A STUDY OF NORAIR DIVISION'S PERFORMANCE AND COST EVALUATION PROGRAM TO DETERMINE ITS VALUE AS AN INDUSTRIAL MANAGEMENT TOOL FOR APPLICATION BY OTHER ORGANIZATIONS

A Thesis

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Master of Business Administration

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by

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PREFACE

This study was conducted at Norair, a Division of Northrop Corporation, during the months of March, April, May, and June of 1959. The plant is located at Hawthorne, California, and its primary products are manned aircraft and guided missiles. The PACE Program, the subject of this study, was developed and pioneered by the Manufacturing Methods Engineering Group of the Norair Division, under the direction of Mr. D. N. Petersen, Chief.

The study included indoctrination lectures and films presented by the PACE personnel; tours of the plant with the PACE observers; personal visits with company first line supervisors, superintendents, chiefs, assistant directors, and directors in their offices, and at two separate panel discussions; discussions with the PACE observers and their supervisors; and independent visits to the plant for investigation.

To obtain independent opinions of the program, some ex-PACE observers who are now working for other employers were contacted and interviewed for their impressions of the PACE Program. To protect their independence of expression, a promise was made to keep them anonymous, though the majority had nothing to say that would require

anonymity.

Large portions of the PACE description, formulas, and definitions contained in Chapter II, and all of the illustrations contained in this thesis were taken from the company's copyrighted PACE Manual with the expressed permission of the company officials. I am very grateful to Mr. R. R. Nolan, Vice-President and General Manager of the Norair Division for making this possible. I am particularly grateful to Mr. D. N. Petersen, Chief of the Manufacturing Methods Engineering Group, the group which contains the personnel of the PACE Program, for his gracious consent in allowing me to write this thesis and for the hospitality and personal help he has given me. Mr. R. M. Wrestler, the PACE Supervisor, was also very patient and helpful as was Mr. L. J. Rajczi, his assistant. Mr. E. W. Peterson, staff assistant to Mr. D. N. Petersen, was of great assistance. Mr. J. A. Parks, B. G. Thomas, J. C. Socci, G. G. Ivanoff, T. M. Frederick, W. L. Bradford, and the other PACE observers were very patient with my impositions upon them. They were always willing to answer my questions and they were of great assistance with their explanations. The entire PACE staff is made up of professionally minded, highly qualified, competent, and motivated personnel.

I would also like to take this opportunity to thank

the many directors, assistant directors, chiefs, and supervisors who allowed me to interview them during my tours with the PACE Observers and during the PACE Indoctrination Lectures.

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CHAPTER I

INTRODUCTION

A Brief Synopsis of the PACE Program

The Manufacturing Methods Engineering Department of Norair, a division of Northrop Corporation, has developed a new and unique approach to the management problem of controlling the effort employees expend upon their assigned tasks. The company has named its program PACE-- an acronym for Performance and Cost Evaluation. The company states[1] that it is a thoroughly proven, inexpensive, analytical, statistical system for measuring group effectiveness in performing an assigned task. The program has been developed primarily to determine when, where, and to what degree employee work effort fluctuates in various departments of the company so that lost effort will be readily pointed up. Once these problem areas are known, prompt remedial action can be taken by management to correct the situation. PACE is applied to such diverse departments as manufacturing, tool design and fabrication, manufacturing control, purchasing, warehousing, facilities engineering, planning and scheduling, finance, engineering, contracts and servicing.

[1]This statement was quoted from the company's PACE manual, p. 1-1.

At the time of this writing the PACE program has been in use at Norair Division for approximately seventeen months. Its unique nature, the professed results, and the fact that it offers an economical solution to a chronic problem currently facing many industries have stimulated an astounding amount of interest in the program. At this date, over 823 companies and 30 government agencies have shown interest in the PACE program and they have received personal briefings by Norair personnel. The company stated in the Northrop Aircraft Corporation's Annual Report for the fiscal year ended July 31, 1958, "Compared with presently established standards in the Manufacturing organization, the PACE Program contributed a 21 percent improvement in group effectiveness during the first six months of its application."

PACE is an attempt by Norair management to establish a more objective basis for judging the effectiveness with which Norair's supervisors are able to keep their assigned employees busy and it measures the effectiveness with which the workers are motivated into expending effort upon their assigned tasks. In essence it is an independent auditing system for objectively determining the effort employees of various departments are expending upon their assigned tasks, the incidence of idleness, and the amount of unauthorized absence from their assigned work stations. Two well estab-

lished industrial engineering tools, work sampling and effort rating, are applied in a new and unique manner to gather the pertinent data. The heart of the PACE Program is the utilization of trained observers who tour various departments of the Norair division on random schedules and random routes. Each observer notes the number of persons working, the number idle, the number out of the assigned work area, and he evaluates the group effort. To evaluate the group effort, each observer carefully notes the effort of each worker in the group, he obtains an average effort for the group and then he assigns the group a percentage effort rating based upon an established standard work pace. The observer's findings are then converted to a basic PACE index by applying a special formula. This PACE index is compared with other selected control indices concerning personnel requirements, budget realization, scheduling, quality control, and parts shortages by superimposing them on a single graphic frame of reference. Management or supervision at any scalar level of the organization is then able to analyze the results of these numerous, complex, and interrelated management factors on an easily read graph or chart.

The PACE Program is a new application of two widely used industrial engineering concepts, effort rating and work sampling. It was put into use for the first time at

the Norair Division of Northrop Corporation in March of 1958.

A Statement of the Problem

It is the purpose of this thesis to objectively study and analyze the PACE program in order to determine its potential for useful application as a management tool by other industrial organizations, including various branches of the federal government, and to independently determine its values, uses, and weaknesses.

The Need for a PACE Program

In former years, most experienced manufacturing and production executives believed they could determine the pace or tempo of factory operations with a fair degree of accuracy merely by listening to the hum of activity in their particular shop or factory, and by counting the daily number of units being produced. Today numerous manufacturing organizations have grown to a gigantic size. Many scalar levels of organization separate the worker from top management. The manufacturing processes are complex and interrelated. Management can no longer rely on such crude rules of thumb to maintain adequate control over the organization's human resources. The complexity of the situation makes it difficult for management to determine whether or

not it is getting a fair day's work for a fair day's pay, except in isolated instances.

Any control system for controlling labor costs involves three fundamental steps: (1) the establishment of a standard; (2) the comparison of actual achievements with the standard; and (3) an action based upon the comparison. Certain types of human endeavor are more difficult and costly to control than others. Since the turn of the century, considerable progress was made towards solving this problem in factories where the volume of unit production is high and where the tasks are highly specialized and repetitive. In such areas of our industry, wages may be geared to vary directly with the worker's output, in the form of piece-rate pay or pay scales which are based upon a standard of performance established by recognized time and motion study techniques. Here, an effective control system can be economically instituted. Standards can be effectively established; actual achievements can be compared with standard; and labor costs can be based upon the standard output rate.

Work effort and work tempo can be controlled to a degree in some factories by manipulating the speed of movement of an assembly line belt. But in many other areas of industry the unit production volume is low, production is accomplished in irregular job lots, tasks are not so spe-

cialized, the operations involved are lengthy and varied, and the work is not repetitive. In these areas of industry, conventional motion and time study techniques are uneconomical because the time required for time studies would be excessive. In these areas of industry the worker's output cannot be objectively and fairly judged in terms of time spent on the job. Management has no objective means for determining whether or not it is getting a fair day's work for a fair day's pay. It is in such areas as these that more sensitive management control is needed. Limited progress has been made toward controlling human endeavor in these areas with the development of ratio delay studies and work sampling (which will be further discussed in paragraphs below). But such techniques have only scratched the surface in meeting the needs of industry at large. The PACE Program is a new and unique approach to the solution of this problem. It is an attempt to control a vast segment of industry that was subject to very little management control up to this time. It establishes standards; then it compares actual achievements with the standard; and this allows management to take appropriate corrective action where needed.

The PACE Program was originally designed by the Norair Division to meet some needs which are currently peculiar to the aircraft industry. But experiments and

development at the Norair Division indicate that the PACE Program is suitable for application in most other businesses and industries, including most branches of the government. The program has been extended to encompass office workers, direct and indirect factory labor, technicians, engineers, draftsmen, etc.

Definitions of Terms and Concepts Used

Effort Rating.--This is the widely used industrial engineering time study practice for which there exist a number of accepted techniques. Other names commonly used for this practice are "pacing", "rating", "speed rating", "performance rating", "levelling", or "coding". By far the most popular rating procedure, according to Abruzzi[2], is Presgrave's "effort rating" procedure. A worker's "effort" is usually defined as his "will to work" as it is overtly expressed by his speed of movement in relation to the work task he is performing. Effort rating is the process whereby an independent observer evaluates the effort of a worker in terms of a predetermined effort standard. The technique adopted by the Norair Division for its PACE Measurement involves the training of observers for the effort rating task by having them view films of the standard expectancy speed of worker-movement until the observers have firmly grasped the desired mental image of this standard speed.

[2]Adam Abruzzi, Work, Workers, and Work Measurement (New York: Columbia University Press, 1956), p. 32.

The observers then proceed to the work area and they compare this preconceived mental image of the standard expectancy speed of movement with the speed at which the worker is actually performing his work. The standard expectancy speed is given a value of 100% and it is based upon the widely used industrial engineering standard speed defined as that speed of movement of a man walking at the rate of 3 miles per hour on level ground. The effort rating which the observer assigns to the worker under observation is valued at some percentage value of the standard expectancy speed.

Work Sampling.--This is an application of statistical sampling techniques to the analysis of work. It was first used by the eminent British statistician, L.H.C. Tippett, in 1935. It was introduced into this country about 1940 by R.L. Morrow who described it by the term "ratio delay study". R. M. Barnes[3] recently extended the use of work sampling to include the analysis of the distribution of rating or levelling factors that concern operator performance. A discussion of applications of work sampling can

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[3]Ralph M. Barnes, et al., "A Statistical Study of Performance Sampling in Work Measurement," Bulletin No. 510, University of California at Los Angeles, June, 1953., pp. i-ii; and Ralph M. Barnes and Robert B. Andrews, "Performance Sampling in Work Measurement," The Journal of Industrial Engineering, vol. VI, no. 6, November-December, 1955.

be found in his recent book[4], "Work Sampling", and it further discusses performance sampling and the testing of performance ratings (effort ratings) through the use of work sampling.

The basic and widely used formula for determining the random sample size (number of observations) for a confidence level 95.45% (two standard deviations) is shown below. This means that approximately 95% of the time the random observations will represent the facts, and that 5% of the time they will not.

$$N = \frac{4\ (1-p)}{S^2 p}$$

Where: S = desired relative accuracy

p = percentage occurrence of an activity or delay being measured--expressed as a decimal (i.e., 15% = .15)

N = the number of random observations

It can be seen that the desired relative accuracy, S, varies with two factors: the random sample size, N; and the percentage occurrence of the activity being measures, p. The percentage occurrence of the activity being measured is usually estimated by a trial study for the first few observations. It becomes more accurate as the number of observations increases. The random sample size, N, will vary with the economic feasibility of taking a large number of

[4]Ralph M. Barnes, Work Sampling (New York: John Wiley and Sons, Inc., 1957).

samples in relation to the desired relative accuracy: a compromise is usually made between the cost of taking samples on the one hand, and the value of increased accuracy on the other. Random number tables are available for use in making the work sampling study time schedule so that the observations will remain random, unbiased and independent. Tables are also available which reduce various possible values of the formula to numerical values for ready reference[5].

PACE Program.--This is the name applied to the entire program which is broken down into two separate sections: one section is devoted to the PACE Measurement of group effort; and the other section concerns the correlation of the PACE Measurement with selected comparative Performance Indices.

PACE Measurement.--This term is applied to the study of group effort and the derivation of an index known as the PACE Index so that it may be directly compared with the other comparative indices used in the PACE Program.

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[5]Ibid., Chaps. 5, 6, 7.

CHAPTER II

A DESCRIPTION OF THE PACE PROGRAM

The Theory of the PACE Program

The PACE Program is designed as a management control over the utilization of manpower.--It is not meant to replace the other established management controls and tools such as methods study, time study, predetermined times, budgeting, cost control, good supervision, work sampling, etc. It is a control superimposed over these other established management controls, and as far as these controls affect the utilization of manpower it is a check against their validity. For instance, if the time standards of a department are too loose and the workers are able to produce at a standard rate without much effort, PACE is designed to point this up. If the manpower budgeted for a given project is excessive and the supervisor is slow to reduce his manpower requirements, the PACE program is designed to point this up. If the supervisor of a given section is weak and he is not adequately motivating his workers into exerting the desired amount of effort, many of the workers are idle or away from their assigned work stations, PACE is designed to point this up. In short, PACE is designed to gather

facts and report on a weekly basis the relative effort being exerted by the employees of specific work groups. It makes no attempt to point up the lagging effort of the individual, but each individual's effort goes to make up the average or composite effort of the group to which he belongs. It does not include supervisory people in the measurement. By rating the group, PACE in effect exerts pressure upon the supervisor responsible for the group to encourage his workers into (1) greater effort, (2) the elimination of idleness, and (3) controlling the absence from assigned work stations. PACE measures the worker's input or effort as it is applied against the assigned task. The output of the group in terms of quantity, quality or productivity is not the subject of PACE measurement. The PACE measurement is correlated with such other controls as personnel requirements, budget realization, scheduling, quality control, and parts shortages by charting them on a single plane of reference, a graph, for direct comparison and analysis.

In order to accomplish this, the Manufacturing Methods Engineering section of Norair Division has carefully selected and trained highly qualified observers. These observers tour specifically assigned and defined work areas on a random basis, taking random samples of three principle factors: (1) Group Effort--the arithmetic mean of the

individual effort ratings of the group, (2) Idle Time, and (3) Out of Area--the unauthorized absence from the work station. These factors are then used in a specially developed PACE formula to derive a PACE index which reflects the percentage of the paid man-hours of that group that were actually utilized by the company, in terms of the standard expectancy work effort.

The PACE Observations and How They Are Taken.--The PACE observers are trained and tested before they are qualified to make PACE Observations in a given work area. The work areas are clearly defined and the supervisor responsible for each area is required to keep the number of employees working in a given area posted in a prominent location so that the total number is readily available to the PACE observer. The PACE observer then proceeds to tour the work area at random times of the day on random routes, making his observations. During the initial study period of a given work group he makes 15 tours through the group per day and later this is reduced to 10 tours per day per group. The observer carries two counters, one in each hand: one is used to count the idle workers; the other counter is used to count those working. The total of the two counters is the number of workers in the work area. The difference between this total and the number of workers officially assigned to the area (and available that day for work) is

the number of workers out of the work area. The observer effort rates each worker, then he computes the arithmetic mean of the individual effort ratings which becomes the group effort rating. He makes appropriate entries on specially designed data sheets (see Appendix A, B, C, and D) as a record of his observations. The workers of each organization are required to wear distinctive identification badges that are color coded for ready identification by the PACE observer, so that he can identify workers foreign to a given department. Thus the observer obtains the three basic factors essential to the PACE Measurement: (1) Group Effort; (2) Idle Time; and (3) Out of Area. These three factors must be discussed in greater length.

Group Effort.--The effort rating of individuals is an old and widely used practice in industry, as mentioned in Chapter I. The group effort rating is the average (arithmetic mean) of the individual effort ratings for all individuals of the particular group that the observer has been assigned to rate. The observer views motion picture films of workers performing at the standard rate of expectancy until he has firmly grasped the mental image of the standard work effort. After he has been sufficiently trained and tested, the observer proceeds to the work area and compares each worker's effort with this mental image of the standard expectancy rate, assigning each worker a percentage

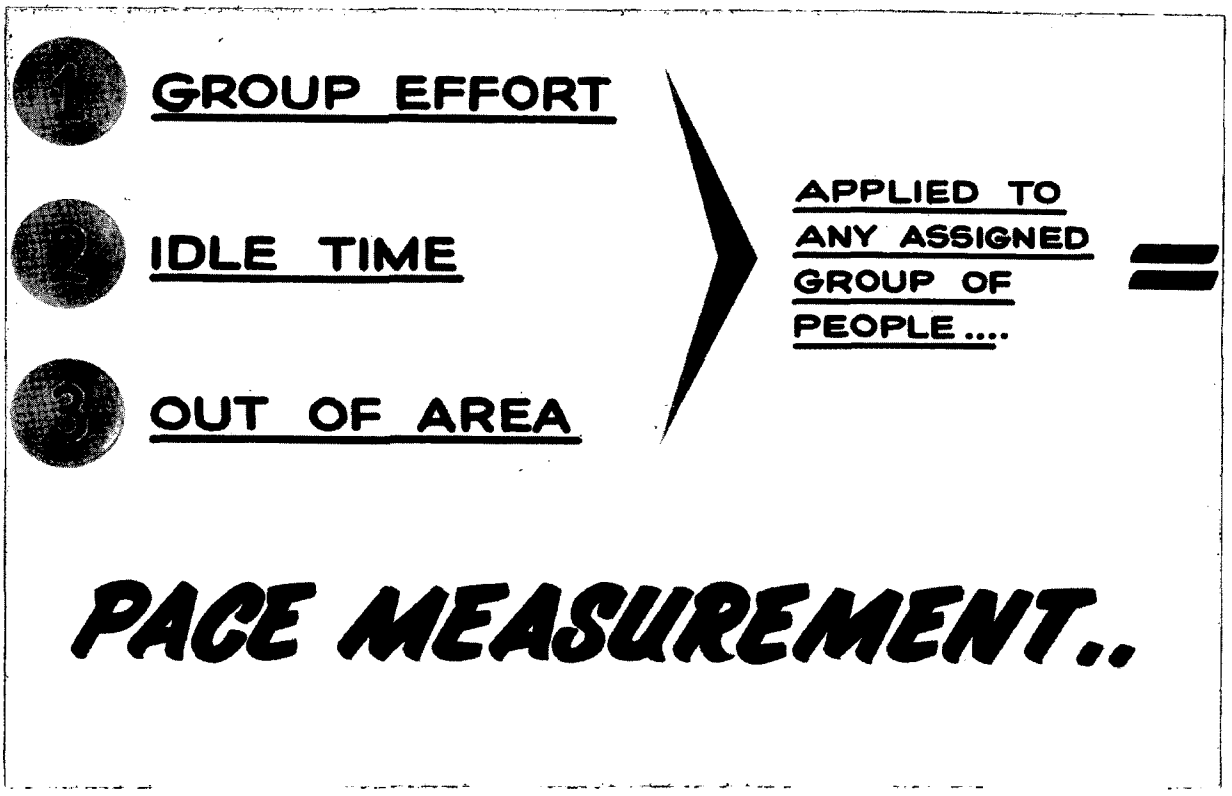

Fig. 1.--The three PACE Measurement Factors

rating. If there were five workers in the group and the individual ratings the observer assigned were 100%, 50%, 105%, 60%, and 75%, the group effort rating would thus be 78% (the arithmetic mean) of the expectancy standard. This standard expectancy is based upon the speed of movement of a man walking at the rate of 3 miles per hour on level ground.

Normally, in effort rating, the observer compares the speed of movement of the worker's body members with his mental image of the standard expectancy speed of movement of the body members of a man walking at the rate of 3 miles per hour. Films of standard speeds can be developed from this rhythm for such operations as typing, operating a lathe, operating a rivet gun, assembling movements, etc. But the judgement of the observer must be used to apply these standards to the task being performed. If a man's task is to operate a machine and he is monitoring its operation while it is running at the proper speed and feed, the operator is deemed to be effectively applying effort to the accomplishment of the assigned task--therefore his effort rating would be 100%, even though he may not be moving. If the machine is idle, the effort rating is based upon the degree of physical activity of the operator if it is determined that he is accomplishing his assigned task.

In the office as well as some supporting functions,

the procedure for assessing group effort is similar to that established for Manufacturing functions. Much of the work is of a manual nature such as writing, typing, filing, invoicing, record keeping, etc. But in addition to the manual type of work two other categories are also observed and evaluated by the PACE observer. These are visual and oral types of work. The visual category encompasses the reading of mail, manuals, blueprints, and other official documents in conjunction with the accomplishment of the assigned task. The oral category includes such activities as discussions between supervision, group leader, and working individuals in establishing procedures for accomplishing the assigned task. These activities are rated by evaluating the diligence with which people apply themselves to the task at hand.

The technical and engineering group functions have, in addition to the other three types of work (manual, visual and oral), still another type of work which the PACE people have termed COED--an acronym for Concentration on Engineering Design. It is impossible for anyone to determine if an engineer is concentrating on his work or daydreaming. In the technical/engineering activities the benefit of the doubt is always given in favor of COED. Individuals in the COED classification are given the same effort rating as that assigned to the rest of the working group.

Idle Time.--There are two types of idle time. One type is the obvious idle time in which working individuals obviously are not effectively expending effort in the accomplishment of the assigned task. The other type is the obscure idle time in which individuals appear to be actively engaged but it is not obvious to the observer that he is working on the assigned task--the worker may be just killing time or he may be working on some personal project. The worker is given the benefit of the doubt for obscure idle time. It is to be noted that specific individuals are not singled out in the reporting of idle time: the idle individual merely becomes a statistic in the computation of group effort. The PACE observers make no comments to individuals, they merely independently record what they see.

The Manufacturing, Supporting, and Administrative Functions at the Norair division have distinct company authorized break periods. The PACE observations and evaluations are not taken during break periods. The Technical/Engineering Organizations have no set break periods, so a flat 4% is deducted from the observed idle time in order to make allowance for this, and the pertinent groups' PACE index is affected only by the idleness in excess of this 4% amount.

Out of Area.--Normally, when a PACE observer is making his observations and a worker is out of his assigned area, the observer doesn't particularly care where the

worker went. He merely tells the supervisor how many men he can't account for, giving him a chance to explain. When an individual leaves his work area for purposes that do not pertain directly to his assigned task, the PACE measurement of his group is adversely affected. If a worker leaves his work area, for example to get parts, his group may be penalized because Norair has a service function charged with the responsibility for moving parts. It is the supervisor's responsibility in this case to exert lateral pressure upon the service function responsible for parts supply. He must avoid using his men for such functions. Engineers in many instances must leave their work stations to go to the laboratory or wind tunnel. The PACE people allow 10% of the time for this normal out of area factor, and penalize them for all in excess of this amount. This 10% figure was arrived at through ratio delay studies.

The PACE Formulae

The fundamental PACE formula.--The fundamental formula used in the PACE Measurement to compute the PACE Index is as follows:

$$\frac{\text{Actual Working Force}}{\text{Assigned Working Force}} \times \text{Effort Factor} \times 100 = \text{PACE \%}$$

This formula in effect shows that fraction of the work force actually working, multiplied by the effort being

exerted by those actually working. When multiplied by 100 this gives the equivalent percentage of individuals required to effectively accomplish the task of the Assigned Working Force, working at 100% of expected effort. This equation equals the PACE index--the Group Effectiveness. For example, if the assigned work force were 100 men, and only 90 were actually working at 90% of the standard PACE, the PACE index would be:

$$\frac{90}{100} \times .90 \times 100 = 81\%$$

In this case only 81 workers, if they worked at 100% of the standard expectancy could theoretically do the same work that the 100 workers are now accomplishing (assuming the workers were completely interchangeable, the work assignments were homogeneous, and their efforts are effective). The company PACE manual further defines the terms used in the fundamental PACE formula:

Actual Working Force.--This is determined on a daily basis by the number of workers assigned plus or minus the number of workers loaned out or acquired, minus the number of workers who are observed idle plus the number of workers who are not in their assigned work station (out of area). This definition is mathematically expressed as:

Number Assigned $\pm$ Loans $-$ (Idle $+$ Out of Area)

Assigned Working Force.--This is determined on a daily basis by the number of workers assigned plus or minus

the number of workers loaned out or acquired. This definition can be mathematically expressed as:

$$\text{Number Assigned} \pm \text{Loans}$$

Effort Factor.--This is the composite Group Effort rating (the arithmetic mean of the individual effort ratings) of the actual working force in accomplishing an assigned task, as described in more detail above.

Development of the Manufacturing Functions' Formula.--Substituting these mathematical values into the fundamental PACE formula, the basic PACE formula for calculating the percentage index of PACE (or Group Effectiveness) can be expressed mathematically as follows:

$$\frac{\left[\text{Number Assigned} \pm \text{Loans} - (\text{Idle} + \text{Out of Area})\right] (\text{Effort Factor})}{\text{Number Assigned} \pm \text{Loans}} \times (100) = \text{PACE\%}$$

It can be seen that this formula penalizes those things that management is constantly striving to eliminate. These include: (a) Idle employees; (b) Employees out of their assigned work area; and (c) Employees who constantly exhibit a low rate of productivity. It encourages the elimination of idleness, keeping workers on their jobs and the exhibition of the desired amount of effort.

Development of the Administrative Functions' Formula.--While the Manufacturing Function formula penalizes those employees who are not at their assigned work stations, there are certain functions in which working individuals

must be, by the very nature of their activities, away from their assigned work stations or out of the confines of their departmental perimeters. These conditions are quite prevalent in the Administrative (or Office) and the Technical/Engineering functions. An adjustment to the basic formula is therefore made by subtracting the number out of area from the denominator of the formula for Administrative Functions, and the formula becomes:

$$\frac{\left[\text{Number Assigned} \pm \text{Loans} - (\text{Idle} + \text{Out of Area})\right] (\text{Effort}) (\text{Factor})}{\text{Number Assigned} \pm \text{Loans} - \text{Out of Area}} \times (100) = \text{PACE\%}$$

Development of the Technical/Engineering Functions' Formula.--In Technical/Engineering functions a portion of the employees are also required to be away from their assigned work stations a part of the time. A constant value for Out of Area has been established as permissible out of area (usually in terms of percentages) by the use of ratio delay studies. These functions are penalized only for that share of the Out of Area that exceeds this allowance. Thus, to the formula calculated for administrations functions (above) the difference between this percentage of Out of Area allowance (called A'), and the actual percentage of out of area observed by the observer (called A) is added to the denominator. Thus the function's index is duly penalized for this excess amount of Out of Area. To be

used in this equation, (A-A') must always be a positive value. The resulting formula is shown below:

$$\text{PACE\%} = \frac{[\#\ \text{Assigned}\pm\text{Loans}-(\text{Idle}+\text{Out of Area})]\,(\text{Effort Factor})}{\#\ \text{Assigned}\pm\text{Loans}-\text{Out of Area}+(A-A')(\#\text{Assigned}\pm\text{Loans})} \times (100)$$

Development of the Formulas for the Percentage Out of Area and the Percentage Idle.--Thus far, only the method for acquiring the PACE Index from the PACE Formulas has been discussed. There are two additional indices which are available from the original data and which are used in subsequent analysis. These are: (a) Percentage of employees observed idle; and (b) Percentage of employees out of area. Their formulas are shown below:

$$\frac{\#\ \text{Idle}}{\#\ \text{Assigned}\pm\text{Loans}-\#\ \text{Out of Area}} \times 100 = \%\text{Idle}$$

$$\frac{\#\ \text{Out of Area}}{\#\ \text{Assigned}\pm\text{Loans}} \times 100 = \%\text{Out of Area}$$

PACE Formula for Simplifying the Comptometer Calculations.--Normally to reduce the mass of raw data down to usable indices, an extremely high labor input would be required. However, in the calculation process by which this data is reduced, a simplified method for quickly computing calculations has been evolved. By analyzing the basic PACE

formula equations it becomes obvious that factors in the numerator and denominator are common and, therefore, cancel themselves out. Through the technique of factoring, the equation becomes as shown below:

$$[100\%-(\text{Percentage of Penalties})](\text{Effort Factor}) = \text{PACE}\%$$

Application of the PACE Program

The application of the PACE Program to a department, group of departments, or an entire organization, is accomplished in three phases: (1) Indoctrination Phase; (2) Basic Study Phase; and (3) Daily Observation Phase.

Indoctrination Phase.--The management and first line supervision of the functions involved are given an indoctrination lecture dealing with the concepts and details of the PACE Program. At this indoctrination lecture, the complete details of the PACE Program are explained via the medium of PACE charts, illustrations, and films. The indoctrination lecture takes approximately one and a half hours to present, plus an additional hour for a question and answer period. The lecture is generally limited to an audience of 35 persons in order to maintain personal contact with the audience. In addition, Engineering Division employees are also given a half hour dissertation on the PACE Program, which is augmented from time to time through the employee-supervision relationship. Other

employees receive their indoctrination from their supervisor. It is to be emphasized that PACE is only interested in the quantitative number of workers in an assigned area and does not single out or pinpoint specific individuals. PACE is a group observation and evaluation procedure, and this is an important selling point from the employees point of view.

Basic Study Phase.--Following the indoctrination lectures, the mechanics for setting up a basic study are initiated in the department (or group of departments) in which the PACE observations and evaluations are to be undertaken. During the basic development week, a PACE technician (a more experienced PACE observer) and a permanent PACE observer are assigned to the area and they become thoroughly acquainted with all levels of supervision. They also become thoroughly acquainted with the type of operations being performed in the department and the company assigned work tasks. During this period the PACE technician and PACE observer meet with supervision and they demonstrate how PACE is an additional tool for assisting supervision in the execution of their activities. Detailed arrangements are made for taking PACE observations.

Determination of Areas.--The department is subdivided into areas conveniently sized for observation purposes. They are determined by: (1) Geographic location;

(2) Type of function; (3) Cost Centers; (4) Isolation of the particular problem area, etc. A preliminary layout or map is made showing the various entrances, exits, aisles, stairways, offices, rest rooms, control centers, or any other specific landmark which would prove to be suitable for easily identifying and describing a particular area.

Observations.--During the basic study period, observations are taken 15 times a day at random periods over random routes. The PACE observer (assisted by the PACE technician) enters the area under study, and utilizing two hand held counting devices he counts the number working and the number idle. The total of these two counts, when subtracted from the total assigned population, gives the number of individuals out of the area. Individuals working are effort rated. In Manufacturing functions, the preponderance of activity is manual. Therefore the manual activity is the only activity factor classified in these areas. In Administrative Functions, the observer also classifies visual and oral activities in addition to the manual activity. For Technical/Engineering functions, manual, visual, oral and COED activities are evaluated. Figure 2 shows a sample Basic Study Observation Sheet. One of the unique features of this PACE Data Sheet is that any of these factors (number working, percentage of effort,

BASIC PACE STUDY

M T (W) T F W/E 9-13

LOCATION OF STUDY PLANT 3 DEPARTMENT 21000 SHEET 1 OF 1

SUPVR M.D. McNUTT OBSERVER SAM SPUT

		OBSERVATION NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	TOTAL	% OF WKG. GP.
		ROUTE Enter-Exit	A-C	B-C	C-A	A-B	C-D	D-A	C-A	D-C	A-C	B-A	B-D	D-A	C-B	A-D	C-A		
		TIME IN & PER TRIP	8/00	9/15	9/55	10/13	10/45	11/15	11/40	1/10	1/25	1/55	2/35	2/55	3/30	3/43	4/25		
EFFORT ANALYSIS		'COED'																	
		MANUAL																	
		VISUAL																	
		ORAL																	
																		TOTAL	
SUPV.	AREA 1	No. WK/% EFT.	7/15	6/80	5/80	6/80	9/80	9/85	8/85	8/85	7/80	10/85	10/85	8/80	5/85	7/80	4/85	109	
		EQUIV. WKRS.	5.3	4.8	4.0	4.8	7.2	7.7	6.8	6.8	5.6	8.5	8.5	6.4	4.3	5.6	3.4	89.7	
		NO IDLE	3	1	-	-	-	-	2	1	1	0	2	1	2	3	3	19	
	NO. EMP 11	TOT NO. OBSERVED	10	7	5	6	9	9	10	9	8	10	12	9	7	10	7	128	
		OUT OF AREA	1	4	6	5	2	2	1	2	3	1	+1	2	4	1	4	37	
		FOREIGNERS	-	-	-	-	1	-	-	-	3	-	-	2	-	-	-	6	
SUPV.	AREA 2	No. WK/% EFT.	8/85	9/80	7/80	10/85	10/85	10/95	11/80	12/95	17/85	9/85	8/90	9/85	9/90	6/85	6/85	139	
		EQUIV. WKRS.	6.0	7.2	9.8	8.5	9.5	9.5	9.9	11.4	10.2	7.7	7.2	6.8	8.1	5.1	5.1	120.0	
		NO. IDLE	3	1	-	-	-	-	1	-	-	3	0	1	1	3	2	15	
	NO. EMP 14	TOT NO. OBSERVED	11	10	11	10	10	10	12	12	12	12	8	9	10	9	8	154	
		OUT OF AREA	3	4	3	4	4	4	2	2	2	2	6	5	4	5	6	56	
		FOREIGNERS	-	-	-	-	-	-	2	-	1	-	-	-	-	1	-	4	
TOTALS		TOTAL NO. WKG.	15	15	16	16	19	19	19	20	19	19	18	16	14	13	10	248	
		EQUIV. WKRS.	11.3	12.0	12.8	13.3	15.7	17.2	16.7	18.2	15.8	16.2	15.7	13.2	12.4	10.7	8.5	209.7	
		IDLE NO.	6	2	-	-	-	-	3	1	1	3	2	2	3	6	5	34	
		IDLE PERCENT	29	12	0	0	0	0	14	5	5	14	10	11	18	32	33	12	
		TOTAL NO. OBSD	21	17	16	16	16	19	22	21	20	22	20	18	17	19	15	282	
		OUT OF AREA NO.	4	8	9	9	9	6	3	4	5	3	5	7	8	6	10	93	
		OUT OF AREA %	16	32	36	36	36	24	12	16	20	12	20	28	32	24	40	25	
T. NO. EMP. 25		FOREIGNERS	-	-	-	-	1	-	2	-	4	-	-	2	-	1	-	10	
		PACE	54	71	80	93	83	91	76	87	79	74	79	73	73	56	57	74	

NOTES

Obs. 1-4 - Several persons arriving late

Obs. 7 - Two people in area #1 leaving for lunch early.

Obs. 10 & 11 - Two people discussing basketball game

General low effort due to lack of work load.

FORM: 5110-1

MFG. METHODS ENGINEERING-ORG. 5110

Fig. 2.--Basic Study Observation Sheet

number of equivalent workers, number idle, total number observed, the number out of area, and the PACE index) can be determined from a single observation period. Further, these factors can be determined at a glance for any single period of a day, for an entire day, or for the entire week. This basic study also serves as a basis, or yardstick, for comparing and evaluating the daily PACE observations which are started immediately after the basic study is completed.

Daily Observation Phase.--When the basic study has been completed, the daily PACE observation and evaluation phase is instituted. An average of 10 observations a day are taken at random times over random routes. The PACE observer then records these daily PACE observations on specially prepared data sheets. The observer's data handbook contains observation data sheets, a map of the department under observation, an organizational chart for the department, the types of activities performed in each area, the starting and quitting times, lunch periods and rest periods, names, telephone numbers, etc. The observation data sheets have provisions for accomodating the PACE observations and evaluations for an entire week. Sample data sheets and other information included in the observer's handbook are shown in Appendix A, B, C, and D.

Utilizing the PACE Information

The Basic Study Observations.--The observer readings taken during the Basic Study Period are inserted into the various formulas discussed above to compute the pertinent factors. The results are then plotted in graph form for further study. These graphs are made to show the variations in PACE Index, Idle Time and Out of Area, by the time of day, and by the day of the week, as shown in Figures 3 and 5. The objectives of the PACE program are to remove the peaks and valleys from the PACE line and to increase the magnitude of this PACE line to the 100th percentile line on the chart. In order to accomplish this the supervisor of the workers concerned must analyze the reasons for these variations and take the necessary corrective action. As an example, the three lowest points of the PACE Index line of Figure 3 were found to occur during the three periods of the day that the foreman was unable to properly supervise his workers due to: (1) a morning foreman's meeting; (2) the foreman working late, into his lunch hour, so that his lunch hour was extended to overlap into the afternoon work period; and (3) the late afternoon period during which the foreman was occupied with the task of completing his daily reports. A change in the foreman's work habits was the necessary corrective action in this instance.

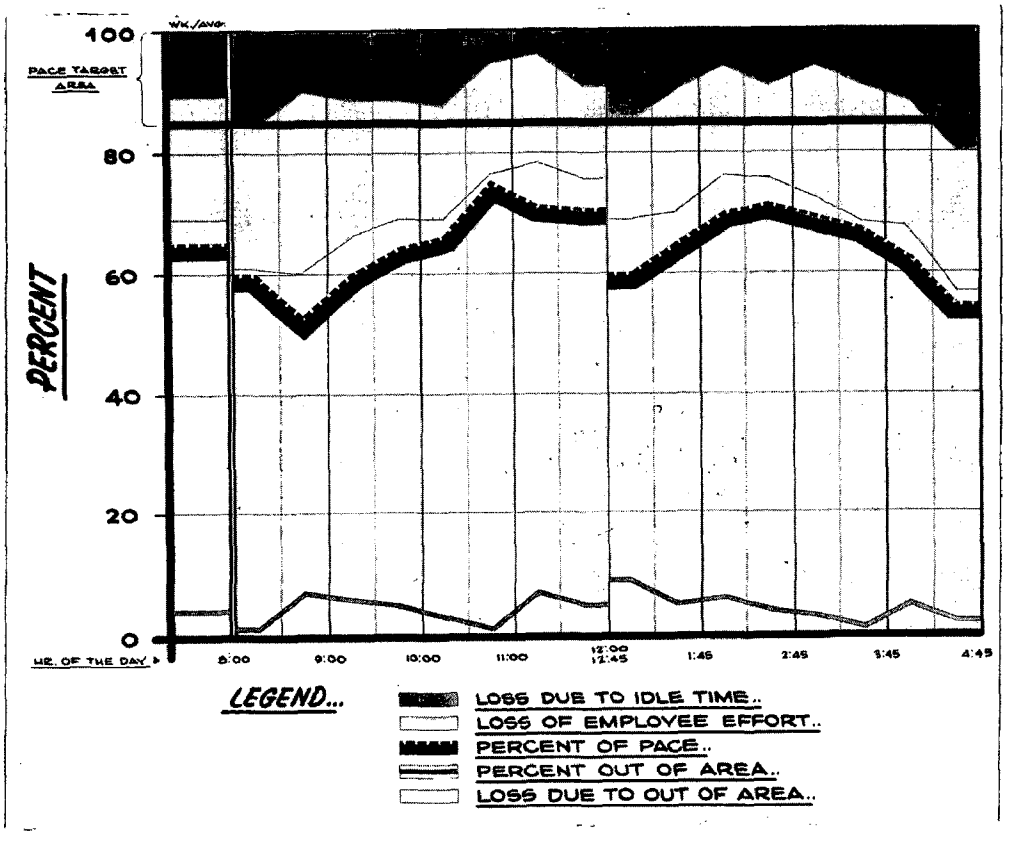

Fig. 3.--Daily work habits of a department as plotted from Basic Study observations

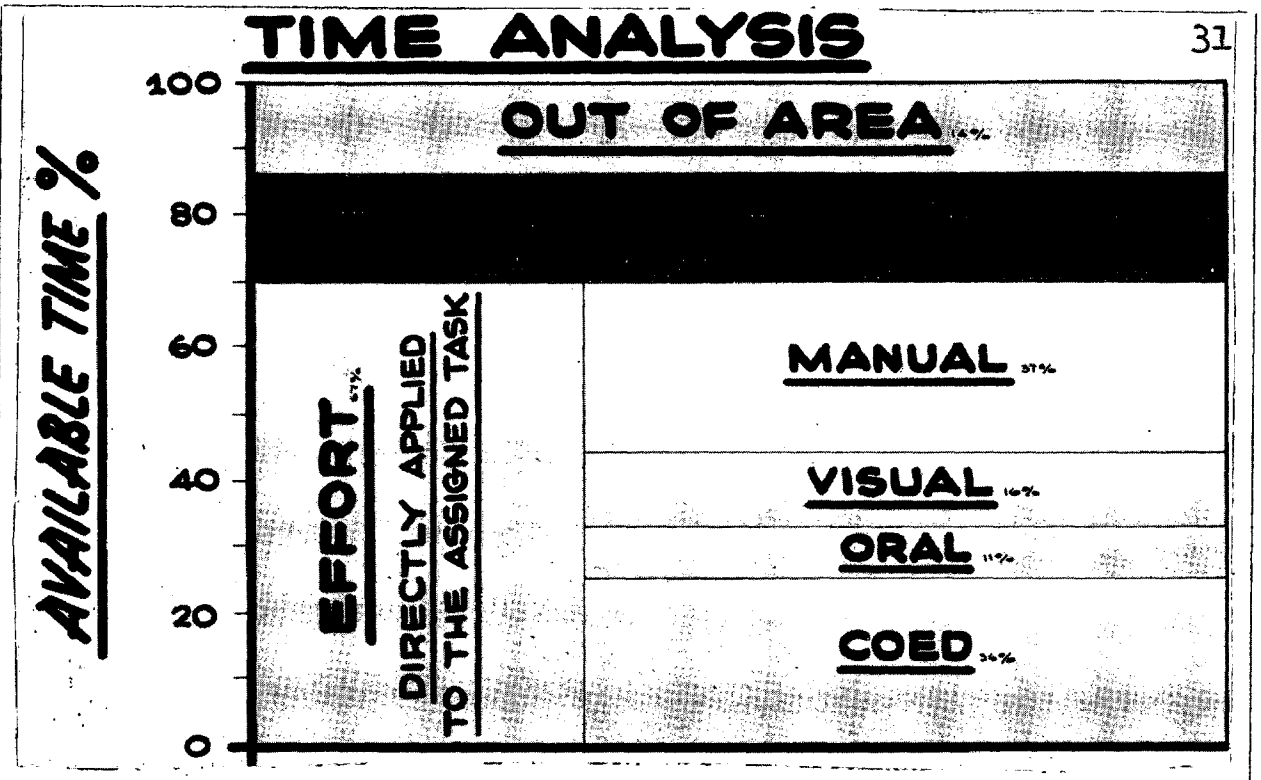

Fig. 4.--Time Analysis derived from a Basic Study

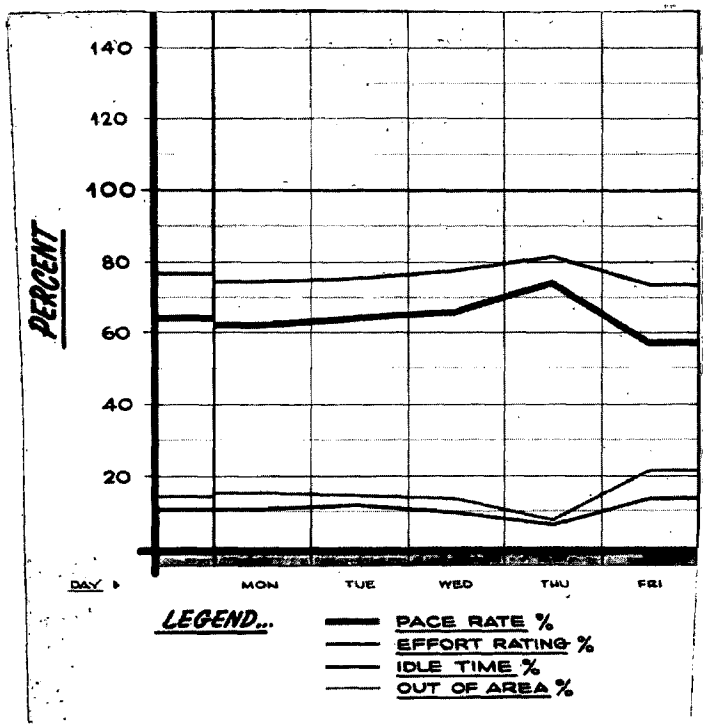

Fig. 5.--Daily PACE Rating pattern as plotted from Basic Study observations

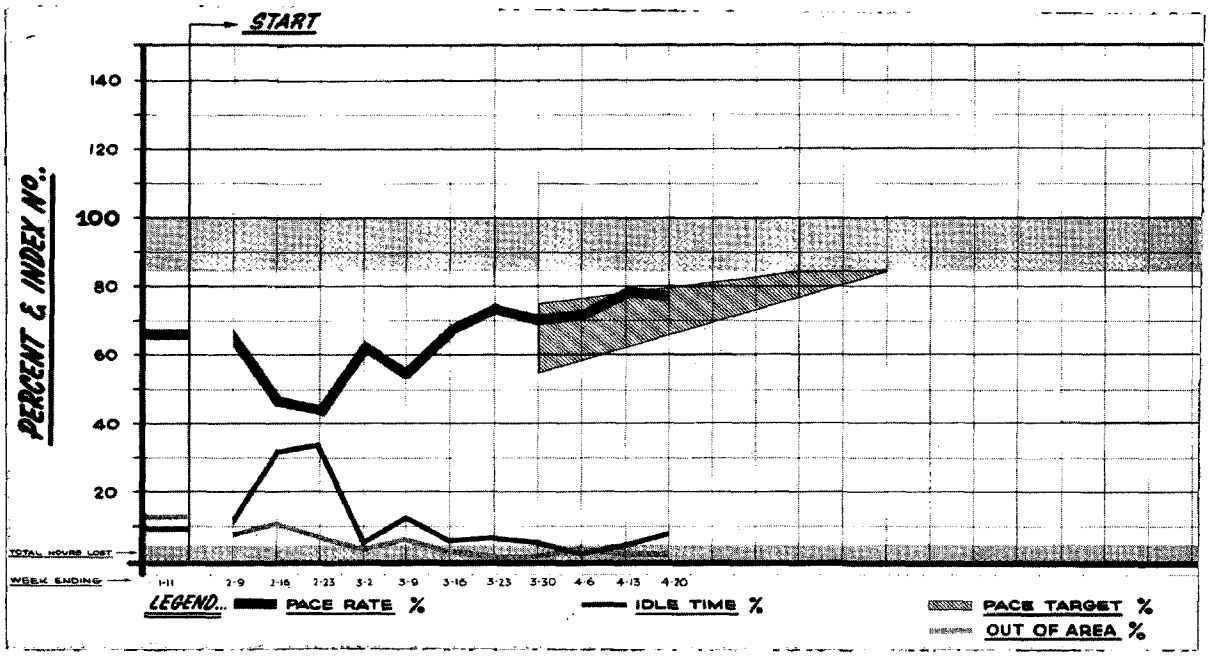

Fig. 6.--Weekly PACE Rating Chart showing the 0-5% and 85-100% control zones, and the improvement target corridor

In Technical/Engineering functions, a third chart is added as shown in Figure 4. This chart depicts the magnitude of the manual, visual, oral, and COED activities in relation to the direct work effort as applied to the assigned task.

The PACE Report Charts.--A PACE analyst plots 20x30-inch report charts for the weekly PACE reports. PACE observations are normally taken 10 times a day for a week (50 per week) then they are computed and plotted to summarize the week's activities. In order to establish managerial control, a working tolerance for the magnitude of the indices has been established. The Norair management has selected a tolerance of 0 to 5% of total work time as the present optimum control zone for Idle Time and Out of Area. The PACE people believe their observational accuracy for effort rating to be within plus or minus 5%. In theory, PACE can be expected to operate at 100%, but with a maximum allowance of 5% for idle time, 5% for out of area, and an estimated 5% observational error in the effort rating, the total error can be as much as 15% if all errors are added in the same direction. Thus the expected PACE index (the desired control zone) has been established between 85% and 100%, as shown by the shaded area of Figure 6. Because of these tolerances, peaks and valleys can be expected to occur within the limits. The Norair

management is primarily concerned with the trends and the rate of change in these trends of the PACE index. If the PACE Index trend should run out of this control zone a close analysis of the situation is made to determine the remedial action necessary to bring it back under control.

With few exceptions, the PACE index for a group is usually below the standard of expectancy (85% to 100%) when the Basic Study Period for the group has been completed. For practical considerations, the group's PACE index cannot be expected to improve overnight to fall within this desired control zone. After an organization has been under observation for approximately six weeks, the Norair management establishes an initial improvement area called a target corridor (as shown in the sloped, shaded area of Figure 6) predicated upon the historical performance of other groups and upon management precepts. The performance index for the group is expected to follow this established corridor. The value of this target corridor is two-fold: (1) it tells the supervisor where he stands and whether he is operating within the established control limits; and (2) if the PACE index trend line should drop below the lower limits of the target corridor, this indicates a potential problem area requiring immediate remedial action.

Charts of Technical/Engineering Functions.--For these functions, since activities encompass more than

manual effort, the effort rating is calculated in a slightly different manner. Instead of measuring the indices in percentages, the indices are evaluated in percentage parameters. PACE, therefore, uses the mean average of these parameters in measuring the group effort of these organizations. For example, as can be noted in Figure 7, instead of exact percentage points, the left hand portion of the chart is divided into a series of percentage parameters reflecting ranges from superior (90-100%), very good (80-90%), good (70-80%), fair (60-70%), medium (50-60%), poor (40-50%) to very poor (below 40%). Special studies are conducted to determine the magnitude of the manual, visual, oral and COED categories as shown in Figure 4. Based upon these studies, the effort rating is then reflected as a mean average of these activities, within the parameters noted above.

Correlating the PACE Index With Other Indices.--To check the relationship between PACE theory and practice, the Norair Division has adopted some indices of performance for comparison with the PACE index. As has been discussed, the PACE index is merely a measure of effort or input to the job. The workers could be working at 100% PACE but instead of producing anything of value, they could be merely producing scrap for the scrap pile. The PACE Measurement does not measure output. In addition, the workers

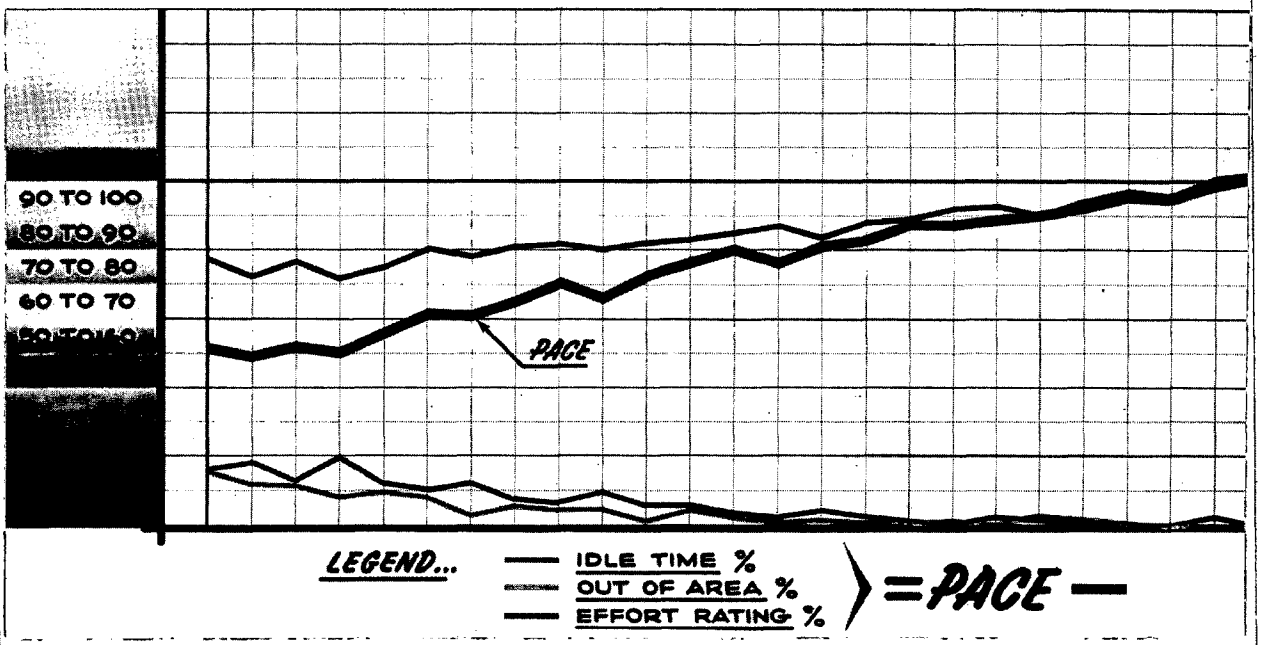

Fig. 7.--Effort Rating Chart for Technical/Engineering Functions

may be staging a great amount of hustle and bustle, without effective effort upon the assigned task, and without producing anything of value. Comparative indices were selected to act as a gauge of the effectiveness of the workers effort. During the search for indices, the desired index attributes were as follows: (a) the index must report a factor which is affected by--or which affects--the overall group performance; (b) the basic information must be readily available in an accurate form; (c) the information should be available for the same time periods as reported by PACE; (d) the information must be amenable to simple conversion from basic form to an index; and, (e) the index trend must be easily interpreted. Indices for personnel, budgets, scheduling, quality, and shortages were selected. These indices were readily derived from existing reports and data without generating must additional reporting.

The Personnel Index.--Because PACE Measurement measures the total input of group effort as it is applied to an assigned task, as the PACE Index improves (holding all other factors constant) an organization should be able to perform the same task with fewer people, or more work should be accomplished with the same number of people. Hence, if the PACE Index is increasing and there is no change in the total number of assigned personnel, the organization should either increase its output or effort is

being expended upon non-productive tasks. Thus the change in the number of assigned personnel of an organization is a valuable factor to compare with the PACE Index.

Calculation of the Personnel Index is accomplished by comparing the total number of persons assigned during a current week to the total number of persons assigned the week previously in an organization. In this manner an index number is developed describing the personnel change. Index numbers above 1.00 indicate the addition of people. Index numbers below 1.00 indicate the deletion of people. An index of 1.00 indicates no change over the time period being checked. Multiplying the index by 100, the resultant answer can be immediately correlated to and plotted on a standard 20x30-inch PACE report chart (see Figure 11). The Personnel Index Formula is as follows:

$$\frac{\text{Personnel This Week}}{\text{Personnel Last Week}} \times 100 = \text{Personnel Change Index}$$

Figure 8 shows a sample Personnel Change Index calculation. Figure 9 illustrates how the Personnel Change Index is plotted and compared with the PACE Measurement indices. It also illustrates how changes in the PACE Index should be accompanied by changes in the Personnel Change Index if all other factors remain constant.

The Budget Index.--This index is the comparison between planned man-hours per unit to be expended with actual man-hours per unit expended. It is computed as

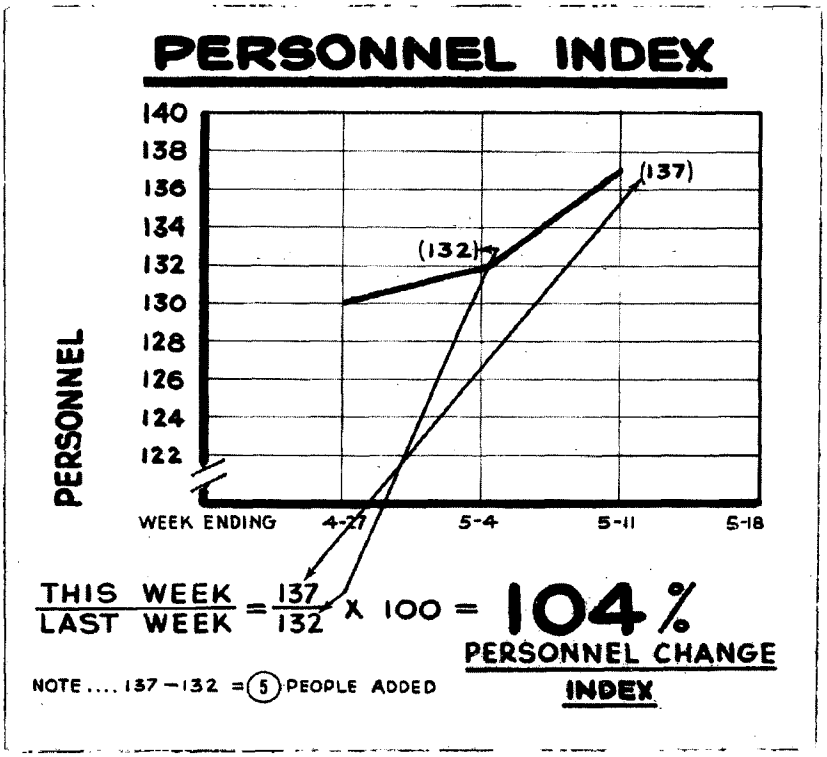

Fig. 8.--Personnel Index calculation

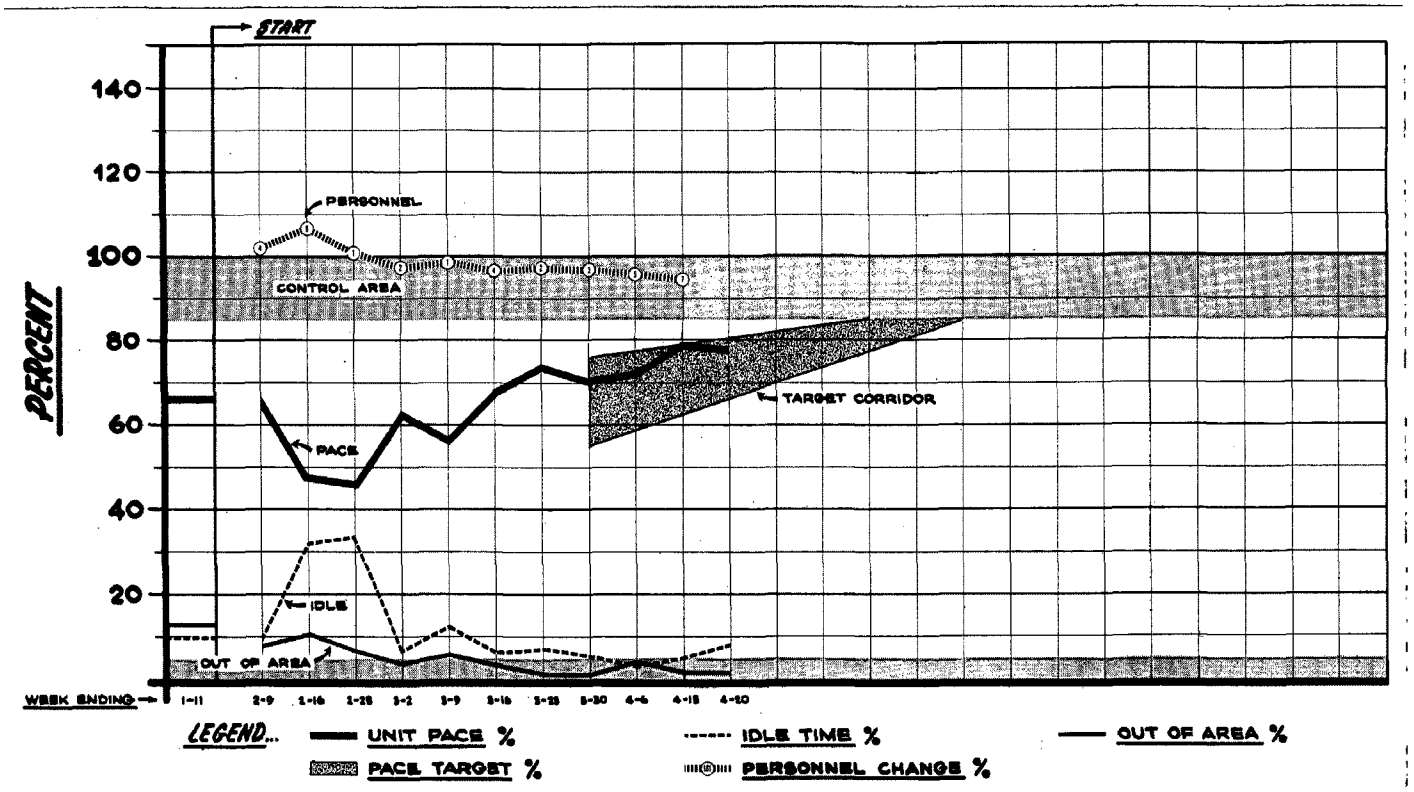

Fig. 9.--PACE Index and Personnel Index

follows:

$$\frac{\text{Earned (Budgeted) Hours Per Unit}}{\text{Actual Hours Per Unit}} \times 100 = \text{Budget Realization Index}$$

To correlate the Budget Realization Index with the PACE Index, it should be noted that as the PACE index improves, more effort is being applied to the task, hence more units produced per given time period should be expected. Thus, less time should be expended per unit. If less time per unit is attained, then less actual hours are expended and budget realization increases. If this correlation does not exist, it could indicate problems in any of the following areas: (a) Line breakdown of tools; (b) Inadequate tools; (c) Improper charge of actual hours; (d) Out of station work; etc. It should also be noted that in most low production rate programs it is important to compare only the trends of the Budget Index and PACE index lines, rather than points of these lines. This is particularly important in small operations because it is difficult to accurately weigh all of the work functions. The smaller operations do not receive the benefit of the smoothing effects that are present in high rate production programs.

If the Budget Realization Index runs consistently above 100% it is an indication that the budgeted hours per unit for that department are excessive. If it runs consistently far below 100% and the PACE Index is high, that

would indicate that the budgeted hours are insufficient to accomplish the job in the time alloted to meet the given schedule. Figure 10 illustrates a sample Budget Realization Index calculation. Figure 11 illustrates how the Budget Index should theoretically vary with the PACE Index, all other factors remaining constant.

As the PACE Index increases, greater effort is applied by the group; thus less people should theoretically be required to perform the same task. As less people are required, there are less actual hours needed to perform the task; and the budget realization should increase as illustrated in Figure 12.

The Schedule Index.--In theory, if PACE measures the total input of group effort applied toward the accomplishment of the assigned task, then as PACE improves, more products should be produced by the same amount of people, or the same amount of products should be produced by fewer people. At Norair, contracts provide for the delivery of products on a given schedule. Good manufacturing control systems dictate that each step in the production flow is predicated upon the product shipping date, with allowances provided for contingencies. Norair's cost control system, known as the integrated cost control system, defines production in terms of equivalent units which are constantly computed and the results disseminated. The term equivalent

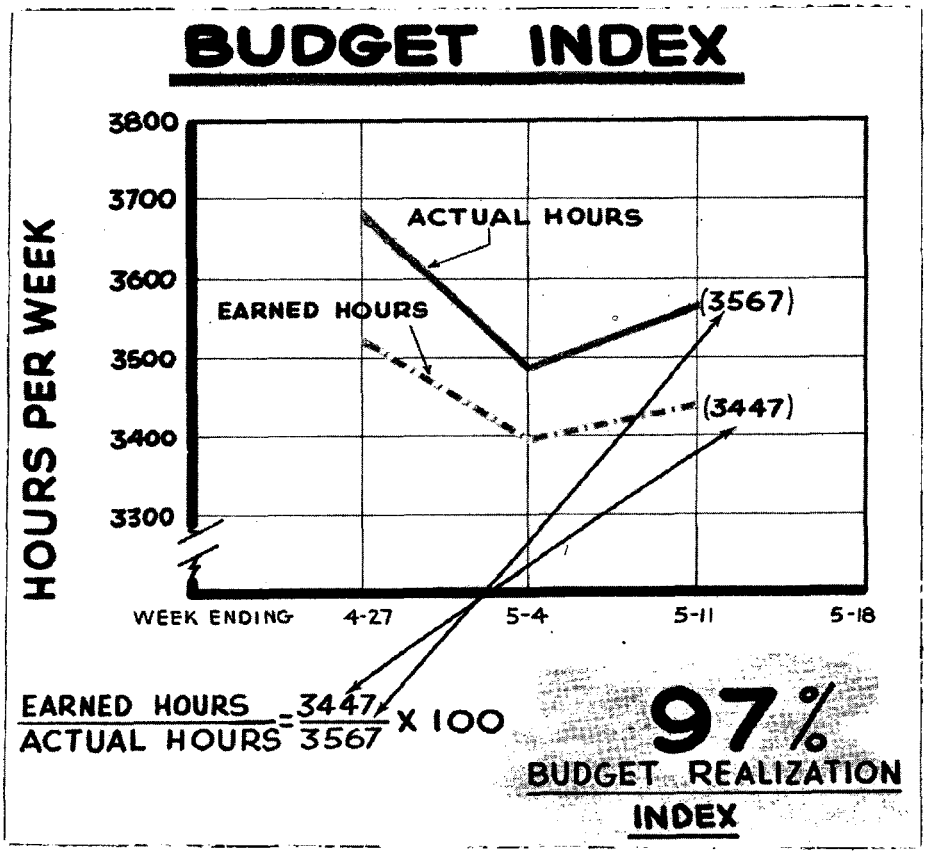

Fig. 10.--Budget Index calculation

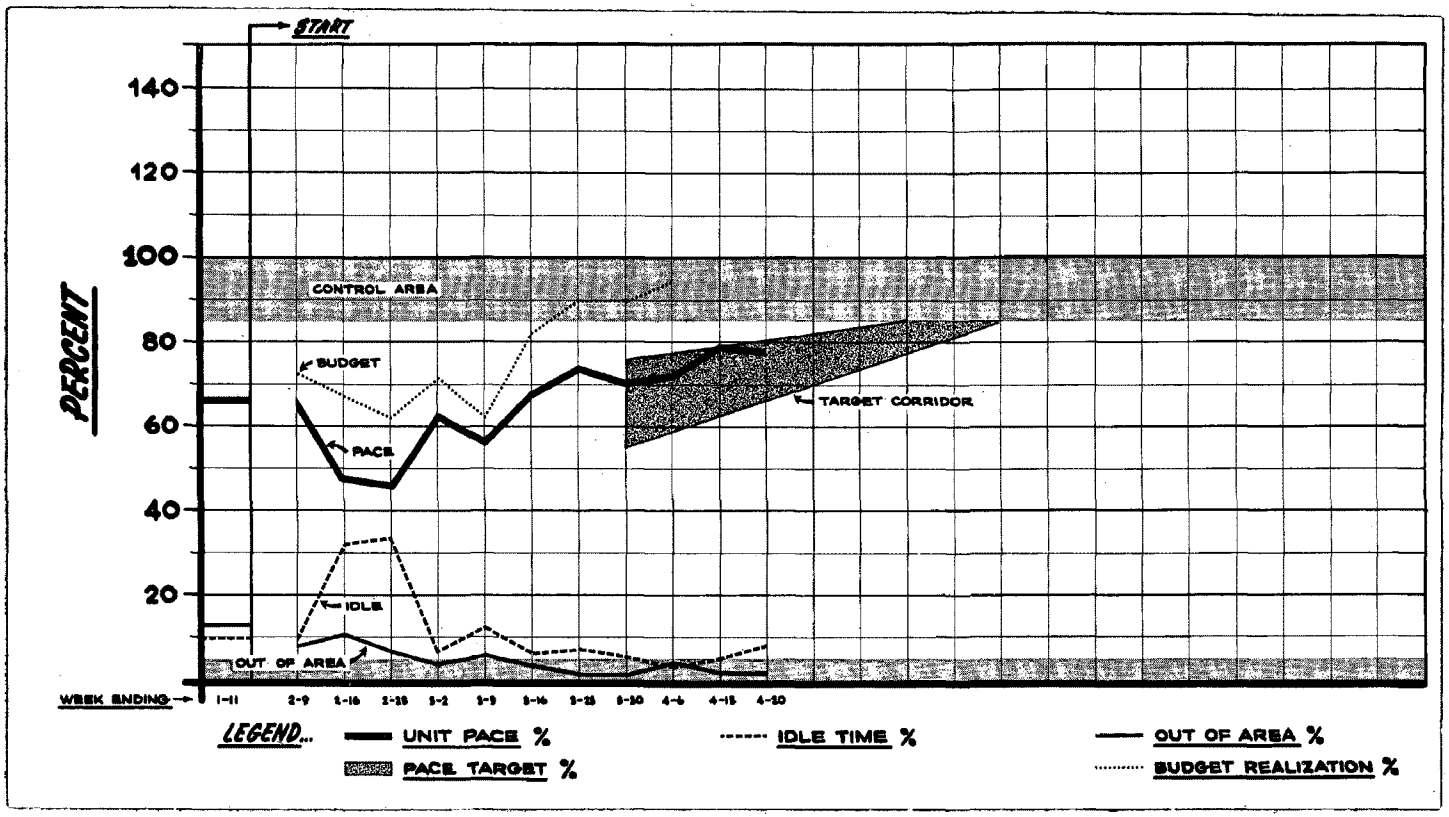

Fig. 11.--PACE Index and the Budget Realization Index

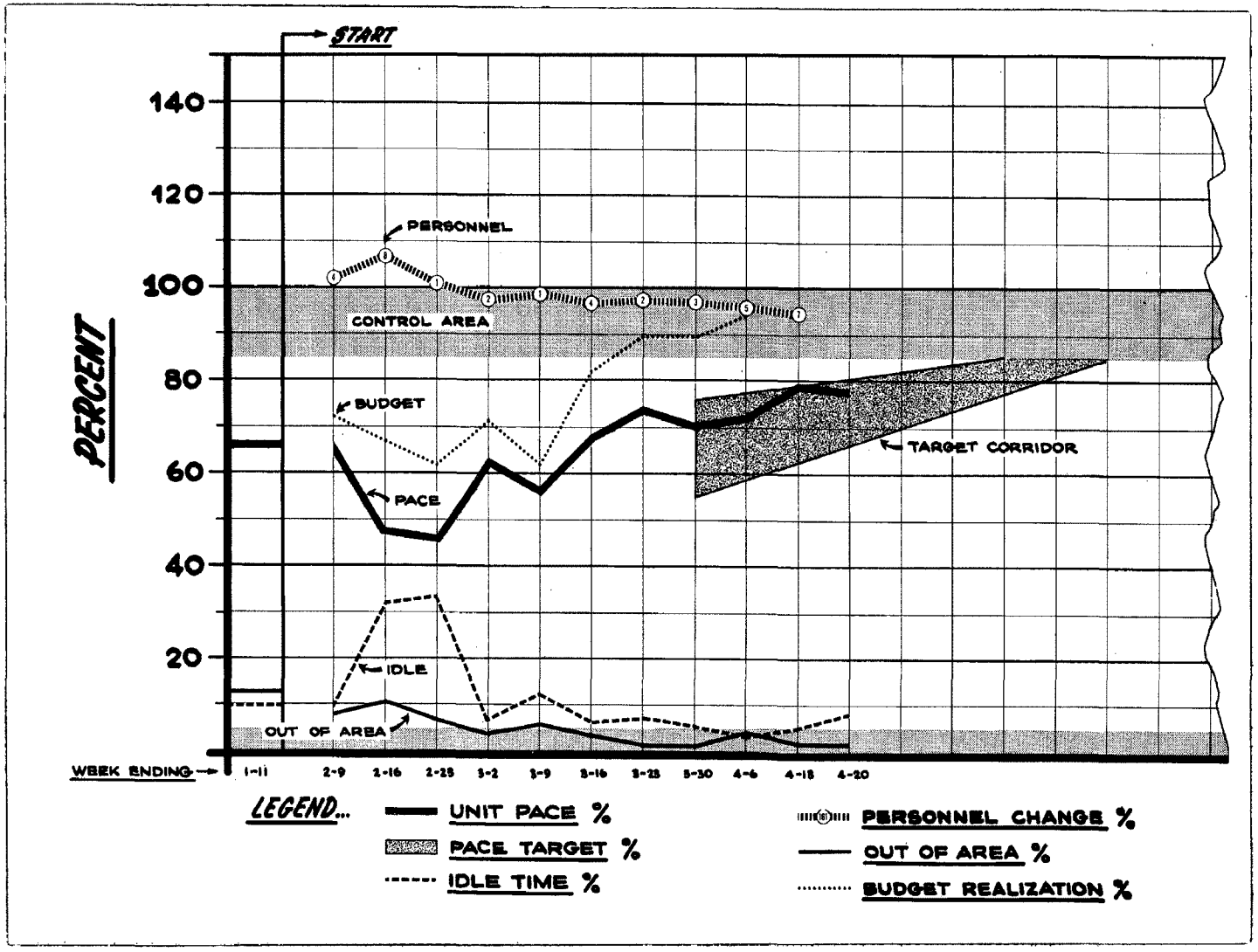

Fig. 12.--Correlating PACE Index with Budget and Personnel Indices

unit is used to allow for partial completion of a product. Norair's Manufacturing Program Planning organization issues a weekly report which shows the scheduled units to be completed, and the actual equivalent units completed. The Schedule Index is computed from this information as follows:

$$\frac{\text{Actual Equivalent Units Completed}}{\text{Scheduled Units}} \times 100 = \% \text{ of Schedule Produced}$$

A Schedule Index number greater than 100 indicates that the organization is producing at a rate that is greater than scheduled; and a number less than 100 indicates that the organization is producing at less than scheduled. By integrating the area between the 100% and the Schedule Index lines, the cumulative schedule position can be ascertained. Of course, to be on schedule, areas above 100% must be balanced by areas below 100%. As PACE improves and greater effort is being exerted, a corresponding increase in the Schedule Index can be expected (other factors remaining constant). If this does not occur, it is an indication that effort is being expended in areas which do not result in increased production (output). Being ahead of schedule cumulatively can be just as undesirable as being behind schedule. If production runs too far ahead of schedule, either the schedule can be changed, or the number of people assigned to the work task can be reduced. Assuming the latter course of action is taken and the PACE Index

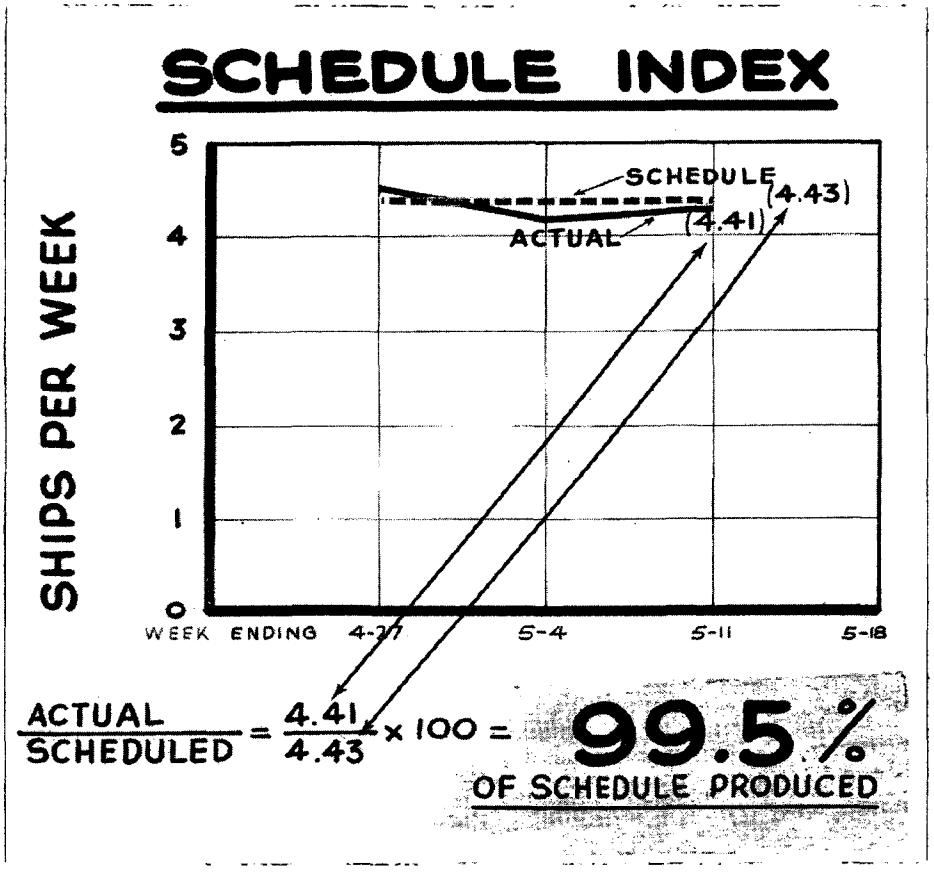

Fig. 13.--Schedule Index calculation

remains the same, the decrease in personnel will decrease the Personnel Index. If the number of people is decreased, the number available hours to be expended is also reduced, thereby increasing the Budget Index. Therefore, the cost per unit is decreased, which is the ultimate goal of the PACE Program controls. Figure 13 illustrates a sample Schedule Index.

The Quality Index.--Early in the PACE program it was believed by some that as greater effort was applied to the accomplishment of the assigned task it was likely to cause a greater number of errors and a reduction in quality would result. In practice quality at Norair is evaluated in each manufacturing organization using accepted statistical principles to establish both quality level and control limits. Empirically, Norair has established that as PACE improves there is a slight improvement in quality level.

Norair uses a quality index that depicts the desired quality control tolerances as being between the 85% and the 100% levels on the PACE charts. An index below 85% means that a serious quality control problem exists in the organization being measured. Above 100% indicates that the quality is excessively high and that costs may possibly be reduced by reducing the quality.

The development of the formula for computing the Quality Index is beyond the scope of this thesis. However,

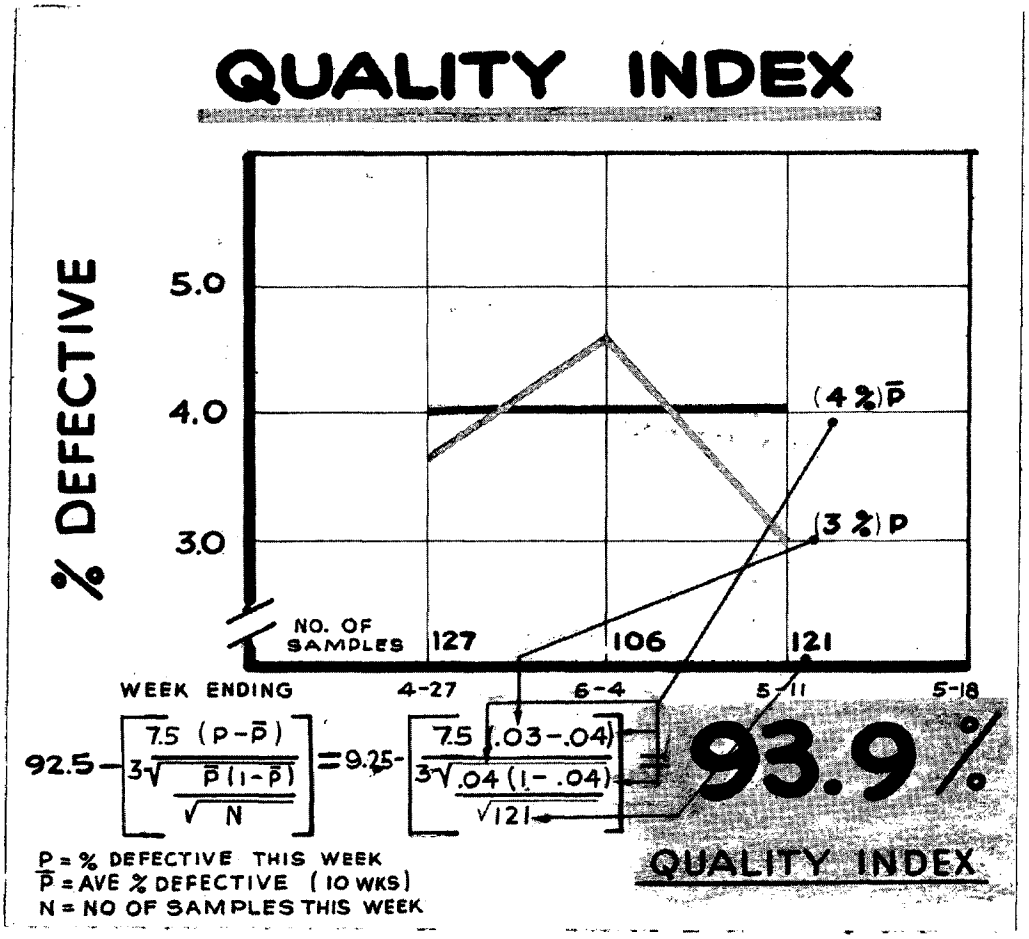

Fig. 14.--Quality Index calculation

the formula which Norair uses and a sample calculation of the Quality Index are shown in Figure 14. Figure 15 illustrates how quality usually varies with the PACE index, all other factors remaining constant.

The Shortage Index.--Due to the peculiarities of the aircraft industry changes in an airframe or its systems occur many times during a production run. Some of these changes occur before the new parts are available. Most of these parts shortages will not slow down the production, but they cost many additional man hours which are required to make the installation at some point other than was originally planned. Other parts shortages will cause a shutdown. Norair has three major classifications of shortages: (1) cushion shortages, which are defined as 10 days' supply or less in the bins; (2) top priority shortages, which are defined as having no supply in the bins; and (3) shutdown shortages, which prevent further activity in a given area. When a part is out of stock it is viewed by the employee as a lack of work load, and his PACE tends to slow down. When working individuals find that there are no parts left in the bin, they tend to stretch out their current work to make sure it lasts the rest of the working day. In the aircraft and missile industry close control of shortage information is maintained. From this information the Manufacturing Methods Engineers have adopted a

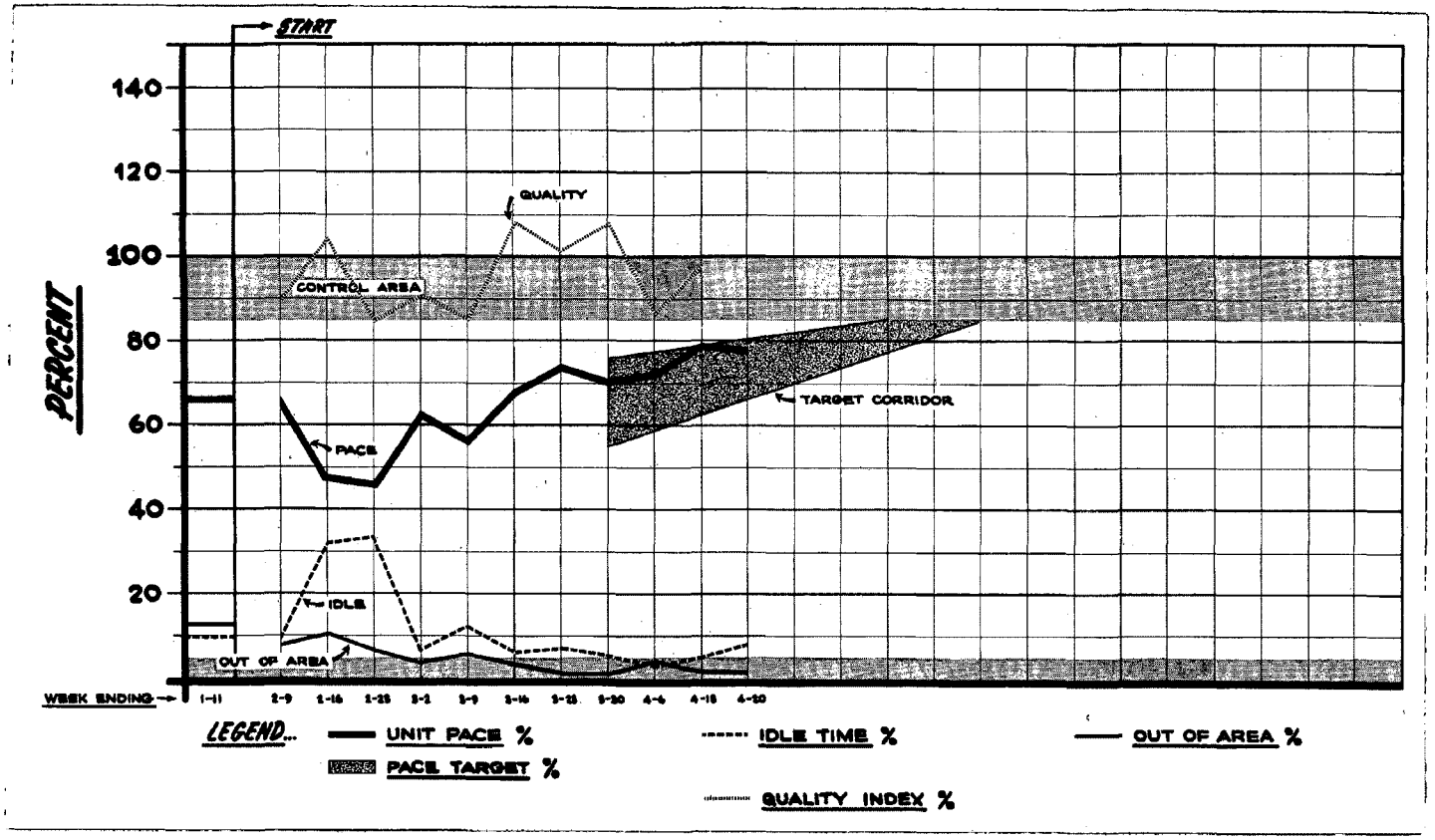

Fig. 15.--PACE Index and Quality Index

ratio of top priority shortages existing in the organization compared to the total number of different parts which are used in that organization, as the significant index to be correlated with the PACE Index. Because this ratio is so small, it is multiplied by an arbitrary shortage factor to increase its size so that it may be plotted upon the reporting charts, and to increase its size so that an index number of five or less will indicate an "in control" condition for shortages. The formula is as follows:

$$\frac{\text{Top Priority Shortage}}{\text{Total Number of Parts}} \times \text{Shortage Factor} = \text{Shortage Index Number}$$

Figure 16 illustrates a sample shortage index computation. Figure 17 illustrates the theoretical correlation between the PACE Index and the Shortage Index.

The correlation between the shortage index and the PACE index is based upon the premise that parts shortages are likely to cause the PACE index to decrease. To offset this there are two alternatives: (a) reduce the number of shortages; (b) reduce the number of employees. Once they occur, shortages are difficult to reduce. If top priority shortages increase, the supervisor must reduce the number of personnel to maintain a given PACE index, thus reducing the personnel index. To improve the budget realization (Budget Index) under these conditions, the Personnel Index must remain below 100%, and this can only be accomplished

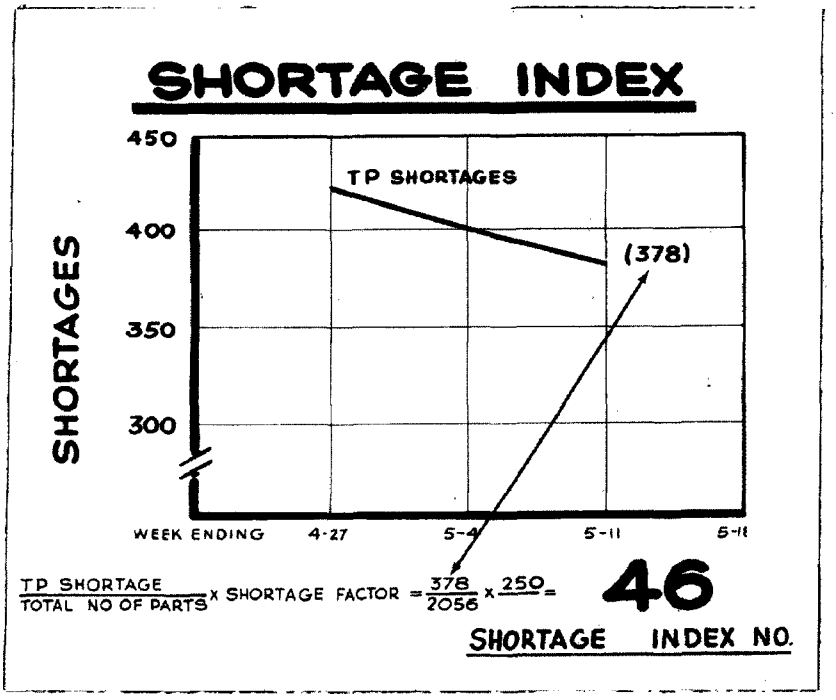

Fig. 16.--Shortage Index calculation

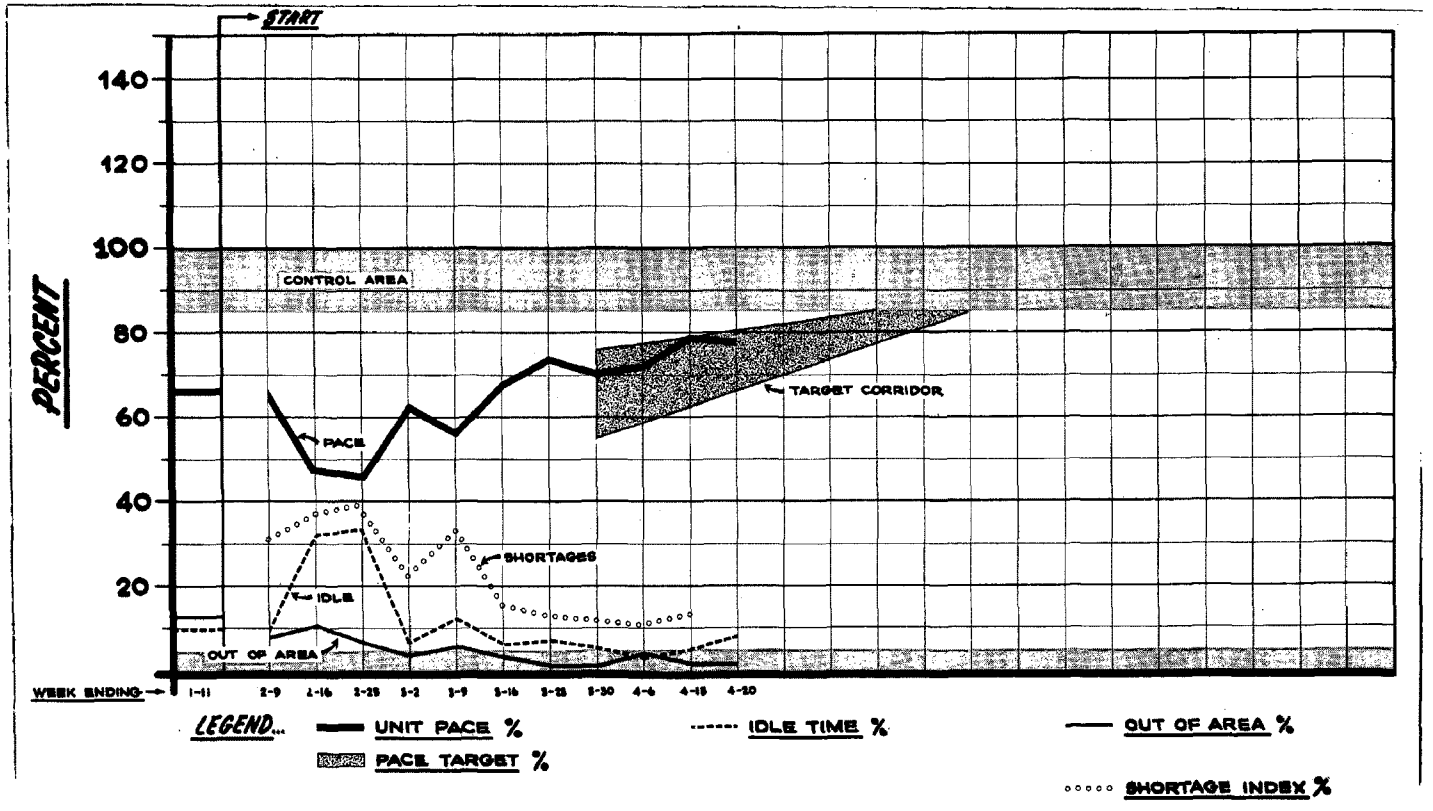

Fig. 17.--Correlating PACE Index with Shortage Index

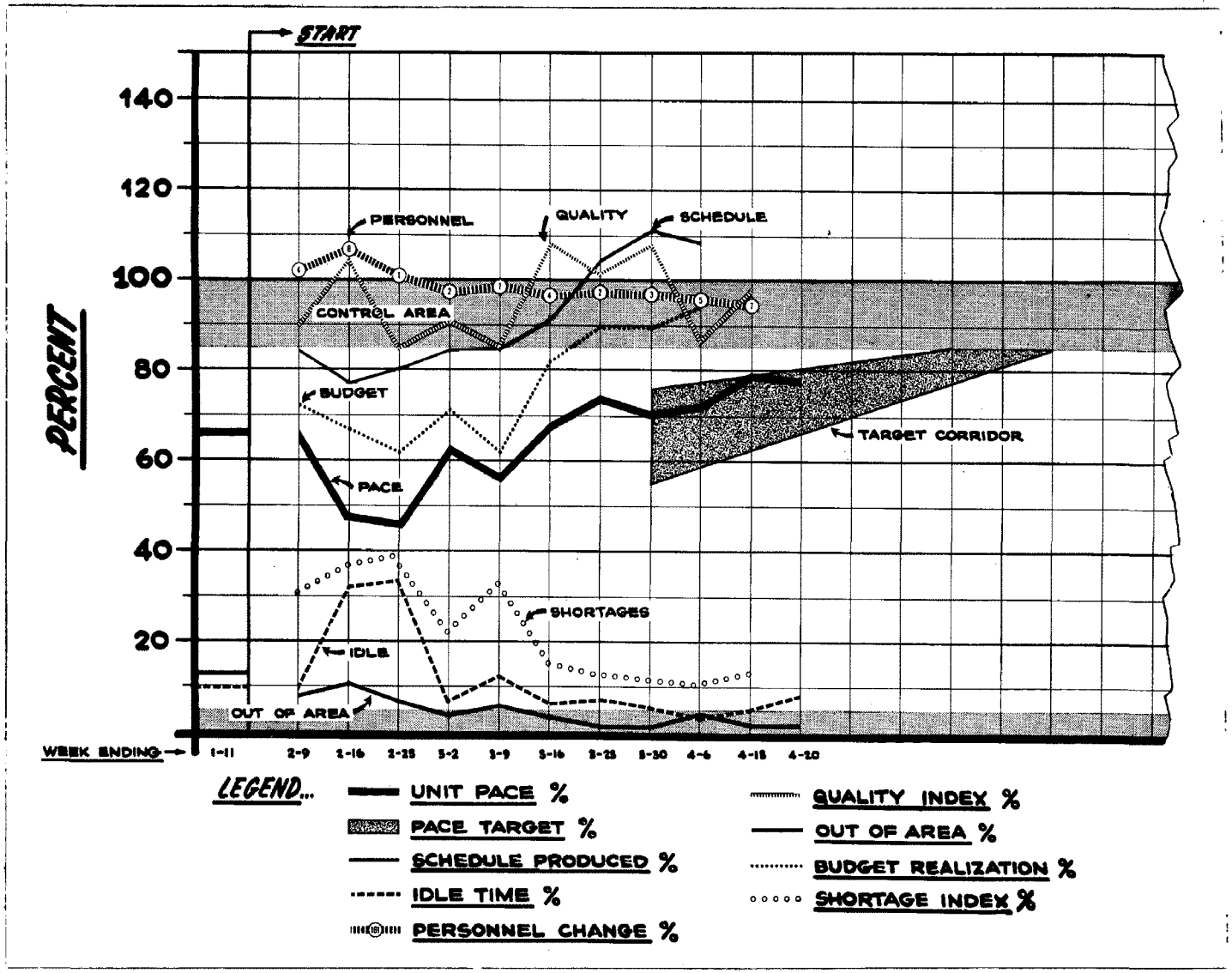

Fig. 18.--Correlating PACE Index with Shortage, Quality, Schedule, Budget, and Personnel Indices

by further improving PACE (applying greater effort) while maintaining schedule (Schedule Index near 100%) and quality (Quality Index between 85% and 100%).

Comparative Analysis In the PACE Program

Having briefly discussed how current performance indices are developed, the interrelationship of all of these indices and PACE Measurement should now be considered. When all of the measures of performance, including PACE, are within the controlled area (PACE, personnel, budget, schedule, and quality around 100%; and shortages, out of area, and idle time below 5%) it can be noted that a department is "in control". Any time any of the measures of performance deviates from this controlled condition, the fact that a problem exists becomes instantly apparent. By considering which index line appears to be out of control, the area in which to begin investigation can be established immediately. By reviewing all of these factors, prompt preventive action can be applied rather than waiting until all parties concerned recognize a serious out of control condition and then have to apply more costly corrective action.

At present, the PACE report chart contains eight lines, each of which is a measure of performance. (See Figure 18.) Considering the variety of trends and directions of these lines, there are over 700 possible combina-

tions in which the trends of these lines may progress. Each combination is indicative of a different set of conditions--some of which are desirable, but most of which are undesirable. Each of the undesirable conditions indicates a problem area. The particular combination of trends indicates a specific problem area rather than a general type of problem, and permits analysis of this problem area so that preventive action can be applied promptly.

One of the greatest advantages of the PACE Charts is that they show at a glance what would take hundreds of pages and much of a manager's valuable time to find otherwise. The charts bring together and correlate masses of information that would otherwise be buried in the figures of numerous separate reports, without generating much additional reporting and red tape.

As can be noted in Figure 18, the PACE, Idle, and Out of Area Indices are plotted a week or more in advance of the other performance indices. This is due to the fact that the PACE observations are computed and plotted every Friday and Friday evening so that the pertinent information is available for reference by management on the Monday following the week being reported upon. The other indices require several days to prepare due to the tremendous mass of data accumulated which must be reduced to indices.

Communicating the PACE Information

The various PACE Program charts are kept on display in a special PACE Chart Room (see Figure 19) for reference by management and supervision. Each chart is kept up to date to reflect the current indices of a department or organization and one chart may be compared as against the other. The room is open 24 hours a day.

Each week the daily PACE measurement observations are summarized on 8½ x 11 inch reproducible charts for the various scalar levels of management, tailor made to fit the needs of each level. These charts are distributed every Monday, covering the previous week's observations.

Each week, regularly scheduled meetings are held at the managerial level to discuss the interpretation of the trends of PACE and the performance indices. At this time, these trends are evaluated and the application of preventive measures necessary to correct the beginning of any adverse trend is determined.

Periodically an organizational ranking chart, as shown in Figure 20, is computed for management, showing the areas of potential improvement which can be accomplished by each department within the organization. Semiannual reports are also made.

Some supervisors have elected to display the PACE ratings at prominent and strategic locations within the

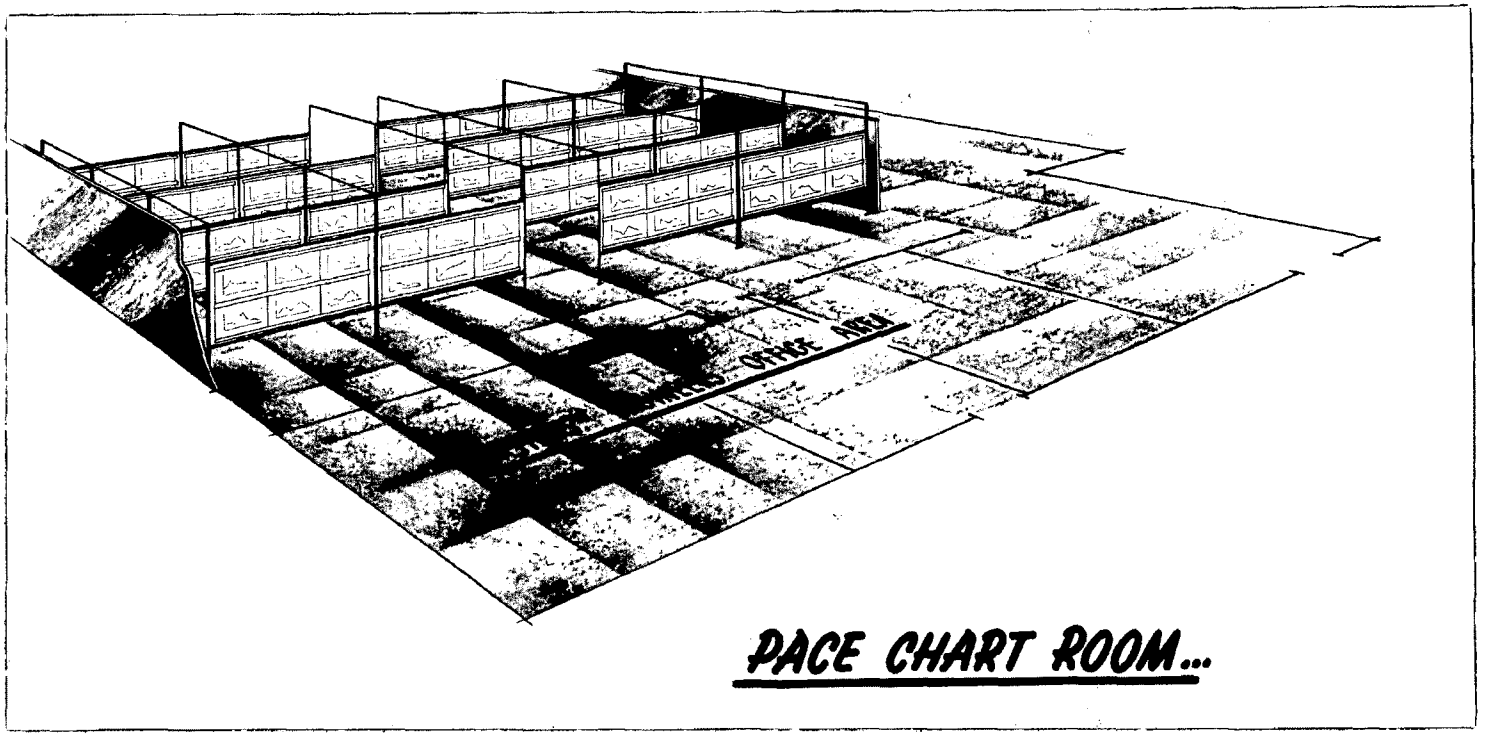

Fig. 19.--PACE Chart Display Room

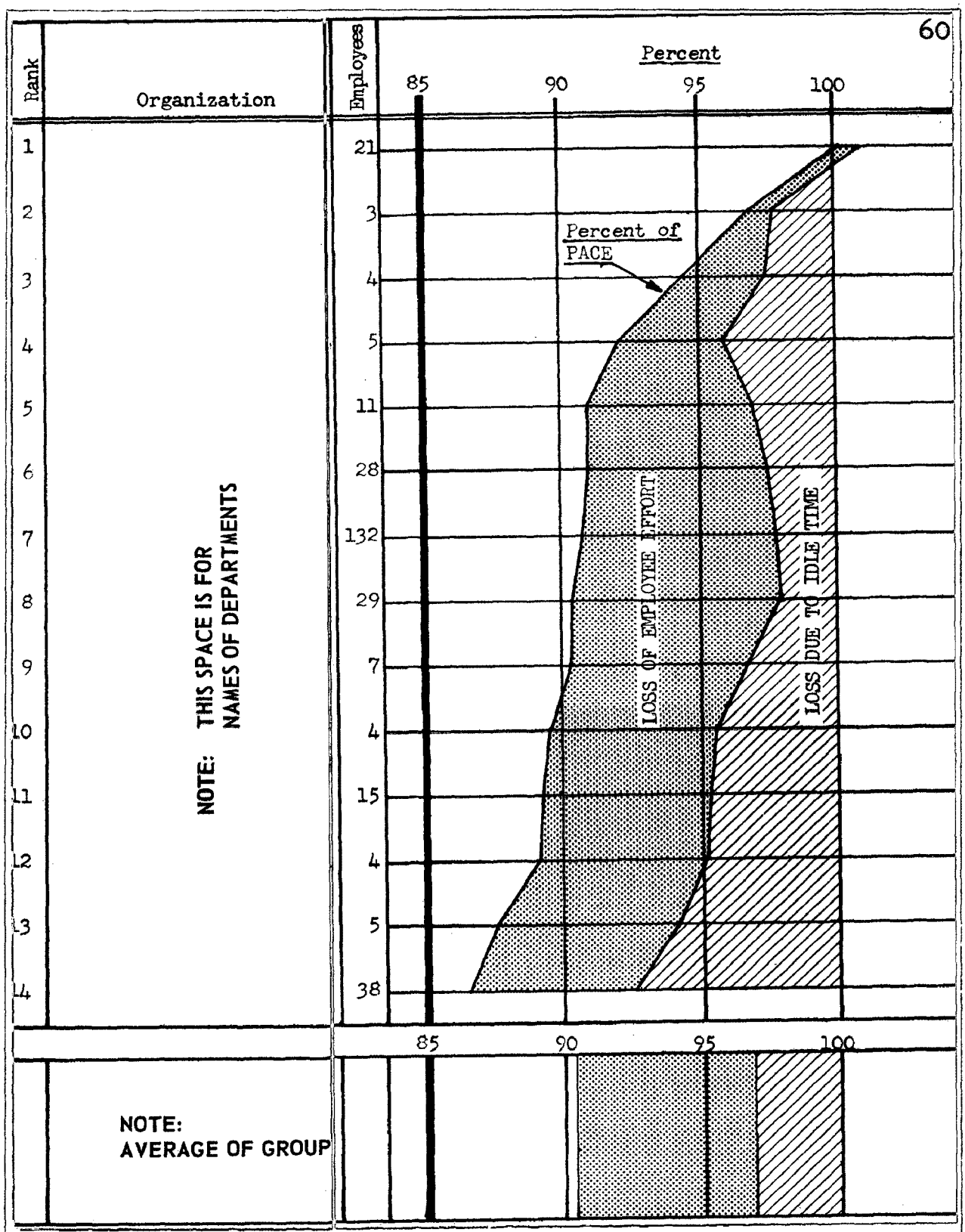

Fig. 20.--PACE Rating Organizational Ranking Chart

work area. This keeps the workers informed as to how they are doing, and it can encourage the workers to improve their effort.

Special Studies

In addition to the regularly scheduled reports, the PACE people continually conduct a number of special studies in areas where potential cost reduction is possible. These studies are usually initiated by management and supervision. The industrial engineers on the PACE Program also institute special studies to improve the PACE Program. Typical special studies encompass such problems as: (1) Tool Crib Survey--to determine manpower requirements and strategic geographical locations relative to the areas they service; (2) Extended Work Week (Overtime)--to determine the point of diminishing returns for premium time; (3) Night Shift Activities--comparative Day and Night Shift performance studies; (4) Employee Pass System--with regard to inter-departmental travel; (5) Machinery Utilization--to determine whether machines are being used at maximum capacity; (6) Starting and Quitting Times--the effective utilization of group effort; (7) Pre-Holiday and Post-Holiday Surveys--to again determine effective utilization of group effort; (8) Secretarial Services--to establish normal work distribution; (9) Layoff--most economical method for processing a

reduction in work force; (10) Coffee Making and Consumption-(a) elimination of excessive abuses over and above normal breaks in making and consuming coffee; (b) better distribution of automatic beverage vending machines; (11) Standby Operations--determination of necessity for, and magnitude of, such operations; plus a number of typical problems relative to effective cost reduction.

The Organization and Operation of the PACE Program

The PACE Program was developed by the Manufacturing Methods Engineering Group of which Mr. D. N. Petersen is the Chief. This group is in the Norair Division's Manufacturing Engineering Section headed by D. F. Beck, Director, which is a section of the Manufacturing Department of which Vice-President F. W. Lloyd is Manager. The development of the program was originally initiated by Norair's General Manager, Vice-President R. R. Nolan who has given the program his strong and vital support.

D. N. Petersen's Manufacturing Methods Engineering Group is further subdivided into two sections, the PACE section and the Methods section, as shown in Figure 21. The PACE Supervisor, R. M. Wrestler, supervises approximately 23 people, which includes 18 highly qualified PACE observers, 3 statisticians, 1 illustrator and 1 secretary-clerk. As shown in Figure 21, there are 8,000 people now

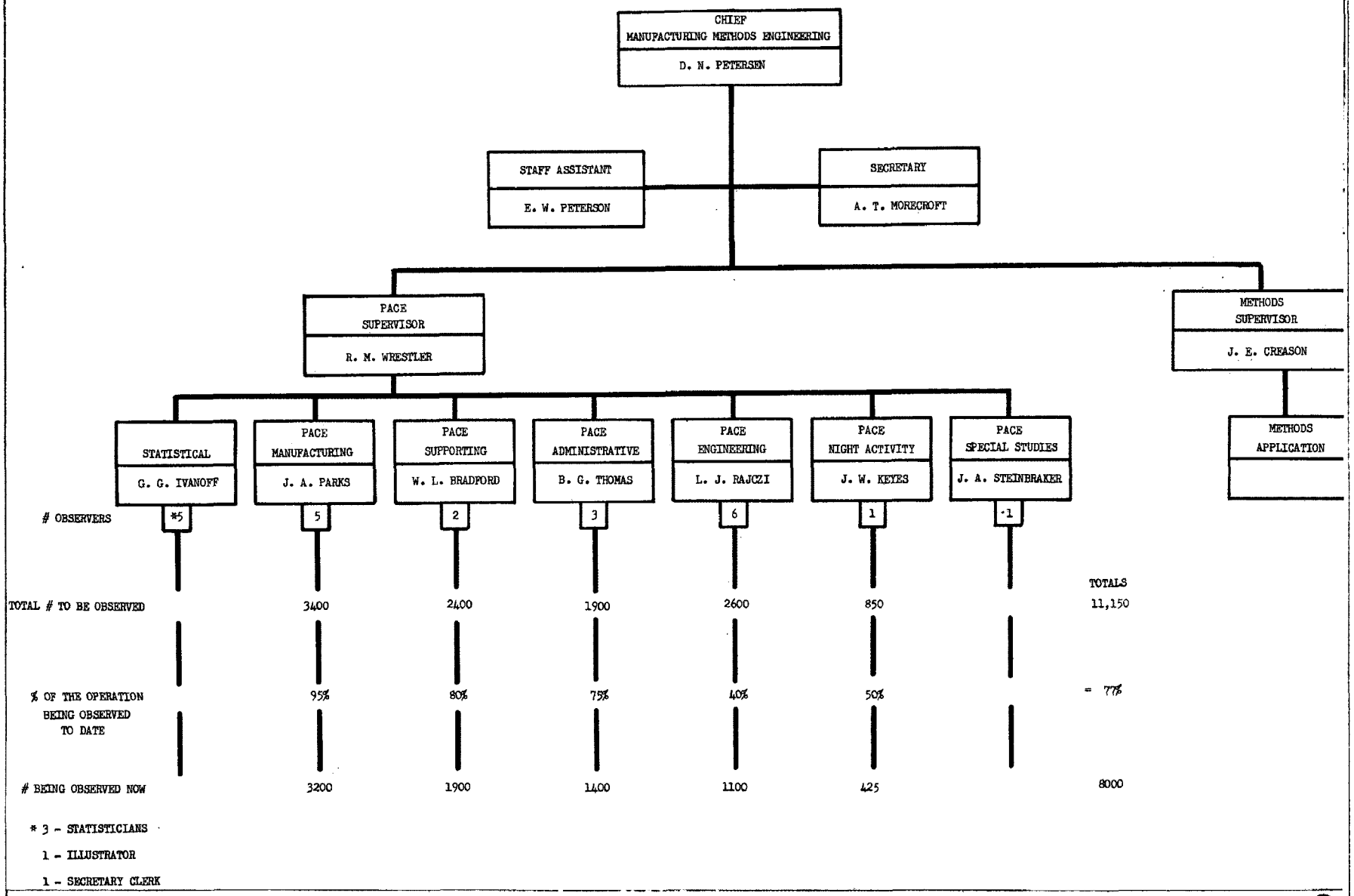

Fig. 21.--PACE Program Organization

being observed and PACE rated at the Norair Division. This represents approximately 77% of the total of 11,150 workers who will eventually be observed. In applying the PACE Program, those areas of the Norair Division's operations that promised the greatest rewards were first selected as targets for the program--the idea was to "skim the cream off" first. Another factor considered was that the amenability to the PACE Program, the degree of available control, was greatest in Manufacturing Functions; and it diminished progressing from the Manufacturing Functions, Support, Administrative, to the Technical/Engineering Functions. Furthermore, the lowest echelon worker is presently more amenable to the PACE observations than supervision or management. Thus it was natural that the PACE Program was instituted in certain Manufacturing Functions first, and that supervisors were not included in the observations.

The PACE Measurement calculations are so streamlined and well organized that they only require the services of two comptometer operators for two days a week. Two of the remaining days are spent plotting the PACE charts and the remaining work day of the five day week is spent converting the various performance reports to Performance Indices.

The qualifications of the PACE observers are high. Although total strangers to a given department are selected

for the PACE observations, the observer selected must be familiar with the various activities of the department. Observers are trained and tested in a given department before they are allowed to make observations on their own. Strangers to a department are preferred so that they can maintain total independence. Observers experienced in motion and time study techniques are preferred.

All of the charts shown in this thesis are theoretical. For security reasons, the Norair Division would not release its actual charts. In practice a surprising number of the charts have worked out to closely resemble the perfect correlation shown on these theoretical charts. The charts for some organizations or projects are wildly erratic. There are actual charts depicting various shades of control between these extremes. When an organization's indices all reach their respective control zones and stabilize in that region (as shown in the right portion of the index lines of Figure 22) for a number of consecutive weeks, that organization's activities are then put on a "surveillance status". This means the organization is merely spot checked periodically to determine if erratic variance occurs. If on a spot check one of the indices is noted to deviate from the control zone, a more intensize observation is continued for that organization. Norair has been able to put a few of its organizations on this surveillance status.

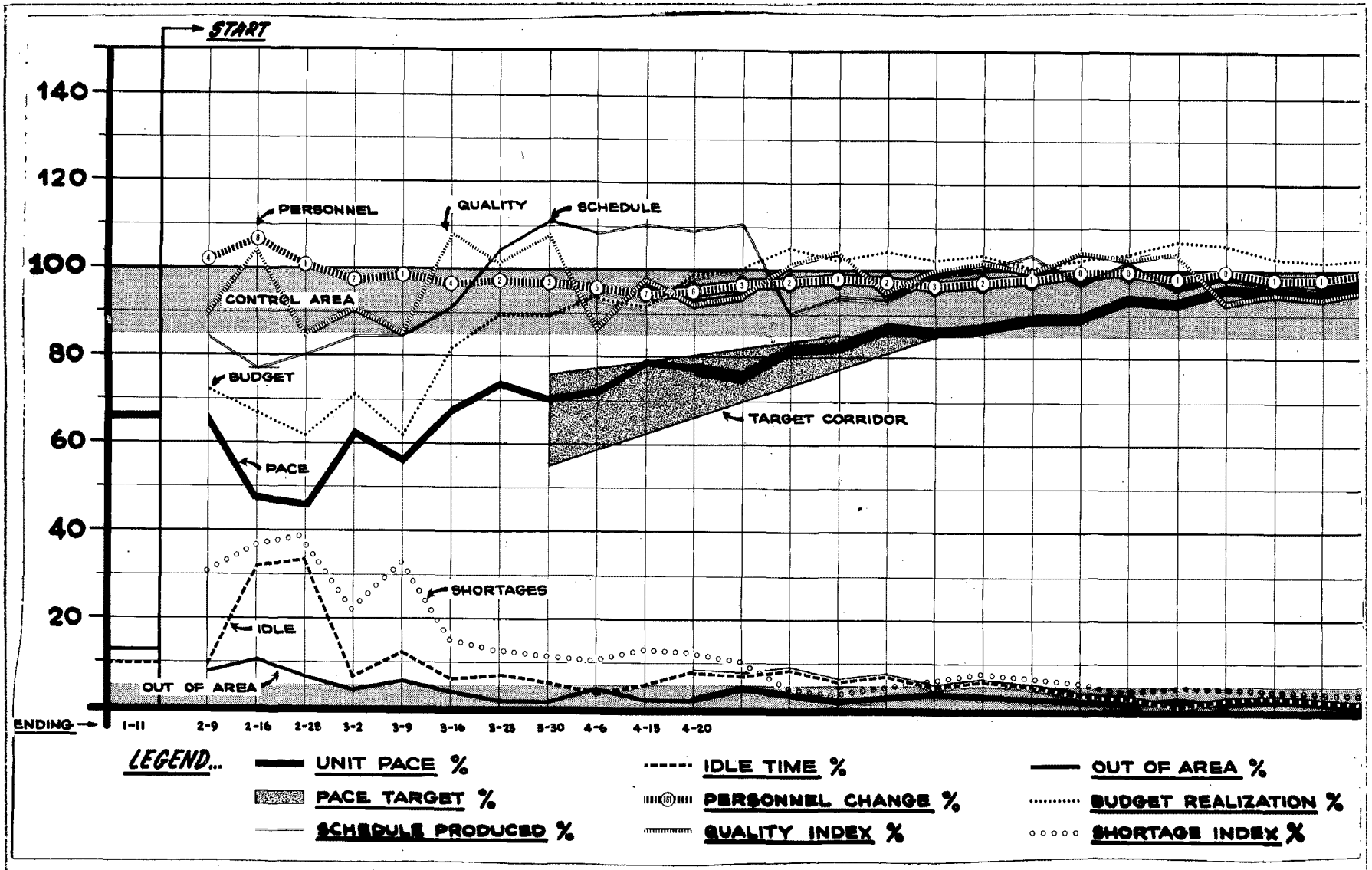

Fig. 22.--Correlation of the PACE Index with all Performance Indices

CHAPTER III

AN ANALYSIS OF THE PACE PROGRAM

The PACE Program in General

What the PACE Program offers that other presently established management tools do not.--The PACE Program is a management tool for judging employee effort of the entire factory on a more systematic and a more objective basis than has been economically feasible on such a vast scale up to this time. It does not replace time study, methods engineering, conventional work sampling, good supervision, production control functions, cost control, budgeting, time study, or any other management controls. The PACE Program is superimposed over these other controls, it supplements them, and in many instances it serves to cross check their validity and/or effectiveness.

The PACE Program augments motion and time study, synthesized time standards or predetermined times, and conventional work sampling. It utilizes certain characteristics of these more established techniques to provide control over vast segments of industry where the older techniques were found to be either too expensive or otherwise impractical. In those portions of industry where unit production

volume is low, production is accomplished in irregular job lots, tasks are not so specialized, the operations involved are lengthy and varied, and the work is not repetitive--these are the areas where previous time study techniques were found to be uneconomical. It is here that the PACE Program provides economical control. But the PACE Program is not limited to manufacturing activities. It has been extended to encompass office workers, technicians, and engineers as well. Thus PACE appears suitable for application in many businesses and industries, as well as many branches of the government. In this respect, the PACE Program represents a breakthrough in management's quest to provide a more sensitive control over all of its human resources.

The cost of the PACE Program versus results.--Each PACE observer can measure between 250 and 450 people, depending upon the density of population of the area measured, and the type of function being observed. It requires more time to PACE Measure engineering functions than office machine or manufacturing functions. Each PACE observer is able to measure this many people because of a company policy which places a department or group on "surveillance status", requiring less frequent observations, once the group or department is "in control" (all indices within the tolerance limits) for an extended period of time. There are a total of 26 PACE observers and administrative people working directly on the PACE Program which encompasses 8,000 people.

If the PACE Program were responsible for increasing the work effort of the 8,000 employees merely one or two percent, the results would possibly warrant the costs. But increases of many times this amount are claimed for the program. The Norair Division management originally decided, as a precautionary measure, that the ratio of estimated savings due to the PACE Program to the cost of operating the program in a given department must be 6:1 before the department in question would be covered by PACE. Mr. Petersen and the Norair Division management are now convinced that this ratio has turned out to be much greater than 6:1, and estimates range as high as 30:1. The results of the PACE Program as reflected historically in the various PACE Charts support this latter estimate. If it were assumed that increased effort, as reflected by the increased PACE index, is directly convertible to cash savings in labor costs, then this 30:1 ratio is conservative. Under this assumption, a mere 10% increase in the PACE Index of the 8,000 employees now being observed, when compared to the operating costs of the 26 man PACE staff, would substantiate this claim. It would mean a payroll saving equivalent to the wages of 800 employees. The overall PACE Index for the 8,000 employees has increased approximately twice this amount!

But other than these inferences drawn from the

records of the PACE Index, there is no further evidence to objectively support the dollar value of the savings which are directly and solely attributable to the PACE Program. Due to the many complex and interrelated factors involved, it is impossible to determine the share of dollar savings which are solely attributable to the PACE Program, apart from the savings due to other cost reduction programs, technological progress, economic conditions, etc. There are numerous isolated indications of direct savings, improved efficiency, or increased productivity, but there is no way of expressing them in dollar values. For example, Norair's Assistant Treasurer, J. G. McDonnel, stated that the ratio of direct labor to indirect labor (overhead wages and salaries) decreased 9% since the PACE Program was instituted, due to the increased productivity of the workers. He also stated that judging by production costs since the PACE Program was instituted which have been so spectacularly less than estimates based upon historical costs and established learning curves that it is evident the savings due to the PACE Program exceed its costs by a ratio greater than 6:1. He also mentioned that in the Finance Department, when the PACE Index increased 10%, some people were laid off but the same amount of work was able to be accomplished. The Assistant Treasurer said that the PACE Program has categorically saved money but there is no technique for

measuring the dollars saved by the program because the effects of other cost reducing factors can't be segregated. M. L. Fayrweather, a superintendent in the Manufacturing Department, stated that when the PACE Index of his manufacturing group increased from 60% to 90%, the number of people required to do the same job decreased by 34%, indicating a possible close correlation between the PACE Index and equivalent workers in the factory. Mr. Petersen mentioned that one department was able to produce at the standard rate (as established by learning curves and historical costs) at a PACE Index of only 69%. As the PACE Index increased, production greatly exceeded the standard rate. Project after project has experienced observable, tangible results, but there are many projects or departments where the results are not as evident. Other general indications of improved efficiency include the Northrop Corporation's financial report[6] for the six months ending January 31, 1959, which reported a net profit increase of approximately 10% over the comparable period of the preceding fiscal year, even though sales decreased approximately 8%. The same trend was noted on the financial report[7] issued October 8, 1958, and covering the fiscal year ended

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[6]The Wall Street Journal--March 26, 1959.

[7]The Northrop Aircraft Corporation's Annual Report for the fiscal year ended July 31, 1958.

July 31, 1958. Though sales during the period declined about 9%, net income increased approximately 7%. As mentioned previously, the company stated in the Northrop Corporation's Annual Report the fiscal year ended July 31, 1958, "Compared with presently established standards in the Manufacturing organization, the PACE Program contributed a 21 percent improvement in group effectiveness during the first six months of its application."

There are numerous other intangible benefits and uses which are attributable to the PACE Program. Some of these will be discussed below.

Improved supervision and management of the human resource.--It is almost a unanimous opinion of the executives at the Norair Division that the PACE Program has lead to a great improvement in supervision. The executives freely express their opinions on this point. The Assistant Director of Industrial Relations (his section was not being PACE Measured at the time) stated that the PACE Program was just good for the entire organization. He mentioned that it stimulated supervision and that the supervisors have started coming up with suggestions for reorganizing their groups, cutting down on personnel, etc. He said that PACE makes managers out of supervisors and his section has improved just by what has rubbed off from the other sections. The Director of the Manufacturing Engineering Section

stated that the PACE Program brings to the attention of each supervisor the necessity for utilizing his men. If the supervisor can't fully utilize his men he must either transfer them out of his group momentarily or get rid of them. The Superintendent of the Missile Manufacturing Group stated, "PACE has caused us to cinch up on loose standards. We have really improved on our learning curves. We have continuously beat standards. It has a beneficial psychological effect on attitudes and the attitudes are contageous. PACE runs through a period of resistance then acceptance. At the beginning of a new program, savings are most phenomenal. They were 40%, not all due to PACE in my section. PACE has definitely increased in our department. We're sold on it." The Assistant Manager in the Engineering Department says, "PACE improves supervision by pointing out specific deficiencies. I was surprised at the professional attitude most supervisors have taken. With few exceptions, all have accepted PACE as an additional tool. If all we get out of PACE is supervision more sensitive to its responsibilities, then we have gained. PACE encourages the supervisors to get out of their offices and on to the floor with their people." An Assistant Superintendent of the Sheet Metal Fabrication Shop states, "PACE puts the supervisors at the worker's level, makes them plan for more effective utilization of their workers' times, eliminating idleness,

and it encourages them to motivate their workers into expending greater effort. Our PACE index has improved to the point where our shop is on a surveillance status, but our lead men have started to PACE the department four times a day to keep the men PACE conscious. The workers are normally slow to start and quick to get away. When PACE stops, this increases." The Chief of the Logistics Group, which had just had the PACE Program introduced into his area, stated, "As I see it PACE is trying to improve work habits, get the line supervisor out on the line, capture 1/2 to 2/3 of the idle time, and to make the line supervisors aware of their responsibilities, PACE points up the problem areas." A supervisor in the Model Shop said that his men have became PACE conscious. PACE inhibits the men's behavior. Mr. R. R. Nolan, Norair Division's General Manager, sums it up when he points out that, "PACE stimulates management's approach to management. It overcomes the stigma of management that it can't improve."

The PACE Program is primarily a check against the effectiveness with which supervisors are able to keep their workers busy and it is a check against supervisors' ability to motivate their workers into expending greater effort. To do this the supervisors must supervise. They are more effectively encouraged to improve worker effort, decrease idle time, and control the out of area time. After much

experience at introducing the PACE Program in department after department, a chronological pattern of first line supervisors' attitudes toward the program has evolved. Their attitudes run through a period of resistance then acceptance. At first each supervisor has the opinion that his group is actually working at the 100% PACE Index rate and that there is no need for the PACE Program in his department. The initial PACE Index is typically in the vicinity of 60%, and this exasperates him. But the areas of weakness are pin-pointed for him and as he goes to work improving on the weak areas, the effectiveness of his workers improves, sometimes with overwhelming results, and he gradually becomes an advocate of the PACE Program. The PACE people have received requests from supervisors to continue the PACE Measurement of their workers after they were put on a surveillance status. The mere expectation of a PACE observer in a supervisor's department assists him at his job of keeping his men working actively on their assigned tasks.

The PACE Program provides a check against the validity of the departmental budgets.--The natural tendency of department heads to provide "cushions" or reserves for contingencies in labor estimates for budget purposes can lead to loose budgets in many areas. The PACE Program provides a check against loose budgeting of labor and PACE has made it possible for management to promptly correct the

loose budgets. It has allowed management to overcome the inertia or the reluctance of department heads to adjust the loose budgets by promptly pointing them up. As the Director of the Manufacturing Engineering Section stated, operations that were believed to be efficient (because of their history of being able to operate within their budgets) were found to have a low PACE Index, and operations that were believed poor turned out to have a good PACE Index. The PACE Program thus enabled an adjustment of the budget allocation to correct these areas. Furthermore, the PACE Program gives a better history for future budgets, making them more dependable; and it improves the competitive position of the company in estimating costs for bids on future work. Instead of having loose labor budgets in some areas and tight ones in other areas, PACE ties them together, keeping them honest.

The PACE Program provides a check against loose time standards.--Closely related to loose budgets is the fact that the PACE Program can be used to point up loose standards established by time study. If the workers are able to produce at the standard rate, with an abnormal amount of idle time or subnormal effort, the PACE Program will point this up. Loose standards established by invalid learning curves are also pointed up.

The PACE Program provides a useful gauge of supervisorial performance.--The PACE Index should not be used as the sole basis for judging a supervisor's performance, but

it is a useful, objective factor to consider in addition to other factors, in the merit rating of supervisors. Furthermore, it can serve to provide proper recognition for good supervisorial performance.

The PACE Program improves management's decisions and saves time.--Without the PACE Program, management was required to make precarious judgements concerning the validity of personnel budgets, the effectiveness of supervision, work effort, etc. The PACE Program has placed these judgements on a much more objective basis. A maze of interrelated factors are summarized for management on the PACE Charts so that a good perspective of the problems can be obtained at a glance. Important problem areas are readily pointed up and management is provided with an objective, current basis for evaluating numerous complex factors.

Other incidental benefits.--There are many benefits attributable to the PACE Program that came about incidentally to its basic objectives. For instance, the PACE studies of one area pointed up the fact that 17% of the production men were normally out of their assigned work area, getting blue print interpretations from design engineers. This lead to the placement of a liaison engineer in the shop as a coordinator to answer these questions for the production workers, solving the problem. The Norair Division had an internal pass checking system that was able to

be eliminated in its entirety because of the close area control over people required by the PACE Program. In a missile test area, the PACE Program pointed up poor coordination between the engineers and technicians: the technicians claimed they couldn't fire the missile until the engineers were present and the engineers claimed the firing people weren't available. This matter was promptly settled when it was drawn to management's attention. The PACE Program has enforced the need for clear lines of responsibility and authority throughout the plant. When it was discovered that highly skilled production men were leaving their work areas to chase down materials or parts, a job normally assigned to a materials moving group, pressure was immediately exerted to correct the situation. In addition, numerous special studies are made for management as mentioned in Chapter II.

An Analysis of the PACE Measurement

The concept of effort rating during work sampling was fairly well established as a valid and reliable technique by Dr. R. M. Barnes in recent years. R. M. Barnes and R. B. Andrews performed a work sampling study[8] to

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[8] R. M. Barnes and R. B. Andrews, "Performance Sampling In Work Measurement", The Journal of Industrial Engineering, Vol. VI, no. 6, Nov.-Dec., 1955. This study is also included in R. M. Barnes, Work Sampling, Ch. 22, referred to in footnote 9.

develope a sampling technique which would provide an accurate and economical method of determining, with pre-assigned reliability, the effort rating of labor activities. One of their conclusions was that "even in a plant where methods are not standardized and where job descriptions are nonexistent, a performance index by operator or by department can be obtained by work sampling. Also, the work sampling data can show the percentage of idle time and delays....." Dr. Barnes performed another experiment[9] which indicated that effort rating during work sampling is a valid technique. Thus, the general theory of effort rating groups by means of work sampling techniques is not without its support. However, the mechanics through which this theory is applied in the PACE Measurement warrants further investigation. The validity and reliability of the PACE Measurement hinges upon three fundamentals: (1) the accuracy of effort rating; (2) the PACE Formulas; and (3) the statistical accuracy of sampling results.

The accuracy of effort rating.--The effort standard described as the speed of movement of the body members of a man walking at the rate of 3 miles per hour on level ground is a widely used industrial engineering standard. Though this verbal definition appears shallow, this speed

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[9]R. M. Barnes, Work Sampling (New York: John Wiley and Sons, Inc., 1957), Ch. 23.

of movement has been translated to other types of work operations by means of standard motion picture films which actually become the factory standard, and a more accurate one. The Society for the Advancement of Management and many universities have produced motion picture films for this purpose.

The management of the PACE Program credits the PACE observers with an observational accuracy of plus or minus 5% of the standard expectancy. This conclusion is based upon the experience gained by cross checking the effort ratings of one observer against another from time to time. Most time study writers are in agreement[10] that the accuracy of effort rating procedures is approximately plus or minus 5% of the given standard. R. G. Carson Jr. reports[11] in respect to ratings made by six time study men on 63 films, over a six year period, "The standard deviation of independent ratings made by men trained together on operations with which they are familiar will be approximately 6.67%. Differences between the standard deviations of different men are so small they can be attributed to sampling errors." Carson attributes his accuracy to similar,

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[10]Adam Abruzzi, Work, Workers and Work Measurement (New York: Columbia University Press, 1956) p. 37.

[11]R. G. Carson, Jr., "Consistency in Speed Rating", Journal of Industrial Engineering, Vol. V, No. 1, January 1954, p. 17.

planned, periodic training given his group. Carson's group placed 56% of their ratings within plus or minus 5% error, 74% within plus or minus 7.5% error, and 87% within plus or minus 10% error.

Morrow[12] states his belief that time study men can learn to rate within plus or minus 5% of standard and he shows the results of ratings by an inexperienced time study observer, indicating results close to this plus or minus 5% tolerance.

But some writers believe this degree of accuracy is not ordinarily attainable using the conventional effort rating methods. For example, Abruzzi[13], Nadler[14], and Gomberg[15] all dispute the claim that the average time study man can rate within this plus or minus 5% limit. Nadler[14] mentions the results of a research project that found only 46% of the effort ratings made by experienced time study men to be within plus or minus 10% of the correct value.

In the Norair Division's manufacturing functions where all of the work effort being PACE measured is manual,

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[12]Robert L. Morrow, Motion Economy and Work Measurement (New York: The Ronald Press Company, 1957) pp. 241-242.

[13]Adam Abruzzi, Work, Workers and Work Measurement (New York: Columbia University Press, 1956) Ch. 3.

[14]Gerald Nadler, Motion and Time Study (New York: McGraw-Hill Book Company, Inc., 1955) p. 383.

[15]William Gomberg, A Trade Union Analysis of Time Study (New York: Prentice-Hall, Inc., 1955) Ch. 14.

the effort rating procedure is not much different than the effort rating commonly used in time study. The PACE observer rates each man in the group. Then he computes the arithmetic mean of the individual effort ratings and this becomes the group effort rating, similar to Dr. Barnes' procedure[16]. But in many other work areas, the PACE observer must effort rate visual and oral effort, in addition to manual effort. The standard of expectancy isn't as clearly defined for these types of work effort, thus the degree of accuracy attainable necessarily diminishes. Visual and oral work effort is judged in terms of the diligence with which people apply themselves, but this diligence can't be measured as accurately as manual effort. These types of work effort are measured in terms of percentage parameters which range from excellent to very poor. The parameters are ten percentage points wide, as discussed in Chapter II.

At the Norair Division, each group is normally rated by the same observer day in and day out. He becomes well trained and acutely sensitive to the activities of his group. He becomes able to detect very small changes in the work tempo. These activities can be rated with a surprising consistency and with a higher degree of accuracy than the somewhat nebulous theory would indicate. But it must be recognized that effort rating accuracy diminishes, the

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[16]R. M. Barnes, Work Sampling, p. 206-(Explanation of Column 22).

further removed from the purely manual tasks one proceeds, and the greater the percentage of visual, oral, and COED activities become. Because the benefit of the doubt which may exist in these latter areas is always given in favor of the employee, the possible error which may exist should always be on the high side.

The PACE Formulas.--The PACE Formulas are all straight forward derivatives. In using the results calculated from the formulas, however, it must be remembered that the results so derived are only as valid and reliable as the information used in them. It must also be considered that the workers and the work assignments are not all homogeneous, interchangeable, or continuous. In addition, increasing work effort by a given percentage, as measured by the PACE Measurement, does not necessarily mean that work output will increase in direct proportion. Method, skill, and job difficulty are only a few of the intervening variables which must be considered which link work input (effort) with work output.

The Statistical Accuracy of the PACE Measurement.--The statistical accuracy which may be expected in work sampling is dependent upon the randomness of the observations, the number of observations included in the sample, and the percentage occurrence of the activity being measured. The formula used for purposes of determining the

statistical accuracy that can be expected from a given sample size, with a confidence level of two standard deviations is as shown below:

$$N = \frac{4\ (1-p)}{S^2 p}$$

Where: S = the desired relative accuracy

p = the percentage occurrence of the activity being measured

N = the number of random observations

The confidence level of two standard deviations means that approximately 95% of the time the random observations will represent the facts, and that approximately 5% of the time they will not. This formula is predicated upon the assumption that the random sample population will approximate a normal or Gaussian curve. This assumption is accurate enough for the measurement of the Idle Time and the Out of Area, but there is reason to believe that this assumption is invalid for effort rating samples, as will be discussed separately in a paragraph to follow.

After the Basic Study Period in a department has been completed as discussed in Chapter II, the daily PACE Measurement observations begin. The PACE observer passes through each group 10 times a day at random times, on random routes, 5 days a week, observing each worker in the group. According to the PACE supervisor, the average group

for which the PACE index is computed contains approximately 80 people. Thus a total of 4,000 individual observations (5 x 10 x 80) per week are normally obtained of Idle Time, Out of Area, and Effort Rating for each group. These observations are used as the basis for computing the weekly PACE Measurement Indices for the group. The Group Measurement Indices for any group are the same as the arithmetic mean percentages of Effort, Idle Time, or Out of Area of the individuals of that group. The absolute statistical error in terms of the percentage of total work time that can be expected due to the size of the statistical sample is computed for each of the three PACE Measurement Factors below.

Statistical accuracy of the Idle Time Measurement.— Assuming that the Idle Time percentage occurrence is 5%, the absolute error is computed as follows:

$$4000 = \frac{4\,(1-.05)}{s^2\ .05}$$

$$s = \pm\ 12.25\%$$

$$\text{Absolute Error} = \pm\ 12.25\% \text{ of } 5\% = \pm\ .6\%$$

This means that approximately 95 times out of 100, in the long run, the Idle Time computed from the work samples will be accurate to within plus or minus .6% of the total work time.

Statistical accuracy of the Out of Area Measure-

ment.--The computations for the Out of Area are identical to those shown above for Idle Time.

Statistical accuracy of the Group Effort Measurement.--Aside from the error that is inherent in effort rating per se, as noted above, the additional error due to the inherent inaccuracy of statistical sampling is computed below. In Barnes' experiments[17] the Chi Squared Test was applied to 8,000 random observations of effort rating which indicated that effort rating populations do not conform to the normal or Gaussian curve. He thus derived the following formula for computing the reliability of a sample estimate of a population mean that does not rely upon this assumption:

$$d = \frac{s}{\sqrt{Nm\,\alpha}}$$

Where: d = the difference between the population mean and the sample mean

α = the level of significance

Nm = the number of observations of a performance level (effort rating) population

s = sample standard deviation

Barnes' experiments indicate that the sample standard deviation usually does not exceed 12. The confidence

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[17]Ibid., pp. 195-198.

level (95%) is equal to $(1-\alpha)$, therefore $\alpha = .05$. The number of effort observations is 4,000 per week. Therefore:

$$d = \frac{12}{\sqrt{4{,}000 \times .05}} = \pm .8\% \quad \text{(approximately)}$$

This means that the group effort rating used to compute the weekly PACE Index will be within plus or minus .8% of the group's mean effort rating for that week 95 out of a 100 times, in the long run. But this error is merely the sampling error, aside from the error inherent in effort rating which was mentioned above.

How the statistical errors effect the PACE Index.--As mentioned in Chapter II, the formula used to compute the PACE Index is as follows:

$$\left[100\% - (\text{Percentage of Penalties})\right] (\text{Effort Factor}) = \text{PACE}\%$$

or

$$\left[100\% - (I + O)\right](E) = \text{PACE}\%$$

Where: I = % of Idle Time Penalty

O = % of Out of Area Penalty

E = % of Effort

To illustrate the effect of the three absolute statistical errors on the PACE Index, the PACE formula may be modified in the following manner:

$$\left[100\%-(I \pm \text{Error} + O \pm \text{Error} \; ?\;)\right](E \pm \text{Error}\;) = \text{PACE}\%$$

Each of the three absolute statistical errors shown in the PACE formula above can be either positive or negative. If by chance all three of the errors are <u>positive</u>, it can be readily seen from the formula above that they will <u>tend</u> to offset or cancel one another: the percentage errors for Idle Time (I) and Out of Area (O) <u>reduce</u> the PACE Index; whereas the percentage error for Effort Rating (E) <u>increases</u> the PACE Index. If all three absolute statistical errors are negative, the Idle and Out of Area errors increase the PACE Index, whereas the Effort Rating error would decrease the PACE Index--thus the statistical errors again tend to cancel one another. Because the three statistical errors will not be of the same magnitude (except in rare instances) and because the resultant effect on the PACE Index for a given increment of change of the errors in the Percentage Penalties (I and O) as compared to a given increment of change of the error in the Effort Factor (E), the degree that the errors tend to cancel themselves will necessarily vary from time to time, as the statistical errors themselves independently vary.

When the two errors of the Percentage Penalties

(I and O) are in opposite directions (one positive and the other negative) the tendency of all three errors to cancel themselves is thus reduced. In this instance, the Percentage Penalties tend to cancel one another leaving the statistical error in the Effort Rating Factor to fully effect the PACE Index.

The greatest possible error in the PACE Index occurs when the two errors of Percentage Penalties are in the same direction (eg. both negative or both positive) and these two errors are in the opposite direction to the error in the Effort Factor. For instance, if the two errors of Percentage Penalties were negative, and the error in the Effort Factor was positive, the errors would be arranged in the configuration that would cause all of the errors to have a common, cumulative effect--they would all tend to increase the PACE Index.

Each of the three statistical errors can occur in two possible directions, plus or minus. Thus, if we can ignore the rare occasions when there will be no error, there are 8 possible combinations[18] of directions (plus or minus) in which the three errors can arrange themselves in the PACE Index formula. Of these 8 combinations, only 2 of the possibilities result in the errors having the maximum cumulative effect: (1) the possibility that the two

[18]Because each of the 3 errors can appear in 2 possible forms, plus or minus, the possible combinations are 2 x 2 x 2 = 8.

errors of the Percentage Penalties will be negative when the statistical error of the Effort Rating is positive; and (2) the possibility that the two errors of the Percentage Penalties will be positive when the statistical error of the Effort Rating is negative. Hence the probability is 2/8 or 25% that the configuration necessary for maximum statistical error in the PACE Index will occur.

Assuming that the maximum statistical error will occur in each of the three PACE factors (I, O, and E) approximately 5% of the time, the probability of all three absolute errors reaching a maximum value concurrently and arranged in the configuration whereby all errors are cumulative (thus maximizing the PACE Index Error), can be computed as follows[19]:

$$.25 \times .05 \times .05 \times .05 = .00001875$$

Hence, the probability is only .001875% that the PACE Index error will reach a maximum.

In summary it may be stated that 75% of the time, in the long run, the statistical errors of the PACE Measurement will tend to cancel themselves to some degree, in the formula used to compute the PACE Index. The other 25% of the time the errors will arrange themselves in a configuration that will tend to make the errors cumulative in the PACE Index calculation. In the long run, less than 2 of

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[19]Frank Loxley Griffin, Mathematical Analysis (New York: Houghton Mifflin Co., 1936) p. 477.

every 1,000 weekly PACE Index calculations, or approximately one every 10 years for each group will the statistical errors approach the maximum.

Significance of the Accuracy of the Individual PACE Indices.--It should be noted that the PACE Index trends are of primary concern in the PACE Program, rather than any given weekly PACE Index, Idle Time Index, or Out of Area Index. Furthermore, whenever a given PACE Index denotes a radical change in trend for a group, the group becomes the subject of more intensive study to determine why. Thus, the effects of the more radical random errors are minimized.

The Affect of the PACE Program Upon Personnel

As mentioned earlier, PACE observers have no direct contact with the individual workers. The observers merely pass through each group making the necessary observations, and they independently and objectively record what they see. The observers ordinarily make no comments to the workers: the individual worker's actions are merely entered in the observer's book as a statistic for computing group effort. No names of individual workers are involved. The only knowledge of what is taking place is gained by the employee from his first line supervisor. Thus the sole responsibility for controlling and motivating employees rests with the supervisors. The PACE Program merely points

out the problem areas, then it is up to the supervisor to take action. Whether or not the employees are apprised of the weekly ratings is left to the individual supervisory technique. The potential for utilizing the program to motivate the workers is great, and as mentioned previously, some supervisors are posting the weekly ratings in prominent positions for their employees to view. If the supervisor uses the proper techniques, he can do much to shape the attitudes and behavior of his men so that the PACE ratings become a strong motivational factor. If the presence of the PACE observer in a department is supplemented by good supervisory leadership and the proper use of psychology, the PACE Measurement can become a valuable aid to the supervisor in his efforts to inhibit undesirable work habits. The use of special awards for consistently high work effort, the effect of individual recognition, group identity, the feeling of pride and self fulfillment--all can contribute much to the benefit of the workers as well as management, if they are properly cultivated by the supervision.

Because so much responsibility rests with the supervision, it is extremely important that the supervisors be fully indoctrinated and sold on the benefits of the PACE Program in order to gain the maximum benefits. The Norair Division gives indoctrinational lectures to help achieve

this. But as mentioned earlier, the normal pattern is to experience resistance, gradual acceptance, then the supervisor becomes an advocate of the PACE Program. In general, the attitudes of the workers sharply reflect their supervisor's attitudes toward the program. In departments where the PACE Program has been in force for a lengthy period, the work effort is usually high, the idleness and out of area is low. Where the PACE Program is being initially installed, the supervisor is usually not quite in complete sympathy with the program or he may have a negative attitude toward it. The status quo of his department is being disturbed, and his problem areas are being brought into view. It is here that employee attitudes concerning the PACE Program are temporarily poor. In one such department, the workers were observed to greet the PACE observer with catcalls and indian signs behind his back. It is in such areas that idleness and out of area are high, and work effort is low. Needless to say, it isn't long before such an area has been straightened out. But the obvious and great contrast between the work efforts of two such groups is a convincing argument to sell the bystander upon the merit of the PACE Program.

At the Norair Division, it is uncommon to see employees gathered in groups, engaged in personal conversation, or otherwise idle, as is prevalent in most large industrial

organizations. One ex-PACE observer, now working with another large industrial firm, stated that he was amazed by the amount of idleness and the generally low effort in his new firm. The Norair people believe that the average PACE Index of the airframe industry is between 55-65%. Some eastern company representatives have admitted to the Norair people that in some areas they would be satisfied with 50%. A cursory look at other industrial organizations makes this allegation appear correct.

Many people credit the influence which the PACE Program has upon personnel as being its most valuable contribution to the company, even more important than its value as a management control. The synergism--the sparking interraction between the members of management, between the supervisors and their workers, and between the workers themselves--has lead to something tangibly more than the sum of its parts. The situation was summed up by the executive who said, "PACE is just good for the whole organization. It stimulates supervision. The supervisors have started coming up with organizational suggestions, suggestions for cutting down on personnel, etc." This was reiterated by Norair's General Manager when he mentioned, "PACE stimulates management's approach to management. It overcomes the stigma of management that it can't improve." PACE has become a state of mind at the Norair Division.

The effect of the PACE Program upon personnel grievances.--The Norair Division has no large union. It is the only large aircraft manufacturing firm in the Los Angeles area that is not unionized. It's a tribute to Norair's good management that the employees have not felt the need to unionize. The company has a formal and an informal grievance procedure. The Assistant Director of Public Relations for the Norair Division stated that a 10-15% increase in the volume of grievance activity was experienced because of the PACE Program. This was not as great an increase as was recently caused by the elimination of food service in some departments. In the engineering functions, a 5% increase in grievance activity was noted, but only part of this was due to the PACE Program. Very few employees have terminated service due to the PACE Program. Some of those that blamed the PACE Program for leaving the company have since returned and they have been re-employed.

The effect of employee sham or "staging" of work effort.--It has been the experience of the PACE Program that a certain amount of sham or staging of effort is encountered during the initial phases of the introduction of the program into a department. However, after the PACE Observers have passed through a group 15 times a day for a number of days during the initial study period and then 10 times a day

after that, on random routes and at random times, the workers soon learn that it is easier to put forth honest effort to the task than to keep up a false front.

The affect of the PACE Program upon industrial relations in general.--As mentioned previously, no major segment of the employees at the Norair Division belong to a union. However, a union would have no valid basis on which to voice an objection against the PACE Program. The PACE Program is merely rating the effectiveness of the supervisor when it measures the group effort: there is no direct dealing with the workers, except for what the supervisor may pass along to them. Furthermore, the union should not object to the company's concern for idleness, unauthorized out of area, or substandard work effort. The standard of expectancy for work effort is one that is not excessive; it has been generally accepted by industry for years; and the employee is given the benefit of the doubt wherever there is a question.

CHAPTER IV

AN ANALYSIS OF DESIRABLE PREREQUISITES FOR APPLYING THE PACE PROGRAM IN OTHER COMPANIES

What Kind of Company Would Profit Most By A PACE Program?

Size of Company.--In general, the PACE Program could possibly be applied to some degree by any size of organization. The small proprietorship employing only a few employees would necessarily use a less formal configuration of the PACE Program. The relative need for the program is probably less in the small organization where all employees are under the direct supervision of the owner than in the huge, sprawling factory employing many thousands of people.

Type of Company.--In factories where the unit production volume is high, production runs are long and stable, the tasks are highly repetitive, there is a fine division of labor, and the work tempo is geared to the speed of movement of an assembly line, the production is probably highly standardized and there is probably less relative need to PACE Measure the direct labor, except to check for loose standards. If there are large numbers of indirect workers supporting the direct factory workers, as is usually the case, there is a greater relative need for the

program.

But the industries where the most impressive need for PACE is apparent are those where production is in job lots, not adaptable to the assembly line; the work is not repetitive and uniform; and/or particularly where the workers' output cannot be adequately, objectively and fairly judged in relation to the time expended on the job. It is here that work effort can vary extensively from day to day in a department, or from department to department, and work effort can't be effectively judged or controlled by management. Management has no objective gauge or basis for requesting improvement. The workers of such a work group have little incentive to increase their productive efforts, because it could not be recognized by management regardless of how well they perform. These types of areas in industry are offered the most impressive rewards by a PACE Program. This should not be interpreted to imply that manufacturing organizations or large repair and maintenance organizations are the only types offering greatest dividends for investment in a PACE Program. Large office and financial centers such as are characteristic of the insurance and banking industries appear just as attractive for a PACE Program. The Norair Division's PACE staff has discovered that the largest share of the operations in these functions is primarily manual (eg. typing, operating calculating machines,

filing, writing, etc.) and therefore many of them can be effort rated with a high degree of accuracy. Furthermore, idle time, out of area, extended coffee breaks, gathering around the water cooler, and personal visiting tend to reach high proportions in these functions; and output ordinarily cannot be gauged accurately in terms of work effort. PACE is a good guard against such a phenomenon as Parkinson's Law.

As mentioned in previous chapters, the degree of control over work effort made available by the PACE Program is less for some technical, engineering, and office functions than it is for most manufacturing functions. The psychological possibilities are the same for each function. Furthermore, the mere possibility of recapturing a portion of idle time and out of area would warrant the use of a PACE Program in most instances.

Necessary Prerequisites to the Use of a PACE Program That Are Dependent Upon Company Initiative

PACE requires the strong support of top management. It is apparent that such a sweeping program as PACE must have the strong support and leadership of the top management of an organization to enable its success. It is not the mere possession of a management tool that gives it value: the manner in which it is put to use determines its value. In some instances even the improper tool may be

successfully "made to work" with the strong backing by management; but in the majority of instances, even a good management tool will fail without good leadership and backing by the top executives. The PACE Program is not a panacea that will work automatically. The program normally encounters some factions that offer strong initial resistance, as mentioned earlier; and a powerful impetus is required to overcome the resistance. The importance of the support given to the PACE Program by the top executives of the Norair Division should not be underestimated.

PACE requires the thorough indoctrination of all concerned.--The results to be expected from the PACE Program will be in direct proportion to the effectiveness with which it is "sold" to everyone in the organization. The Norair Division utilizes highly professionalized indoctrinational lectures and films which are unusually effective. This phase of the PACE Program cannot be neglected. People naturally resist changes, new ideas, or new methods. This resistance is emotional in nature and it is usually rooted in some sort of unfounded fear or distrust. Fear that positions will be made insecure, fear of appearing clumsy or inept, fear that employees may not accept the new idea, fear that prestige or importance will be lost--these are merely a few of the many variations. These fears can be allayed by proper indoctrination and explanation. Without

proper indoctrination the entire program could possibly degenerate into a farce.

The PACE Program requires highly qualified observers.--The PACE Observers must be professionally minded, carefully screened, and highly trained individuals, preferably with experience in motion and time study. They must have a high degree of integrity because the integrity of the entire PACE Program rests with them. If confidence in their skill, independence, or objectivity is lost, the program can fail or lose much of its value. The Norair Division's PACE staff includes many people with extensive industrial experience and people with advanced educational degrees.

The PACE Measurement results must be interpreted fairly and objectively.--All limiting factors of the PACE Measurement as discussed in Chapter III must be given due weight and consideration in making decisions or reaching conclusions which are based upon the PACE Measurement. Otherwise, confidence and respect for the program may be lost along with much of its value.

Possibilities for Improvement of PACE

The PACE Program is a flexible management tool. It can be tailor made to fit the individual needs of a given situation. It can be made more accurate, if conditions

warrant, by improving upon the effort rating skills of the observers, and by a more narrow definition of the standards. The Norair Division's PACE staff has been continually improving and developing the PACE Program. Methods and procedure are undergoing constant change and refinement; and the program is continually being extended to cover more types of work specialty. Depending upon individual company conditions, closed circuit T.V. may be used, allowing each observer to cover more people, take more samples to increase accuracy, decrease the number of observers required, and to possibly enhance the psychological affect of inhibiting undesirable work habits. The cost of the T.V. installation and maintenance could be shared by other functions that could profitably utilize it. For instance, supervisors, department heads, night watchmen, firemen, security police, etc., may have an important enough need for the T.V., depending upon conditions within the company. However, the people of Norair's PACE Program have carefully investigated this possibility and they have reached the opinion that T.V. would not be suitable. They believe that there would be adverse psychological effects. This view was shared by other people questioned on the subject by the writer.

The Comparative Indices selected by the Norair Division for comparison with the PACE Index were selected to show a correlation or lack of correlation. In many

instances a lack of correlation reveals more than correlation itself. But these indices were selected primarily because they were readily available to the PACE staff without generating extensive additional reporting and paper work. Any organization instituting a PACE Program could possibly select indices that were peculiar to its own operations. It would not necessarily have to use the Comparative Indices selected by the Norair Division.

Observers talented at lip reading, in addition to the other skills can be profitably used in certain areas. As mentioned earlier, some type of system for rewarding outstanding work effort, group identification, individual recognition, etc. may be of value in certain circumstances. The possibilities for improvement are manifold, and the Norair PACE staff is continuously making changes in the program to increase its effectiveness.

CHAPTER V

SUMMARY AND CONCLUSIONS

Early in the course of this investigation it became apparent that management-oriented people tended to accept the PACE concept much more readily than the technically-oriented engineers and scientists. The reasons for this are apparent and they help point up an important conclusion concerning the PACE Program. Management people are generally more cost conscious and they tend to be more people-oriented than the engineers, mathematicians, and scientists. Technically-oriented people are more used to dealing with things than with people, and their problems are normally solved with much greater mathematical precision and accuracy than those of management. The engineers, mathematicians, and scientists tend to object to the PACE Measurement on the ground that it is not scientifically exact. The degree to which the PACE Measurement is founded upon judgement and approximation makes it difficult for technically-oriented people to accept: this characteristic does not particularly repel management-oriented people because the overwhelming majority of management's decisions and conclusions are necessarily based upon judgement and approximation. Most of management's established controls

and tools are based upon subjective opinion and approximation. The allocation of overhead in cost accounting, the computation of depreciation in accounting, the rating of merit ratings, the computation of bonus payments for a bonus program, wage and salary administration, sales and production forecasts (used as the underlying basis for most other management controls), etc.--all are based upon subjective opinion substantially less objective in some cases than the PACE Program. This does not preclude their use as valuable management tools.

The PACE Program is a systematic procedure for judging employee effort and it economically places this judgement on a much more objective basis than has been available up to this time. The potential rewards of a PACE Program are phenomenal and it appears that the program can be effectively utilized by a large segment of business and industry. But there are many links in the chain of events leading to a successful PACE Program. PACE is a management tool, and like any other tool, the manner in which it is put to use is more important than its mere possession. The best tool, if improperly used or unused, can be valueless. The PACE Program developed by the Norair Division of Northrop Corporation, properly used, is a valuable management tool. It represents a breakthrough in management's long search for means of controlling

employee effort. Judging by the fabulous interest it has generated throughout the United States during its year and a quarter existence, it will soon become one of the established management controls.

APPENDIX

ORG. NAME NUCLEAR ENERGY
SUPV. VON ENGLEBAUM

W/E 4-7-64 AREA 2 ORG. 1331
OBSERVER DAN SCHEICK SHEET 1 OF 1

MONDAY NO. ASSIGNED 17

OBS. NO.	TIME	TOTAL NO. OBS.	IDLE	NO. WKG.	% EFT.	EQUIV. WKRS.	OUT OF AREA	MAN'L	VISUAL	ORAL	COED
1	4¹⁵	16	-	16	90	14.4	1				
2	5⁰⁰	16	-	16	95	15.2	1				
3	6⁴⁵	16	-	16	100	16.0	1				
4	7⁰⁵	16	-	16	95	15.2	1				
5	7³⁰	17	-	17	95	16.2	-				
6	8⁴⁰	17	-	17	95	16.2	-				
7	9²⁵	16	1	15	95	14.3	1				
8	10²⁰	17	2	15	90	13.5	-				
9	12⁰⁰	17	-	17	95	16.2	-				
10	12⁵⁰	17	-	17	80	13.6	-				
TOTAL		165	3	162	-	15.8	5				

THURSDAY NO. ASSIGNED 17

OBS. NO.	TIME	TOTAL NO. OBS.	IDLE	NO. WKG.	% EFT.	EQUIV. WKRS.	OUT OF AREA	MAN'L	VISUAL	ORAL	COED
1	6¹⁵	17	1	16	80	12.8	-				
2	9³⁵	17	-	17	85	14.5	-				
3	9⁰⁵	17	-	17	90	15.3	-				
4	9¹⁰	16	1	15	85	12.2	1				
5	9⁴⁰	17	-	17	85	14.5	-				
6	10¹⁰	17	-	17	90	15.3	-				
7	10³⁵	17	-	17	90	15.3	-				
8	11¹⁰	17	1	16	85	13.6	-				
9	11⁴⁰	17	-	17	85	14.5	-				
10											
TOTAL		152	3	149	-	128.0	1				

TUESDAY NO. ASSIGNED 21

1	5⁵⁵	21	-	21	80	16.8	-				
2	6³⁵	21	-	21	95	20.0	-				
3	9¹⁵	21	-	21	95	20.0	-				
4	9²⁰	21	1	20	95	19.0	-				
5	9⁵⁰	21	-	21	95	20.0	-				
6	11⁰⁰	21	-	21	90	18.9	-				
7	11²⁰	21	-	21	85	17.9	-				
8											
9											
10											
TOTAL		147	1	146	-	132.4					

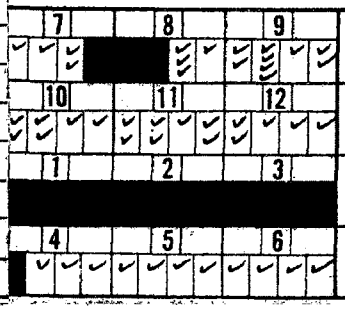
FRIDAY NO. ASSIGNED 18

1	4⁵⁰	18	-	18	90	16.2	-				
2	6⁰⁵	18	-	18	90	16.2	-				
3	7²⁰	18	-	18	90	16.2	-				
4	8⁵⁰	16	-	16	95	15.2	2				
5	9⁵⁵	17	-	17	100	17.0	1				
6	10¹⁰	18	-	18	95	17.1	-				
7	11⁴⁵	17	-	17	95	16.2	1				
8	11⁵⁵	18	-	18	95	17.1	-				
9	12³⁰	18	-	18	90	16.2	-				
10	12⁴⁵	18	-	18	85	15.3	-				
TOTAL		176	-	176	-	162.7	4				

WEDNESDAY NO. ASSIGNED 23

1	4³⁰	23	-	23	90	20.7	-				
2	5²⁵	23	-	23	90	20.7	-				
3	5³⁵	23	-	23	95	21.9	-				
4	7⁴⁰	23	-	23	95	21.9	-				
5	9³⁵	21	-	21	85	17.9	2				
6	9²⁰	20	-	20	90	18.0	3				
7	10⁴⁰	22	-	22	95	20.9	1				
8	11²⁰	22	-	22	90	19.8	1				
9	12⁰⁰	23	1	22	85	18.7	-				
10	12³⁵	23	4	19	75	14.3	-				
TOTAL		223	5	218	-	194.8	7				

	OBS.	IDLE	NO. WKG.	EQUIV. WKRS.	OUT OF AREA	MA	VI	OR	CO
TOTAL	863	12	851	769.7	17				
					%				



87	% PACE
90	%AVER. EFFORT
1	% IDLE TO THOSE OBSERVED
2	% OUT OF AREA

Appendix A
PACE Observer's Data Book Record Sheet showing one week's observations in a Manufacturing Function

ORG. NAME SPACE VEHICLE W/E 1-20-64 AREA 5 ORG. 1313

SUPV. VON SCHMIDT OBSERVER DON SCHEICK SHEET 1 OF 1

MONDAY NO. ASSIGNED 23

OBS. NO.	TIME	TOTAL NO. OBS.	IDLE	NO. WKG.	% EFT.	EQUIV. WKRS.	OUT OF AREA	MAN'L	VISUAL	ORAL	COED
1	9⁵⁰	22	4	18	60	10.8	1	4	6	5	3
2	10⁵⁵	21	-	21	70	14.7	2				
3	10⁴⁹	22	2	20	65	13.0	1	2	9	7	2
4	11²⁰	21	4	17	70	11.9	2				
5	1¹⁵	22	-	22	80	17.6	1	10	3	7	2
6	2³⁵	21	-	21	75	15.8	2				
7	3²⁰	20	2	18	80	14.4	3	7	3	5	3
8	3⁵⁵	23	-	23	80	18.4	-				
9	4¹⁹	21	5	16	60	9.6	2	10	2	8	1
10	4³⁵	20	2	18	70	12.6	3				
TOTAL		213	19	194	71	138.8	17	33	23	32	11

TUESDAY NO. ASSIGNED 24

OBS. NO.	TIME	TOTAL NO. OBS.	IDLE	NO. WKG.	% EFT.	EQUIV. WKRS.	OUT OF AREA	MAN'L	VISUAL	ORAL	COED
1	9²⁹	23	4	19	75	14.3	1	3	4	9	3
2	8⁴⁶	22	2	20	70	14.0	2				
3	9²⁰	23	-	23	65	15.0	1	12	3	5	3
4	10³⁷	23	2	21	80	16.8	1				
5	11⁴⁵	22	-	22	75	16.5	2	12	3	5	2
6	12⁰⁵	24	3	21	65	13.7	1				
7	1³⁵	22	2	20	70	14.0	2	9	2	4	5
8	2³⁵	21	6	15	65	9.8	3				
9	3⁴⁵	23	-	23	75	17.3	1	9	4	7	3
10	4⁰⁰	23	2	21	60	12.6	1				
TOTAL		226	21	205	700	144.0	15	45	16	30	16

WEDNESDAY NO. ASSIGNED 22

OBS. NO.	TIME	TOTAL NO. OBS.	IDLE	NO. WKG.	% EFT.	EQUIV. WKRS.	OUT OF AREA	MAN'L	VISUAL	ORAL	COED
1	8⁰⁰	22	9	13	60	7.8	-	3	2	5	3
2	8³⁵	22	6	16	75	12.0	-				
3	9¹⁹	21	-	21	75	15.8	1	3	6	9	3
4	9⁵⁵	22	-	22	70	15.4	-				
5	10⁵⁰	21	-	21	80	16.8	1	4	4	11	2
6	11⁵⁰	20	-	20	70	14.0	2				
7	1¹²	20	2	18	80	14.4	2	4	3	10	1
8	3⁰⁰	21	3	18	55	9.9	-				
9	3⁴³	18	-	18	75	13.5	4	2	1	12	3
10	4⁵⁵	19	3	16	65	10.4	3				
TOTAL		206	23	183	705	130.0	13	16	16	47	11

THURSDAY NO. ASSIGNED 22

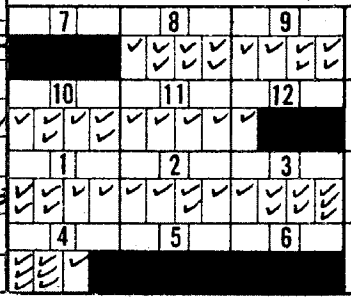
OBS. NO.	TIME	TOTAL NO. OBS.	IDLE	NO. WKG.	% EFT.	EQUIV. WKRS.	OUT OF AREA	MAN'L	VISUAL	ORAL	COED
1	8²⁰	22	3	19	70	13.3	-	7	3	9	-
2	8⁵⁰	22	2	20	80	16.0	-				
3	10¹⁵	21	-	21	75	15.8	1	4	3	12	2
4	10³⁵	20	-	20	65	13.0	2				
5	11³¹	22	-	22	75	16.5	-	6	2	11	3
6	2⁰⁰	20	-	20	80	16.0	2				
7	2⁵⁰	22	4	18	75	13.5	-	4	4	10	-
8	3²⁹	19	2	17	70	11.9	3				
9	3⁵⁵	22	-	22	85	18.7	-	5	6	8	3
10	4¹⁵	21	-	21	80	16.8	1				
TOTAL		211	11	200	755	151.5	9	26	18	50	8

FRIDAY NO. ASSIGNED 23

OBS. NO.	TIME	TOTAL NO. OBS.	IDLE	NO. WKG.	% EFT.	EQUIV. WKRS.	OUT OF AREA	MAN'L	VISUAL	ORAL	COED
1	8⁵⁸	22	6	16	70	11.2	1	1	3	8	4
2	9¹⁸	22	-	22	90	19.8	1				
3	9⁵⁰	22	3	19	75	14.3	1	9	4	3	3
4	1¹²	20	-	20	65	13.0	3				
5	1²⁰	21	2	19	75	14.3	2	11	3	3	2
6	1⁵¹	23	3	20	80	16.0	-				
7	2¹⁵	21	2	19	95	18.1	2	5	11	3	-
8	9³⁵	20	-	20	90	18.0	3				
9	4⁰⁵	21	2	19	90	17.1	2	5	11	3	-
10	4²⁰	23	4	19	70	13.3	-				
TOTAL		215	22	193	800	155.1	15	31	32	20	9

	OBS.	IDLE	NO. WKG.
TOTAL	1071	96	975

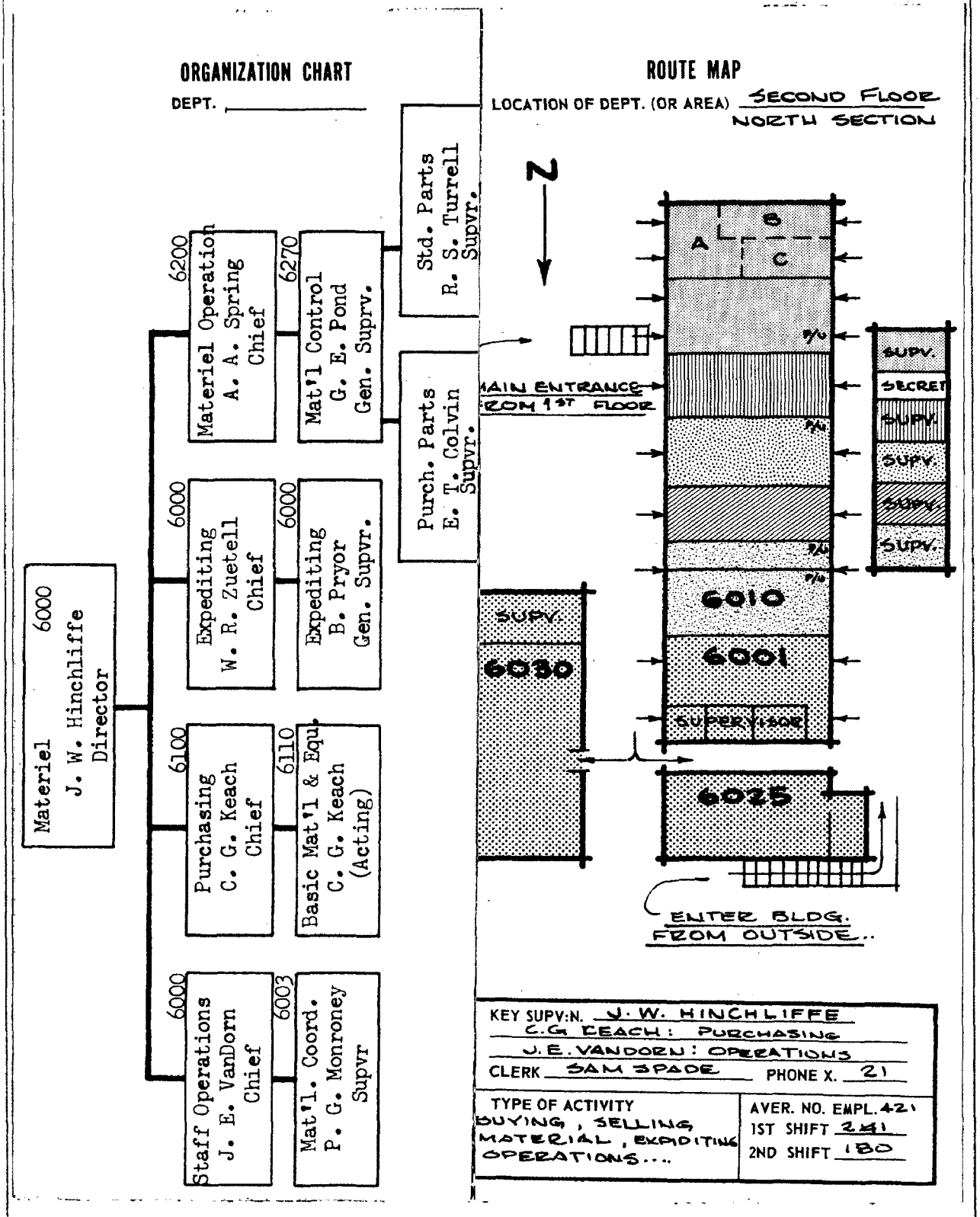
EQUIV. WKRS.	OUT OF AREA	MA	VI	OR	CO
719.4	69	151	105	179	52
	%	31	21	37	11



67	% PACE
74	% AVER. EFFORT
5	% IDLE TO THOSE OBSERVED
6	% OUT OF AREA

Appendix B

PACE Observer's Data Book Record Sheet showing one week's observations in a Technical/Engineering Function



Appendix C
Organization Chart and Area Map carried in PACE Observer's Data Book

DAY	OBS. NO.	PERTINENT NOTES
M	1-4	1 man in pchool
M	8	2 men waiting for
		spins from H.T.
W	9	work load
		decreasing
W	10	out of work -
		early clean up
		by working
		people
Th	1-9	work load light
		much stretch out
		or clean up
		activity, some
		maintenance work.
Th	4	1 man to tool
		storage to pick
		up small jig
F	4-5	1 man to first
		aid.
Tu		Special PACE
		meeting
Th.		attended by
		observer
		reducing time
		available to take
		readings

Appendix D
PACE Observer's Data Book pertinent notes sheet

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