the desk, without the necessity of attempting to maintain a clean desk top, as though you were a presiding judge at a trial. Then, too, if you have a need for frequent conferences or meetings, it may be that you should have a table around which the conferees can gather. If you have a great many personal contacts and discussions, you may care to effect a "living-room atmosphere," in which you have casual chairs wherein you and your visitors can sit and discuss matters in a casual way. This informal, even "no-desk" approach, is catching on in many top-level offices.

4. Be Sure To Make Time With Your Secretary.

Many executives do not take the time to share their values and feelings with their secretaries. A secretary who knows what the boss deems to be *important* and *urgent* can do a great deal to sort his mail and other material so that he gets immediate contact with those things which are urgent and important. Likewise, an informed secretary can be an effective filter and aid regarding personal and telephone contacts. It is usually undesirable to have a secretary "filter" one's calls and visitors, but, certainly, the secretary can unobtrusively and un irritatingly find out who is calling or what the business is about and so prepare her superior for ensuing discussions and conversations. Most of the time, a secretary has not been sufficiently prepared to be a bona fide personal staff assistant to an executive.

5. Set Specific Times for Subordinate Contacts.

Each person should have a designated period during which he can expect to have an uninterrupted period with his organizational superordinate. The frequency of these contacts depends on the nature of the work and the spatial proximity of the individuals involved. It is safe to generalize, however, and to say that every individual should have some time with his immediate superior each week, if this is geographically feasible. If these are properly scheduled as uninterrupted periods for general discussions and reporting, they can be important time savers both for the subordinate and for the superordinate.

Likewise, each superior should have a regular group session with all of his immediate subordinates. Again, this should be a scheduled period which is on the appointment calendars of all concerned and should be an inviolable uninterrupted

period. This is the time when the real "team building" responsibilities of a boss can be fulfilled and wherein he can do a great deal of his educational and communications activity.

V. MAKE TIME FOR LIVING AND GROWING

One of the problems which every busy person faces is to have adequate time for personal relaxation and recreation. This does not mean only rest, but it means planned exercise and time for essential refurbishment and revitalization. One of the characteristics of men who fail is that they have often made their personal lives expendable to their job.

A study was made several years ago of successful and unsuccessful executives. The results indicated that another characteristic of failing executives was their readiness to sacrifice their family lives to their occupational lives. Here, again, is one of the areas in which marriage and family counsellors claim that modern living has exacted a serious toll: the inadequate amount of time which many people "on the way up" seem to allow for their family and personal lives.

Much could be said about the importance of keeping up with one's professional field and with life in general. One of the questions which we always ask executives coming into our management program is the extent and nature of their reading. It is probably no surprise to you that the average business executive is a poor reader and that he is usually inadequately read in anything except a very narrow field of specialization. We consider it one of our responsibilities to encourage him to broaden his reading horizons and, thereby, broaden his ability to be an effective leader in society. "Tell me what a man reads, and I will tell you what he thinks . . . tell me what he thinks, and I'll tell you what he is."

A great deal of philosophizing could be done concerning the influences of TV and other diversions upon one's time for personal growth and development. It goes, almost without saying, that every person expects to accomplish worthwhile things in his life needs time during which he can "get away from it all" and permit himself to become acquainted with his culture and with society in general.

An important part of this kind of broadening has to do with time for community and related professional activities. Theodore Roosevelt once said that every man owes a part of his time to the profession to which he belongs. Likewise, he owes some of his time to his community and to its betterment and growth. There are many transfer values which carry back into one's occupational growth and development from experience in community service. Obviously all of these things take time and, therefore, provision must be made in one's overall time planning and budgeting.

INFORMALS



A session in Dwinelle Hall

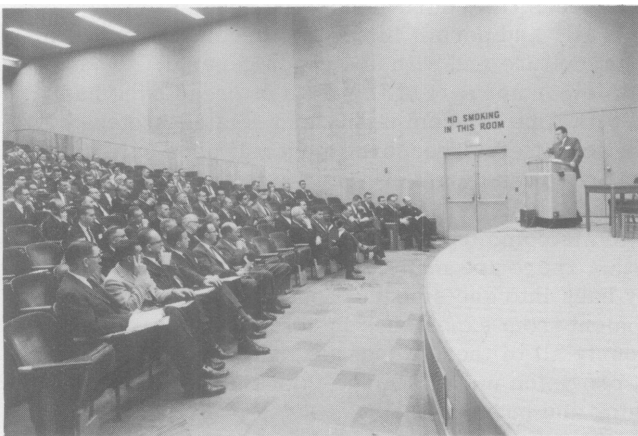


Thomas H. Hazlett, Chairman,
Berkeley Sessions

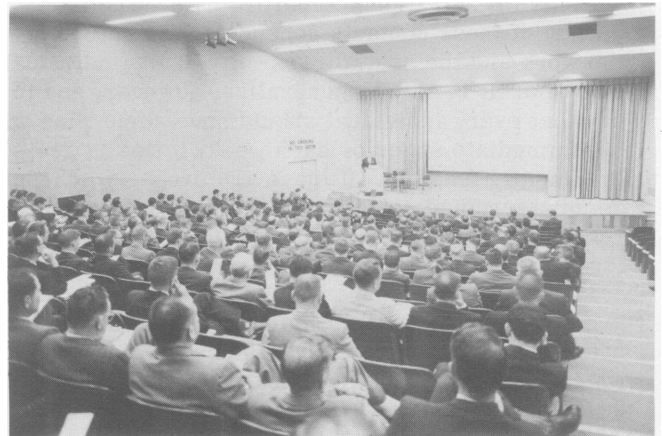
BERKELEY



John R. Whinnery,
Welcome Address



Audience at Welcome Address



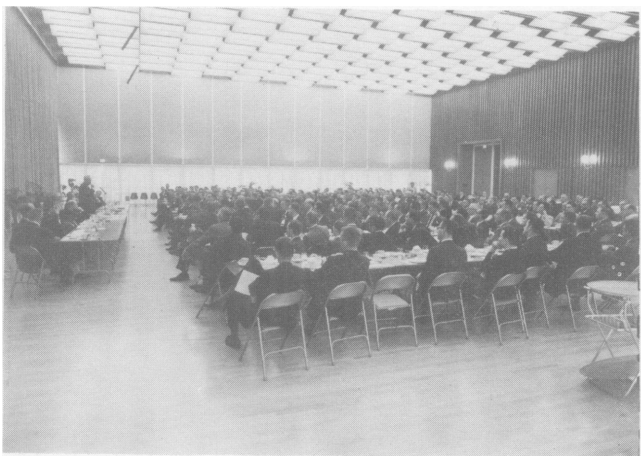
A session in Dwinelle Hall



**Gilbert Brighthouse
Luncheon Address**



**Luncheon, Session 1,
Student Union Building**



Luncheon, Student Union Building



**Luncheon, Session 1,
Student Union Building**



**John W. Cowee,
Luncheon Address**



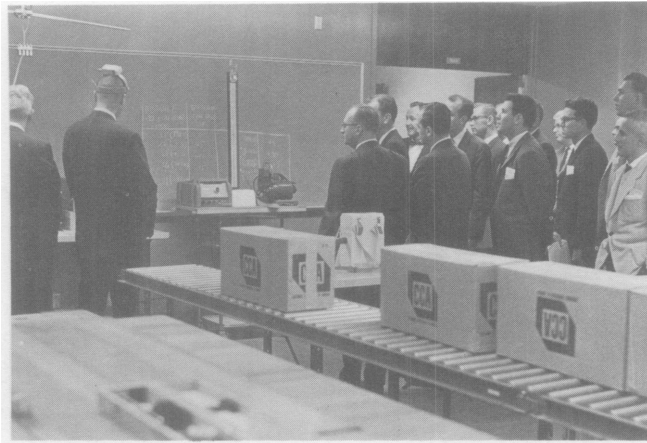
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Luncheon Address**



Representatives of co-sponsoring societies

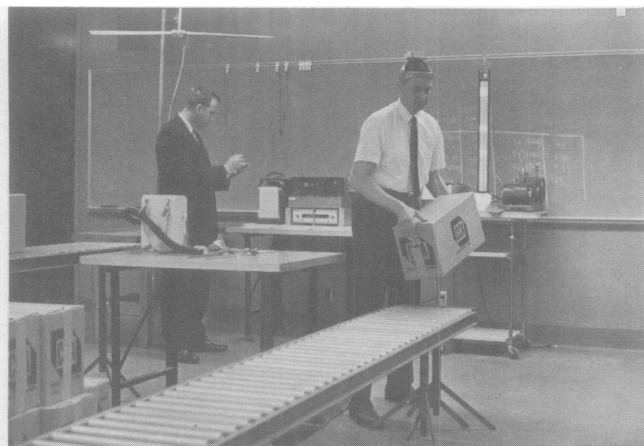


Tour Group, Production
Management Laboratories, UCLA

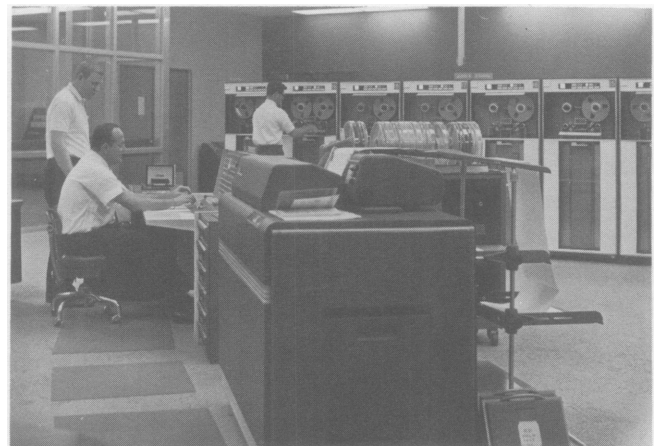


Tour Group, Production
Management Laboratories, UCLA

LOS ANGELES



Demonstration,
Production Management Laboratories



Demonstration, Western Data
Processing Center, UCLA



**Luncheon Session,
Grand Ballroom, Student Union Building**



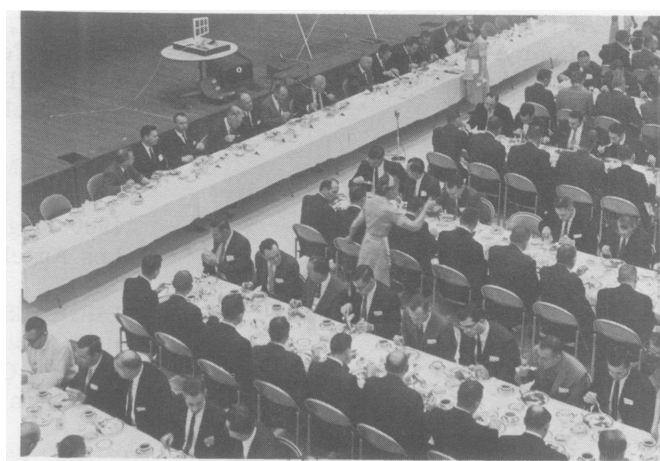
**(Left to right): L. M. K. Boelter, Paul D. O'Donnell,
Joseph D. Carrabino, Henry K. Schierhold**



**(Left to right): Robert Lockwood, Ralph M. Barnes,
Edward V. Sedgwick, Elwood S. Buffa, Gilbert Brighthouse**



**Luncheon,
Grand Ballroom, Student Union Building**



**Luncheon,
Grand Ballroom, Student Union Building**

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DE SANZE, Richard 2989 Serrano San Bernardino	ESTABROOK, Sheldon P. 11-C Camp Standard Oil Co. Taft	FORD, Carl 16010 Lahey Granada Hills
DI STEFANO, Mike Robertshaw Santa Ana Freeway at Euclid Anaheim	EVANS, John Packard Bell 1905 Armacost Los Angeles	FORE, Wallace E. North American Aviation International Airport Los Angeles 45
DE VISSER, Burton Lockheed-California Co. P.O. Box 551 Burbank	EVANS, R. Litton Systems 6700 Eton Ave. Canoga Park	FOTTER, Millard J. California State Polytechnic College, San Luis Obispo
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DRAKE, Edwin H. Mattel, Inc. 5150 Rosecrans Ave. Hawthorne	FASSUM, R. C. Hughes Aircraft El Segundo	FREEBURG, Dwain C. North American Aviation International Airport Los Angeles 45
		FRENCH, M. A. North American Aviation 12214 Lakewood Downey

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		HINKSON, Bruce 757 H St. San Bernardino

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2	1950 Jan. 27-28	D. G. Malcolm	M. P. O'Brien, Dean, College of Engineering, Berkeley
3	1951 Feb. 2-3	D. G. Malcolm	George A. Pettitt, Assistant to President, Berkeley
4	1952 Feb. 1-2 Feb. 4-5	D. G. Malcolm	H. A. Schade, Director, Institute of Engineering Research, Berkeley Wesley L. Orr, Assistant Dean, College of Engineering, Los Angeles
5	1953 Jan. 30-31 Feb. 2-3	D. G. Malcolm	E. Paul DeGarmo, Assistant Dean, College of Engineering, Berkeley L. M. K. Boelter, Dean, College of Engineering, Los Angeles
6	1954 Jan. 29-30 Feb. 1-2	Bruce G. McCauley	M. P. O'Brien, Dean, College of Engineering, Berkeley Raymond B. Allen, Chancellor, Los Angeles
7	1955 Jan. 28-29 Jan. 31, Feb. 1	Joseph D. Carrabino (Gen.Ch.) Bruce G. McCauley (Ed.)	Paul H. Sheats, Associate Director, University Extension, Los Angeles Arthur M. Ross, Director, Institute of Industrial Relations, Berkeley
8	1956 Feb. 3-4	John R. Huffman	M. P. O'Brien, Dean, College of Engineering, Berkeley David F. Jackey, Dean, College of Applied Arts, Los Angeles
9	1957 Feb. 1-2	Louis E. Davis	E. Paul DeGarmo, Chairman, Industrial Engineering, Berkeley L. M. K. Boelter, Dean, College of Engineering, Los Angeles
10	1958 Feb. 7-8	Robert B. Andrews	Robert Gordon Sproul, President, University of California, Berkeley William G. Young, Chancellor, Los Angeles
11	1959 Feb. 6-7	E. C. Keachie	Glenn T. Seaborg, Chancellor, Berkeley Vern O. Knudsen, Acting Chancellor, Los Angeles
12	1960 Feb. 5-6	John G. Carlson	L. M. K. Boelter, Dean, College of Engineering, Los Angeles John R. Whinnery, Dean, College of Engineering, Berkeley
13	1961 Feb. 3-4	George P. Redman	Franklin D. Murphy, Chancellor, University of California, Los Angeles Ronald W. Shephard, Chairman, Department of Industrial Engineering, Berkeley
14	1962 Feb. 2-3	Edward V. Sedgwick	Franklin D. Murphy, Chancellor, University of California, Los Angeles John R. Whinnery, Dean, College of Engineering, Berkeley

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