A WORK SAMPLING INVESTIGATION OF WHITE COLLAR WORKERS (FEMALE-CLERICAL)

by

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ABSTRACT

This investigation was carried out to determine the distribution of the work-effort of clerical workers into the different work-activities. It was also intended to determine the amount of time spent on personal needs by the above group of workers and compare it with the personal and/or fatigue allowances reported by various authors in texts on motion and time study.

In the four departments selected, a total of 30 workers were observed. Fourteen work- and delay-activities were listed on an observation sheet and some of them were further qualified by such suffixes as "a," "b," "w" and "p."

The workers were observed at all times of the working hours, except official rest periods, using a scheme of systematic sampling. The purpose of the investigation was made known to the workers prior to the beginning of actual observations, to ensure a normal and relaxed atmosphere.

An examination of the computed data shows that although there is considerable variation in the productivity of the different departments, the percentage of the total personal delays is consistent from one department to another. This again varies significantly within each department, as does the "direct work" and supporting delays." There is enough evidence to believe that, within each department, individual workers have stable work patterns, although at different levels.

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PURPOSE

In 1910, the clerks and the kindred workers formed 10.2 per cent of the total work force in U.S.A. In 1954, the same group formed 19.5 per cent of the total. In this age of strong competition, the management is increasingly faced with the problem of cost reduction. There is a constant effort to widen the existing areas of cost reduction, and the search for new fields continues. Thus it is consistent, both from an operating and an economic view point, that the management should have complete knowledge of the amount of time actually consumed by different types of delays among the white collar group. The purpose of this research is to determine, using statistical methods, the relative amount of time spent on different work activities by a group of white collar workers and to provide, through representative measure, the estimate of the rates of different types of non-productive activity.

INTRODUCTION TO THE THEORY OF WORK SAMPLING

Sampling, in statistical references, is defined as the process of drawing inferences concerning the characteristics of a mass of items, by examining closely the characteristics of a somewhat smaller number of items drawn from the entire mass. "Sample," is the term used for this small number, and "population," or "universe," is the term for the large mass.

Work sampling marks the beginning of the use of statistical methods to cope with the variability inherent in work measurement. It advocates taking qualitative observations in a random manner over a protracted interval, as opposed to the classical procedures of "interruption study," which require that quantitative observations be taken over a continuous but limited period.

Work sampling is based upon the laws of probability, which are well illustrated by the examples of coin tossing and drawing beads from a bowl, where the distribution of the universe is known in advance. It will not be undertaken here to enumerate the different laws of probability, but a brief discussion of the Binomial Theorem is in order.

In work sampling, most authors assume the simplest possible model--that, under conditions of random sampling, the probability of finding the activity in question in a particular state is the same throughout the period of study. Under this assumption, the relative frequency with which "X" of the "n" observations are to be found in a particular state, when the probability of finding any one observation in that state "p," is given by the binomial distribution:

$$f(X/n) = \frac{n!}{X!\ (n-X)!}\ p^X\ (1-p)^{n-X}$$

where $0 \leq p \leq 1$

$0 \leq X \leq n,$ X is an integer.

For this simple binomial model, the sample proportion (X/n) is an unbiased estimator of the probability "p"--the average of the sample proportions from an infinitely large number of samples from the same population would be equal to the probability "p." Thus, the estimating formula does not introduce a bias.

The variance of the sample proportion, a measure of its precision as an estimator, is given by the expression:

$$\text{Var}\ (X/n) = \frac{p(1-p)}{n}$$

Since the probability "p" is unknown, an approximation to the variance is obtained by substituting for the unknown "p" its estimator, the sample proportion (X/n).

In general, there are three common methods of sampling:

1. Random Sampling
2. Systematic Sampling
3. Stratified or Selective Sampling

It is difficult to define "randomness," but it can be described as a method of drawing samples where "no apparent order" or connection between and/or among items is present. A human being is a poor randomizng device; hence, one of the following methods is usually adopted for random sampling:

1. Card Randomization

Card are prepared with the days and the minutes marked on them, mixed well and then drawn, one at a time; the day and the minute is noted down and the card replaced before another drawing. The required number of samples are obtained in this way and then ordered chronologically.

2. Table Randomization

From any arbitrary number in the random number table, the digits are read, either horizontally or vertically, four at a time. The first number is associated with the day of the week, the second number with the hour of the day, and the third and fourth numbers, together, represent the minute of the hour. N samples are obtained in this way and then ordered chronologically.

Systematic sampling is a method in which a regularly ordered interval is maintained between items chosen. A great deal of work sampling is performed using some form of systematic sampling. If there is no cyclic behavior present in the phenomenon under study, systematic sampling is acceptable, and certainly advantageous from an operating point of view.

In many applications of work sampling, where it is suspected that the probability of finding the activity in a given state does not remain constant, stratified sampling is resorted to. Here the population is divided into periods, or strata, in each of which the probability is assumed to remain constant. Advantageously, the allocation of observations among periods can be proportional to the length of the period and either random or systematic sampling is used in making the observations. It has been shown that proportionally allocated stratified sampling is always at least as precise as the simple random sampling, which is appropriate for the binomial model.[1]

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1. Richard W. Conway, "Some statistical aspects in work sampling," Journal of Industrial Engineering, March-April, 1957. p.107.

DEFINITION OF THE ACTIVITY ELEMENTS

1. Writing Operations

   Writing with pen or pencil, on papers, forms, cards, and so forth. "Make ready" and "Put away" included.

2. Handle Papers

   Papers, forms, slips, cards in hand; sitting or standing; all arm and body motions except walking.

3. Operate Office Equipment

   Operating all mechanical and electrical equipments such as typewriter, adding machine, duplicating machine, stamping and paper-punch, photographic equipment, and so forth.

4. Conversation

   A. Pertaining to work, with co-workers or outsiders.

   B. Personal conversation with anybody.

5. Filing

   Taking out from or putting into drawers or regular files, papers, cards, and so forth.

6. Walking

   Walking empty handed or with papers, cards, books or anything else in hands. "Getting up" from chair or "Sitting down" on chair, before after "walking" included.

7. Absent

   A. Not in sight; out of work area on business.

   B. Not in sight; out of work area on personal needs.

8. Use Telephone

   Receive incoming calls or make calls to outside.

9. Counter Service

   Attending to outsiders at window or counter, exchanging information, or making business transactions.

10. Wait on Customer

    Not used

11. Make Sale

    Not used

12. Delay

    Receive instructions from supervisor; wait for supervisor; obtain supplies; sharpen pencil; clean table; unavoidable accidents, such as spill ink; raise window shade and like.

13. Miscellaneous

    Usually reading, checking, varifying, and so forth, connected with "operate office equipment" and other major elements.

14. Relax

    Attending to personal needs while on the work station, read newspapers, or just idle.

DESIGN AND EXECUTION OF THE SAMPLING PLAN

A work sampling investigation is usually divided into three phases as follows:

A. Preparing for Work Sampling

1. Deciding upon the main objectives or purposes of the study.
2. Obtaining the approval of the supervisor of the department in which the work sampling study is to be made.
3. Announcing the fact that the study will be taken.

B. Performing Work Sampling

1. Classifying into elements the activity to be studied and describing in detail each element to measured.
2. Designing the observation form.
3. Determining the number of observations to be made, the number of days over which to continue the study, the time for taking the observations, the number of workers to be included in the study, the confidence level, the accuracy of the estimates, and other details.
4. Observing activity and recording data.

C. Evaluating and presenting results of Work Sampling

1. Evaluating the validity of the data.
2. Evaluating the reliability of the data.
3. Determining the accuracy of the data.
4. Analyzing and presenting the data in forms of tables, charts, etc.
5. Drawing conclusions.

The discussion here will be confined to the first two phases, and the third phase of the investigation will be dealt with under "Discussion of Results."

The purpose of the study has been stated under the same heading; hence, no reiteration is necessary.

After the main objectives of the study were formulated, the departmental heads of the departments selected were approached and the purpose of the study was explained to them. The whole-hearted support received was more than expected. Assurance was given that all efforts to conceal the identity of the departments and the workers observed will be made. Accordingly, in the presentation of the results, the departments are identified by the capital letters A, B, C, and D; while the workers within each department are identified by small letters a, b, c, and so forth. It was also pointed out that the sampling plan would involve little direct contact with the workers being observed and, as such, would not be a hindrance to them in carrying out their assigned duties.

After obtaining the approval of the departmental heads, further details were discussed with the immediate supervisors in charge of the workers. The need to announce the fact that the study will be taken and to explain the purpose of the study to the workers to be observed was stressed. In all but one department, this announcement was made by the supervisor and the purpose briefly explained. Later in the course of the study, questions of the individual workers were answered by the observer from time to time.

In a work sampling study, the need to seek worker cooperation cannot be exaggerated. It is essential that the workers should proceed with their work in the normal manner during the period of the study. This is one of the main reasons why, in the present investigation, a scheme of systematic sampling was adopted, although the work sampling literature recommends the random sampling method. A biased formula can give biased estimates, but of greater importance in work sampling is the bias introduced through a poor design and execution of the sampling plan.

In most work sampling applications, the observer makes trips of the different work stations at random intervals. In fact, if the work stations are spread over a large area, there is no other choice for the observer except to make trips. This further limits the type of sampling to random sampling, in order to avoid introducing a bias. If the trips are made at regular intervals (systematic sampling), it is obvious that the workers would anticipate the appearance of the observer or that the trips might coincide with certain periodical elements of the activity.

Now even if the trips are made at random, the workers may be expected to change their behavior at the appearance of the observer. To the extent that the worker can anticipate the time of observation and is able to alter the state of activity that will be observed, work sampling is susceptible to a very serious amount of bias.

Now these difficulties can be eliminated if the observer can observe the activities of any one of a group of workers, from a single observation post. Under such a method, firstly, a systematic sampling is possible and desirable. Secondly, a worker certainly cannot know at what instance he is being observed. It was believed that this system would result in a relaxed atmosphere in which the workers would work in their normal fashion. It was found later that this belief was amply justified. Of course, this did not, in any way, eliminate the need to explain the program to the workers in advance. On the contrary, since this study was to be undertaken for a group of white collar workers, it was emphasized that effort should be made to clear their doubts, if any.

Other possible sources of bias in the design of the plan are the precise definition of the population to be sampled, the definition of the different states of activity, and the method of selecting the observation times.

It should be noted here that, even within a department, different workers were not supposed to be performing the same type of work, in the sense that they were assigned different duties. Thus, a single universe, in this respect, cannot be rightly assumed. This makes the data non-homogeneous and this characteristic will be further discussed at a later stage. Some of the workers, whose duties approached those of a supervisor, were not included in the population.

The breakdown of the work activity into the elements was detailed enough to cover all the situation encountered. Again, the written definition of activity-elements made it easy to identify, instantaneously, each element as it occurred. The continuous observations, at regular intervals of one-half minute, made it further impossible for the observer to introduce a bias, even unintentionally, by choosing the moment of observation to coincide with any particular activity-element.

In each department, the observer occupied an observation post from where he could watch the activity of all the workers included in the study. In fact, some of the workers were not included in the study just because they were not observable all the time or part of the time. The constant presence of the observer in the department did not seem to distract the attention of the workers or hinder their work in any way.

Observations were made at all times of the day, from 8 a.m. to 5 p.m., excepting the official rest periods. A major difficulty in designing the plan was the scattered coffee breaks and lunch breaks for different workers. This was taken care of, although not completely, by not taking any observations at all or by taking fewer observations on the coffee break groups, at one time or other. This procedure resulted in an unequal number of observations on different workers.

A confidence level of 95 per cent was adopted for the estimates of activity-elements as well as the element groups, with the exceptions noted in the tables. In literature on work sampling, this has been considered to represent typical estimation requirements on delays, towards which the main attention of this study is directed. Most authors further recommend that the number of observations be determined in advance. In an industrial application of work sampling, this is a "must," since the number of observations would directly determine the cost of the study. This was no problem in the present study.

The formula for determining the number of observations required, for a 95 per cent confidence level, is

$$Sp = 2\frac{\sqrt{p(1-p)}}{\sqrt{N}}$$

where

S = desired accuracy

p = percentage occurrence of the activity-element being measured, expressed as a percentage of the total number of observations

N = number of observations

Of the two unknowns, S and p, p is usually determined from a preliminary study of one day or so. S is the accuracy requirement and depends upon the use to which the results of the study will be put. In many work sampling studies, a relative accuracy of ±5% is termed acceptable, but this leads to abnormally high requirements for the number of observations for different values of p. For example, when p is 5%, N will become 30,400; and when p is 50%, N will be 1600.

To avoid this excessive observations requirements, some people recommend an absolute error of ±2.5% or ±3%.[1] In the present investigation, 1700 observations for department A (which was the least number of all the departments) meets very well, the above requirements of absolute accuracy.

In "Introduction to the theory of work sampling" (p.5), it was mentioned that systematic sampling is acceptable if no cyclic behavior is present in the phenomenon under study. Clerical work is non-repetitive in nature; hence, the above condition is met. Another condition is that the successive observations must be statistically independent. According to this, a long delay, or, for that matter, any activity-element should be counted only once, even though the formal sampling schedule might require it to be observed several times. With as fine a breakdown of activity elements as adopted in the present study,

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1. A. J. Rowe, "Relative versus Absolute Errors in Delay Measurements" Research Report No.24, University of California, 1953, as reported by Ralph M. Barnes in "Work Sampling," pp.20.

there were few occasions when an activity-element was longer than the average observation cycle of four minutes, necessitating repeated observations; and to obtain the best estimates of the delay percentages, all readings were recorded as often as they occured, although at the expense of some accuracy in the estimate of the standard error.

Since the purpose of the study was not to set standards, the workers were not rated.

DISCUSSION OF RESULTS

On the work sampling observation sheet (see Appendix), fourteen work- and delay-activities are listed. Some of these were further qualified with such suffixes as "a," "b," "w," and "p." It was assumed that this comprehensive list would take care of most of the situations encountered during the actual observation. With a few exceptions, this assumption did hold good in all the departments.

For the purpose of analysis, these activities are grouped into different "element groups" best suited to bring out certain points of interest. The element groups under consideration here are:

1. Direct work activities (elements 1, 2, 3, 5, 8, 9, 13)
2. Supporting delays (elements 4a, 6, 7w, 12)
3. Personal delays (elements 7p, 14)
4. Conversation-personal (element 4b)

Element group 2, "supporting delays," has been termed in time-study literature as "unavoidable delays," meaning delays associated with the work and beyond positive control of the worker. The term, "unavoidable delays," has been dropped from the present study in favor of the term, "supporting delays," because of some evidence from the data that the so-called "unavoidable delays" are partially within the control of the worker, if only in a preventive sense. This aspect will be discussed later.

In some cases, in the presentation of the results, element groups 3 and 4 have been combined to form "delays within worker control" or "total personal delays." Here again, the latter term is preferred since delays in connection with the physiological needs are not within complete worker control. Element 4b (conversation-personal) has been, in a few places, treated independently because, although originating with the worker, it is not a personal (need) delay. At other times, it has been included in "total personal delays" because of the belief that an increased amount of time spent on this element is an evidence of increased fatigue. It must be understood though that there are no means to substantiate this hypothesis, since a correlation with production records is impossible.

Table 1 contains some significant figures. The productive time, which is an average of the direct work activities of all the workers of a department for all the days, varied from 61.6% to 80.4%; the supporting delays from 12.15% to 31.3% and the total personal delays from 7.1% to 10.8%. One fact is too obvious to escape attention and that is the amazing consistency of the total personal delays in the departments A and B. The wide variations in the productive time and the supporting delays could be attributed to the non-homogeniety of the population from a functional as well as the procedural viewpoint. The relative consistency of the personal delays shows that they are less influenced by the operation. Charts 7 and 8 give further evidence of this effect.

One of the purposes of the present investigation was to compare the personal delays of the white collar workers with the personal and/or fatigue allowances in the industrial operations. Time study writers have recommended these allowances ranging from 2 to 20 per cent of the total work time. For example, Barnes[1] recommends a personal allowance of 2 to 5 per cent per day for an average worker and believes that "fatigue is of such little consequence in some kinds of work that no

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1. Barnes, "Motion and Time Study," 4th edition, pp. 385-386.

allowance is required at all." Holmes[1] similarly recommends a fixed personal (need) delay allowance of 3 to 5 per cent of the available work time. Carroll[2] suggests that fatigue and personal (need) delays should account for about 20 per cent of the total work time in most industrial operations. Shumard[3] allows 2.5 per cent personal (need) delays for male workers and 4 per cent for female workers. Some of these recommendations are based on all-day time studies of various classes of work; others have an essentially evaluative nature. The unscientific way in which time study writers have approached this problem of personal and fatigue allowances is summed up by Davidson[4] as, "Fatigue allowances in contemporary time study might be generally characterized as: a heterogeneous collection of compensations for a number of different, not-too-well-defined natural effect, as well as for mistakes in time study procedures; difficult to determine in accord with objective criteria; and for which no adequate measure of "correctness" exist."

In the present study, an effort was made to determine what is, rather than what ought to be, the time spent on personal delays. The average of the four departments for total personal delays is 8.14 per cent. To this must be added the time of two official rest periods of 15 minutes each.

$$\frac{30 \text{ min.}}{480 \text{ min.}} \times 100 = 6.25 \text{ per cent}$$

1. Holmes, "Applied Time and Motion Study," p.180
2. Carroll, "Time Study For Cost Control," pp.98-100
3. Shumard, "A Primer of Time Study," pp.242-245
4. Davidson, "Functions and Bases of Time Standards," p.181

Thus, the total amount comes to (8.14 + 6.25) = 14.39 per cent of the working time.

During the course of the investigation, it was noticed that, quite frequently, the official rest periods averaged 20 minutes each. On this basis, the total time spent on personal delays would be (8.14 + 8.33) = 16.47 per cent of the working hours.

Table 1 also contains figures on absolute accuracies with which the estimates on element groups were made. In the design of the sampling plan, the accuracy requirements were set at ± 2.5%. The highest figure reported in Table 1 (±2.15% for department D) is well within the limit set above.

Referring to Tables 2 and 3 in the departments A and B, definite trends of increasing absolute and relative consistency (decreasing standard deviation s, and the coefficient of variation s/p respectively) in all the element groups were found as the study progressed from the first day to the last. The trend in departments C and D is not quite discernible but it is believed that, with a larger amount of data, it would have been more pronounced. It is not possible to assign definite causes to this effect, but it may be conjectured that the group consistency bears some relation with the period of the week, since, in all but one department, the study was begun either on Monday or Tuesday and ended on Friday. Another guess would be the group-consciousness of the presence of the observer.

A few common characteristics of the data shall be discussed here. For the same worker, as the mean time ($\bar{p}$) increases from one element group to another, the absolute consistency decreases, as evidenced by increasing standard deviation (s) estimates shown in Tables 7a and 7b.

These Tables further show that, for the same worker, as the mean-time ($\bar{p}$) increases from one element group to another, the relative consistency increases as evidenced by the decreasing coefficient-of-variation (s/p) estimates. The above characteristics were expected as a feature of the statistical analysis. A further proof of this phenomenon is contained in Tables 4, 5, and 6. Different workers in the same department show a definite trend of increasing absolute consistency (decreasing s) with increase in level ($\bar{p}$), in case of element group "direct work." Similar trends of decreasing consistency (increasing s), with increase in level ($\bar{p}$), are found in the element groups "supporting delays" and "personal delays." The reason behind above trends is that, in any statistical measurement, the variation will be maximum when $p = 50\%$ and will tend to decrease for the extreme values of p.

Table 7 was also arranged to bring out the relationship, if any, between the length of experience and the amount of productive and non-productive activities. No direct relationship was found.

Table 9 shows the relationship between the work experience and the total personal delays. Although no direct correlation exists, it is interesting to note that workers with the same length of experience in different departments differ widely in their delay percentages. It will be further observed that this difference increases with an increase in the length of experience. In absence of further supporting evidence, this effect is believed to be a chance occurrence. A look at Table 8 reveals that, within each department, workers vary substantially in their personal delays and that the range of variation is about the same for departments A, B, and C.

Table 10 and Chart 9 show the relationship between the supporting delays and the total personal delays. Each point on the chart represents the total personal delays and the total supporting delays for a worker, for the entire observation period. In the chart, there is some evidence of tendency for higher personal delays to be associated with higher supporting delays. With the limited amount of data, no statistical significance can be attached to this trend, but if personal delays can be considered to be within worker control, the so-called "unavoidable delays" too may be partially within the control of the worker. Abruzzi[1] writes that, "Apparently unavoidable delays are partially within the control of the worker but only in a preventive sense. The occurrence of unavoidable delays cannot easily be traced to the worker, but a reduced incidence of unavoidable delays can."

Since the concept of control chart has been extensively used in the presentation of the data, an explanation about the derivation of the control limits seems appropriate. For example, in Table 11b, the average value for the element group in question, for the 3rd day, for the six workers observed, is 22.0%. The total number of observations for that day is 654. Then the daily limits would be

$$\text{Upper Control Limit (UCL)} = p + 2\sqrt{\frac{p(1-p)}{n}}$$

$$= .22 + 2\sqrt{\frac{.22(1-.22)}{654}}$$

$$= 29.94\%$$

$$\text{Lower Control Limit (LCL)} = .22 - 2\sqrt{\frac{.22(1-.22)}{654}}$$

$$= 14.06\%$$

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1. Abruzzi, "Work, Workers, and Work Measurement," p.110

and the central line would be 22.0%.

The worker limits are obtained as follows:

In Table 11b, worker "a" has been observed for four days. The total number of observations for that worker for four days is 298. The average value for the element group in question for worker "a," for the four days observed, is 30.5%. Then the worker limits would be

$$\text{Upper Control Limit (UCL)} = p + 2\sqrt{\frac{\bar{p}(1-p)}{n}}$$

$$= .305 + 2\sqrt{\frac{.305(1-.305)}{298}}$$

$$= 40.62\%$$

$$\text{Lower Control Limit (LCL)} = .305-2\sqrt{\frac{.305(1-.305)}{298}}$$

$$= 19.38\%$$

and the central line would be 30.5%.

The control limits in Table 15 are obtained as follows:

In Table 15a for department A, the grand average ($\bar{p}$) for the element group in question is 74.0%. This grand average, which is an average of all the workers in that department over all the days they were observed, can be obtained from Table 11a. The grand average is found to be 73.5%. For calculations of control limits, the grand average is taken as 74.0%. Next from Table 11a for department A, the total number of observations for the 1st day was found to be 150. Then the control limits for the 1st day would be

$$\text{Upper Control Limit (UCL)} = \bar{p} + 2\,\frac{\sqrt{\bar{p}(1-\bar{p})}}{\sqrt{n}}$$

$$= .74 + 2\sqrt{\frac{.74(1-.74)}{150}}$$

$$= 81.16\%$$

$$\text{Lower Control Limit (LCL)} = .74-2\sqrt{\frac{.74(1-.74)}{150}}$$

$$= 66.84\%$$

and the central line would be 74.0%. For calculation of the control limits for the 2nd day, $\bar{p}$ would remain unaltered; but the value of "n" would change to 412, the total number of observations for the 2nd day for department A, again obtained from Table 11a. In this manner, the control limits for all the days for all the departments for all the element groups are calculated.

Table 14e summarizes the data presented in Tables 11-12-13-14 (a,b,c,d). This condensation of data leads to an important finding. It will be observed that, in general, there are more points lying beyond daily-limits (all workers) than there are beyond worker-limits (all days). In departments A and B, this ratio for the total number of points is approximately 3 to 1, while in departments C and D, it is approximately 1.5 to 1. On the whole, there is some evidence to believe that the individual workers have more stable work patterns than the groups. This is because the differences in level of the productive times of the workers are great. This fact is important, in view of the common false assumption in many time studies the daily variability and the variability among the different workers is negligible. According to Cote,[1] "the use of binomial formula alone to compute the accuracy

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1. L. J. Cote and B. J. Scott, "Comparison of All-day Time Study with Work Sampling by Use of Analysis of Variance," Journal of Industrial Engineering, Jan.-Feb. 1956, Vol.VII, No.1

level obtained in a work sampling program ignores sources of error of larger magnitude, namely the variation among men, and the day-to-day variation of the men." It must be admitted here that the results of the present study are subject to the above mentioned limitations. Analysis of variance was not applicable because of unequal number of observations on different workers and the functional non-homogeniety of the population.

Although not directly concerned with the present study, it would be interesting to examine from closer quarters this problem of variability among workers. Abruzzi[1] considers it to be an outcome of the purposive behavior (of the workers) "which has an individualistic and varying component, as well as an expected and relatively constant component .... this component ... shows up in terms of a common level of (cycle-time) consistency among the workers in a group..... On the other hand, the individualistic and varying component shows up as widely varying mean (cycle) times for workers in a group and as stable mean (cycle) times for individual workers. This component can be considered a reflection of the planning activities of individual workers." Abruzzi's hypothesis is based on data gathered on jobs of repetitive nature and performed with standardized methods by groups of industrial operators. The present situation was totally different, nevertheless his comments are enlightening.

Table 16 shows the number of points for each worker, for each element froup, that either lie above or below the 2s limits. A further examination of the table shows that, of the total, about

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1. Abruzzi, "Work, Workers, and Work Measurement," pp.245-250

equal number of points lie above and below the limits for element group "direct work" in all departments but B. In general, whenever more points (total or for each worker) are lying above UCL than below LCL, for element group "direct work," an opposite effect is visible in the other three element groups, as would be expected. Analysis of data presented in this table further establishes that, with the exception of department B, the variability among workers is considerable. The reason behind a great number of points beyond control limits is that these limits are based on grand averages of pooled data on all workers.

Tables 17 through 20 show the daily percentages and the cumulative percentages for each element. The element groups shown here differ from those previously described, and are formed as follows:

1. Productive (elements 1,2,3,5,9,13)
2. Absent (elements 7w, 7p)
3. Delay (elements 4a, 4b, 6,8,12,14)

The above reformation of element groups was deemed necessary, in view of the fact that, in some of the departments, element 7w constituted a significant percentage of the supporting delays. Again, absence of a worker from the department, in connection with the work, cannot be branded entirely as a delay. Thus, the element group "delay" here presents a different perspective of the total personal and non-personal delays within a department, unaffected by the element 7w, which has a dubious character.

Charts 1 through 4 show the frequency distributions of the daily percentages of all the workers in all the departments, for the different element groups. The distributions are far from being normal, for several reasons. As mentioned earlier, the samples representing the daily percentages cannot be considered to have been drawn from a single homogeneous universe. Again, errors of sampling could alter the distribution to a considerable extent. These errors are,

1. Sampling errors (errors of observation)
2. Process variation
   (a) Differences from time-period to time-period.
   (b) Differences from worker to worker.
   (c) Residual (but real) process variations.

Another important factor regarding the shape of the distribution is the sample size. Davidson[1] has shown how radically the shape of a small sample size distribution can differ from that of another small sample size distribution, both samples drawn from a known universe which is normally distributed. Regarding random sampling errors, Davidson writes, "The effects of sampling fluctuations are such that if we continued sampling from our model of a normal universe we would by chance alone obtain samples illustrating all five of the "typical" curves." The five typical curves are (A) symmetrical (B) positively skewed (C) negatively skewed (D) rectangular and (E) bimodal.

According to Correll,[2] "The reliability may be evaluated by comparison of two or more ratio-delay studies taken on the same subject under similar conditions. If the results agree closely, the coefficient of reliability is high." The scope of the present investigation did not allow taking two independent studies in each department; but in department A, an independent check study of 4 days was conducted,

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1. Davidson, "Functions and Bases of Time Standards," pp.200-204

2. D. S. Correll and Ralph Barnes, "Industrial Application of the Ratio-Delay Method," Advanced Management, Aug.-Sept. 1950

which included the same workers and was carried out under essentially similar conditions as the main study. The scheme of systematic sampling consisted of trips at regular intervals with continuous observations as before. The results of the two studies are compared below:

	Main Study	Check Study
Element groups:	$\bar{p}$	$\bar{p}$
1. Direct work	73.5	75.6
2. Supporting delays	19.3	17.9
3. Personal delays	3.91	3.47
4. Conversation-personal	3.29	3.03
No. of observations	1792	626

The results of the two studies are in excellent agreement in spite of the fact that the number of observations for the main study is almost three times as great as that for the check study. The obvious conclusion is that a high degree of reliability exists, subject to a constant bias.

It would be only proper to conclude this discussion with remarks by Abruzzi:[1] "It seems clear that a theory of work must recognize that some (apparently) unproductive work activities are needed for optimal results. .... It may be unwise, for example, not to have formal and involuntary rest periods, but it may be even more unwise not to allow or even encourage informal and voluntary rest periods. Standardized rest periods give worker groups the rest they need to prevent the gross work method from becoming unstable; the informal rest periods give

1. Abruzzi, "Work, Workers and Work Measurement," p.256

individual workers the rest they need to prevent the more subtle aspects of the work method from becoming unstable."

SUMMARY OF DATA AND CALCULATIONS

Element Group:	Direct Work $\bar{p}$	Direct Work Ab.Acc.	Supporting Delays $\bar{p}$	Supporting Delays Ab.Acc.	Personal Delays + Conversation-Personal $\bar{p}$	Personal Delays	Conversation-Personal	Ab.Acc.	No.of Days	No.of Obs.
Dept. A	73.5	±2.08%	19.3	±1.85%	7.20	3.91	3.29	±1.22%	4	1792
Dept. B	80.4	±1.65%	12.15	±1.34%	7.45	5.13	2.32	±1.09%	4	2338
Dept. C	69.2	±1.42%	20.0	±1.23%	10.8	5.94	4.86	±0.98%	7	4194
Dept. D	61.6	±2.15%	31.3	±2.05%	7.10	4.85	2.25	±1.14%	5	2021

TABLE 1. DISTRIBUTION OF WORK ACTIVITIES

WITH RESPECTIVE ABSOLUTE ACCURACIES

TABLE 2. AVERAGES (p) AND STANDARD DEVIATIONS (s) FOR THE ELEMENT GROUPS

Element Group:	Direct work		Supporting Delays		Personal Delays	
Dept. A						
Day	p	s	p	s	p	s
1st	82	7.69	12	6.5	4.7	4.23
2nd	68	5.14	22	4.56	4.3	2.23
3rd	71	4.35	22	3.97	3.8	1.83
4th	77	3.93	16	3.74	3.5	1.87
Dept. B						
1st	82	6.40	10.7	5.15	5.1	3.67
2nd	80	4.46	13.0	3.75	5.1	2.45
3rd	83	3.95	10.6	3.23	4.9	2.26
4th	78	3.67	13.3	3.01	5.4	2.01
Dept. C						
1st	62	6.32	30	5.98	5.6	3.03
2nd	70	4.84	20.4	4.25	6.0	2.55
3rd	78	4.25	13.8	3.54	5.0	2.23
4th	66	5.32	21.2	4.60	6.0	2.72
5th	68	5.50	19.7	4.67	5.8	2.79
6th	69	5.54	20.0	5.10	6.3	3.13
7th	69	5.53	18.6	4.89	6.8	3.17
Dept. D						
1st	55	7.42	40.0	7.27	3.2	2.62
2nd	59	8.70	32.0	8.31	5.5	4.10
3rd	60	5.50	34.0	5.34	4.7	2.38
4th	61	5.20	29.5	4.85	6.0	2.57
5th	74	6.50	21.0	6.07	3.8	2.85

TABLE 3. COEFFICIENTS-OF-VARIATION (s/p)

FOR THE ELEMENT GROUPS

Element Group:	Direct Work	Supporting Delays	Personal Delays
Dept. A			
Day	s/p(%)	s/p(%)	s/p(%)
1st	9.39	54.2	90.1
2nd	7.56	20.7	51.9
3rd	6.13	18.0	48.1
4th	5.11	23.4	53.4
Dept. B			
1st	7.81	48.2	72.0
2nd	5.58	28.9	48.0
3rd	4.76	30.5	46.1
4th	4.70	22.6	37.2
Dept. C			
1st	10.20	19.95	54.2
2nd	6.93	20.80	42.5
3rd	5.45	25.60	44.6
4th	8.06	21.70	45.3
5th	8.09	23.70	48.1
6th	8.04	25.50	49.7
7th	8.03	26.30	46.6
Dept. D			
1st	13.50	18.15	82.0
2nd	14.75	26.00	74.5
3rd	9.17	15.72	50.6
4th	8.53	16.45	42.8
5th	8.79	28.90	75.0

TABLE 4a. AVERAGES (p), STANDARD DEVIATIONS (s) AND COEFFICIENTS-OF-VARIATION (s/p) WITH p ARRANGED IN DESCENDING ORDER OF MAGNITUDE.

Direct Work

	p	s	s/p
Dept. A			
Worker			
f	90	3.0	3.33
e	80	4.45	5.56
d	78	4.68	6.00
b	75	4.93	6.58
a	64	5.56	8.70
c	57	5.50	9.65
Dept. B			
c	89	3.39	3.81
d	84	3.94	4.69
e	84	4.41	5.25
a	82	4.31	5.26
f	81	4.30	5.31
g	80	4.25	5.32
h	72	5.70	7.92
b	66	5.46	8.29

TABLE 4b. AVERAGES (p), STANDARD DEVIATION (s) AND COEFFICIENTS-OF-VARIATION (s/p) WITH p ARRANGED IN DESCENDING ORDER OF MAGNITUDE.

Direct Work

	p	s	s/p
Dept. C			
Worker			
e	86	3.94	4.58
d	82	4.80	5.85
j	70	5.47	7.82
a	67	5.40	8.06
h	66	5.56	8.42
b	65	5.60	8.62
c	65	5.60	8.62
g	63	5.50	8.74
f	58	5.56	9.60
Dept. D			
g	75	5.50	7.34
c	72	5.90	8.20
a	70	6.00	8.57
b	57	5.50	11.4
f	56	6.57	11.7
d	52	7.00	13.45
e	47	6.40	13.60

TABLE 5a. AVERAGES (p), STANDARD DEVIATIONS (s) AND COEFFICIENTS-OF-VARIATION (s/p) WITH p ARRANGED IN DESCENDING ORDER OF MAGNITUDE.

Supporting Delays

	p	s	s/p
Dept. A			
Worker			
c	38	5.39	14.2
a	30	5.31	17.7
e	14	3.86	27.6
b	13	3.83	29.4
d	11	3.54	32.2
f	5.5	2.30	41.8
Dept. B			
h	22.6	5.31	23.5
b	22	4.78	21.7
a	13.8	3.87	28.0
g	11.0	3.32	30.2
d	9.5	3.15	33.2
f	8.8	3.11	35.3
e	8.2	3.30	40.3
c	7.3	2.82	38.6

TABLE 5b. AVERAGES (p), STANDARD DEVIATIONS (s) AND COEFFIECIENTS-OF-VARIATION (s/p) WITH p ARRANGED IN DESCENDING ORDER OF MAGNITUDE.

Supporting Delays

	p	s	s/p
Dept. C			
Worker			
f	27	5.01	18.55
a	26	5.03	19.35
h	23.8	5.00	21.00
c	23.6	5.00	21.20
b	23.0	4.95	21.50
g	21	4.65	22.10
j	14.6	4.09	28.00
d	11.5	3.99	34.70
e	7.4	2.97	40.10
Dept. D			
e	49.5	6.43	13.0
d	44.0	6.94	15.8
b	39.0	6.39	16.4
a	28.0	5.93	21.2
f	21.0	5.40	25.70
c	20.0	5.21	26.0
g	18.0	4.92	27.30

TABLE 6a. AVERAGES (p), STANDARD DEVIATIONS (s) AND COEFFICIENTS-OF-VARIATION (s/p) WITH p ARRANGED IN DESCENDING ORDER OF MAGNITUDE.

Personal Delays

	p	s	s/p
Dept. A			
Worker			
b	7.5	3.0	40.0
d	6.0	2.74	45.7
e	5.0	2.42	48.4
a	2.0	1.62	81.2
f	2.0	1.40	70.0
c	1.0	1.10	110.0
Dept. B			
b	9.0	3.31	36.8
e	6.8	3.03	44.6
d	6.0	2.60	43.4
f	5.0	2.39	47.8
h	4.8	2.71	56.7
g	4.5	2.20	48.9
c	3.0	1.85	61.7
a	2.5	1.74	69.6

TABLE 6b. AVERAGES (p), STANDARD DEVIATIONS (s) AND COEFFICIENTS-OF-VARIATION (s/p), WITH p ARRANGED IN DESCENDING ORDER OF MAGNITUDE.

Personal Delays

	p	s	s/p
Dept. C			
Worker			
c	9.6	3.47	36.2
j	9.0	3.42	38.0
f	7.5	2.97	39.6
b	7.4	3.08	41.6
g	7.2	2.96	41.1
h	4.5	2.46	54.7
d	4.2	2.52	60.0
a	3.8	2.18	57.4
e	1.3	1.27	92.7
Dept. D			
f	20.0	5.3	26.5
g	6.0	3.09	51.6
d	1.9	1.9	100.0
c	1.8	1.72	95.6
b	1.4	1.52	108.5
e	1.3	1.43	110.0
a	0.7	---	---

		Direct Work			Supporting Delays			Personal Delays		
Dept. A Worker	Experience	p	s	s/p	p	s	s/p	p	s	s/p
b	15 mo.	75	4.93	6.58	13	3.83	29.4	7.5	3.0	40.0
f	10 mo.	90	3.0	3.33	5.5	2.3	41.8	2.0	1.4	70.0
c	4 mo.	57	5.5	9.65	38	5.39	14.2	1.0	1.1	110.0
e	4 mo.	80	4.45	5.56	14	3.86	27.6	5.0	2.42	48.4
a	2 mo.	64	5.56	8.70	30	5.31	17.7	2.0	1.62	81.2
d	0 mo.	78	4.68	6.00	11	3.54	32.2	6.0	2.74	45.7
Dept. B										
h	52 mo.	72	5.7	7.92	22.6	5.31	23.5	4.8	2.71	56.7
e	48 mo.	84	4.41	5.25	8.2	3.3	40.3	6.8	3.03	44.6
b	19 mo.	66	5.46	8.29	22	4.78	21.7	9.0	3.31	36.8
c	10 mo.	89	3.39	3.81	7.3	2.82	38.6	3.0	1.85	61.7
a	4 mo.	82	4.31	5.26	13.8	3.87	28.0	2.5	1.74	69.6
g	3 mo.	80	4.25	5.32	11.0	3.32	30.2	4.5	2.2	48.9
d	3 mo	84	3.94	4.69	9.5	3.15	33.2	6.0	2.6	43.4
f	1 mo.	81	4.3	5.31	8.8	3.11	35.3	5.0	2.39	47.8

TABLE 7a. AVERAGES (p), STANDARD DEVIATIONS (s), AND COEFFIECIENTS-OF-VARIATION (s/p) WITH THE WORKERS ARRANGED ACCORDING TO THE LENGTH OF EXPERIENCE

Dept. C		Direct Work			Supporting Delays			Personal Delays		
Worker	Experience	p	s	s/p	p	s	s/p	p	s	s/p
d	28 yrs.	82	4.8	5.85	11.5	3.99	34.7	4.2	2.52	60.0
h	5 yrs.	66	5.56	8.42	23.8	5.0	21.0	4.5	2.46	54.7
b	3 yrs.	65	5.6	8.62	23	4.95	21.5	7.4	3.08	41.6
a	19 mo.	67	5.4	8.06	26	5.03	19.35	3.8	2.18	57.4
g	17 mo.	63	5.5	8.74	21	4.65	22.1	7.2	2.96	41.1
j	7 mo.	70	5.47	7.82	14.6	4.09	28.0	9.0	3.42	38.0
f	4 mo.	58	5.56	9.60	27	5.01	18.55	7.5	2.97	39.6
c	3 mo.	65	5.6	8.62	23.6	5.0	21.2	9.6	3.47	36.2
e	1.	86	3.94	4.58	7.4	2.97	40.1	1.3	1.27	92.7

TABLE 7b. AVERAGES (p), STANDARD DEVIATIONS (s) AND COEFFIECIENTS-OF-VARIATION (s/p) WITH THE WORKERS ARRANGED ACCORDING TO THE LENGTH OF EXPERIENCE.

Dept. D		Direct Work			Supporting Delays			Personal Delays		
Worker	Experience	p	s	s/p	p	s	s/p	p	s	s/p
e	14 yrs.	47	6.4	13.6	49.5	6.43	13.0	1.3	1.43	110.0
g	27 mo.	75	5.5	7.34	18	4.92	27.3	6.0	3.09	51.6
d	17 mo.	52	7.0	13.45	44	6.94	15.8	1.9	1.9	100.0
f	17 mo.	56	6.57	11.7	21	5.4	25.7	20	5.3	26.5
a	7 mo.	70	6.0	8.57	28	5.93	21.2	0.7	---	---
b	7 mo.	57	6.5	11.4	39	6.39	16.4	1.4	1.52	108.5
c	5 mo.	72	5.9	8.2	20	5.21	26.0	1.8	1.72	95.6

TABLE 7c. AVERAGES (p), STANDARD DEVIATIONS (s) AND COEFFICIENTS-OF-VARIATION (s/p), WITH THE WORKERS ARRANGED ACCORDING TO THE LENGTH OF EXPERIENCE.

TABLE 8. RELATION BETWEEN WORK EXPERIENCE AND THE TOTAL PERSONAL DELAYS.

Workers arranged in descending order of experience in the respective departments.

Element Groups: (Personal Delays + Conversation-personal)

	Dept. A	Dept. B	Dept. C	Dept. D
	b- 12.30	h- 5.60	d- 6.35	e- 3.60
	f- 4.02	e- 7.28	h- 10.00	g- 6.15
	c- 4.30	b- 12.40	b- 11.90	d- 3.80
	e- 6.10	c- 3.77	a- 7.10	f- 22.50
	a- 5.70	a- 3.78	g- 15.80	a- 2.10
	d- 10.60	g- 9.04	j- 15.37	b- 4.10
		d- 6.56	f- 14.80	c- 7.20
		f- 10.26	c- 11.40	
			e- 6.14	
Average	7.17	7.33	10.98	7.06
Range	8.28	8.63	9.66	20.40

TABLE 9. RELATION BETWEEN WORK EXPERIENCE AND THE TOTAL PERSONAL DELAYS.

Dept.	Worker	Present Experience	Delay%(14 + 7p + 4b)
C	d	28 yrs.	6.35
D	e	14 yrs.	3.60
C	h	5 yrs.	10.00
B	h	4 yrs. 2 mo.	5.60
B	e	4 yrs.	7.28
C	b	3 yrs.	11.90
D	g	2 yrs. 3 mo.	6.15
C	a	19 mo.	7.10
B	b	19 mo.	12.40
D	d	17 mo.	3.80
C	g	17 mo.	15.80
D	f	17 mo.	22.50
A	b	15 mo.	12.30
B	c	10 mo.	3.77
A	f	10 mo.	4.02
D	a	7 mo.	2.10
D	b	7 mo.	4.10
C	j	7 mo.	15.37

TABLE 9. (Continued)

RELATION BETWEEN WORK EXPERIENCE AND THE

TOTAL PERSONAL DELAYS

Dept.	Worker	Present Experience	Delay%(14 + 7p + 4b)
D	c	5 mo.	7.20
B	a	4 mo.	3.78
A	c	4 mo.	4.30
A	e	4 mo.	6.10
C	f	4 mo.	14.80
B	d	3 mo.	6.56
B	g	3 mo.	9.04
C	c	3 mo.	11.40
A	a	2 mo.	5.70
C	e	1 mo.	6.14
B	f	1 mo.	10.26
A	d	0 mo.	10.60

Worker	Direct Work	%	Supporting Delays	%	Personal Delays	%	Conversation-other	%	Total No. Obs.
Dept. A									
f	182	90.5	11	5.48	4	2.01	4	2.01	201
e	260	80.3	44	13.6	16	4.94	4	1.16	324
d	245	78.5	34	10.9	18	5.77	15	4.83	312
b	230	74.7	40	13.0	23	7.47	15	4.83	308
a	190	63.8	91	30.5	5	1.67	12	4.03	298
c	186	57.4	124	38.3	3	0.9	11	3.4	324
Dept. B									
c	303	88.9	25	7.33	10	2.93	3	0.84	341
e	175	84.5	17	8.22	14	6.76	1	0.52	207
d	290	83.9	33	9.54	21	6.07	2	0.49	346
a	262	82.4	44	13.8	8	2.52	4	1.26	318
f	269	81.0	29	8.74	17	5.13	17	5.13	332
g	285	80.0	39	10.96	16	4.52	16	4.52	356
b	206	65.6	69	22.0	28	8.92	11	3.48	314

TABLE 10a. RELATION BETWEEN THE SUPPORTING DELAYS

AND THE TOTAL PERSONAL DELAYS.

E

Worker	Direct Work		Supporting Delays		Personal Delays		Conversation-other		Total No. Obs.
		%		%		%		%	
Dept. C									
e	470	86.5	40	7.36	7	1.34	26	4.8	543
d	369	82.1	52	11.55	19	9.23	9	2.12	449
a	356	66.8	139	26.1	20	3.75	18	3.35	533
b	329	65.0	117	23.1	37	7.35	23	4.55	506
c	330	65.0	120	23.6	49	9.64	9	1.76	508
g	338	63.1	113	21.1	38	7.2	46	8.6	535
f	320	58.3	148	26.9	41	7.46	40	7.34	549
Dept. D									
g	230	75.5	56	18.35	19	6.15	0	0	305
c	214	72.5	60	20.3	5	1.77	16	5.43	295
a	199	69.6	81	28.3	2	0.7	4	1.4	286
b	165	56.7	114	39.2	4	1.37	8	2.73	291
f	161	56.5	60	21.0	59	20.7	5	1.8	285
d	134	52.4	112	43.8	5	1.9	5	1.9	256
e	142	46.9	150	49.5	4	1.29	7	2.31	303

TABLE 10b. RELATION BETWEEN THE SUPPORTING DELAYS

AND THE TOTAL PERSONAL DELAYS.

Element Group: Direct Work

Dept. A

Day:	1st	2nd	3rd	4th	UCL	LCL	Ave. for worker	No. Obs.
					3s Limits			
Worker								
a	88.0	61.2	58.0	65.58	80.7	47.3	63.8	298
b	88.0	68.28	69.5	82.3	89.8	60.2	74.7	308
c	68.0	53.46	55.54	60.38	73.5	40.5	57.4	324
d	76.0	76.75	75.16	84.37	92.1	63.9	78.5	312
e	84.0	80.22	81.2	78.11	93.3	66.7	80.3	324
f	---	---	88.54	92.71	99.0	81.0	90.5	201
g	88.0	---	---	---	---	---	88.0	25
Ave. for the day	82.0	68.25	71.2	77.3			73.5	
UCL	100.0	83.4	84.0	89.88				
LCL	58.5	52.6	58.0	64.12				
No. Obs.	150	412	654	576				1792

TABLE 11a. AVERAGES FOR THE DAYS AND FOR THE WORKERS WITH DAILY PERCENTAGES AND CONTROL LIMITS AS SHOWN

Element Group: Supporting Delays

Dept. A

Day:	1st	2nd	3rd	4th	UCL (2s Limits)	LCL (2s Limits)	Ave. for worker	No. of Obs.
Worker								
a	4.0	30.6	37.2	30.26	40.62	19.38	30.5	298
b	12.0	18.3	15.25	6.24	20.66	5.34	13.0	308
c	28.0	38.4	41.9	36.5	48.78	27.22	38.3	324
d	8.0	11.62	16.2	5.21	18.08	3.92	10.9	312
e	12.0	12.8	13.68	14.6	21.72	6.28	13.6	324
f	---	---	6.66	4.17	10.1	0.90	5.48	201
g	8.0	---	---	---	---	---	8.0	25
Ave. for the day	12.0	22.1	22.0	16.15			19.3	
UCL	25.0	31.12	29.94	23.48				
LCL	0.0	12.88	14.06	8.52				
No. Obs.	150	412	654	576				1792

TABLE 11b. AVERAGES FOR THE DAYS AND FOR THE WORKERS WITH DAILY PERCENTAGES AND CONTROL LIMITS AS SHOWN.

Element Group: Personal Delays

Dept. A

Day:	1st	2nd	3rd	4th	UCL (2s Limits)	LCL (2s Limits)	Ave. for worker	No. Obs.
Worker								
a	0.0	2.7	1.94	1.04	5.24	0.0	1.67	298
b	0.0	7.32	9.53	7.30	13.5	1.5	7.47	308
c	4.0	2.33	0.0	0.0	3.2	0.0	0.9	324
d	16.0	4.65	4.76	5.21	11.48	0.52	5.77	312
e	4.0	4.65	5.12	5.21	9.84	0.16	4.94	324
f	---	---	1.94	2.08	4.80	0.0	2.01	201
g	4.0	---	---	---	---	---	4.0	25
Ave. for the day	4.66	4.31	3.82	3.47			3.91	
UCL	13.16	8.76	7.46	7.24				
LCL	0.0	0.0	0.14	0.0				
No. Obs.	150	412	654	576				1792

TABLE 11c. AVERAGES FOR THE DAYS AND FOR THE WORKERS WITH DAILY PERCENTAGES AND CONTROL LIMITS AS SHOWN.

Element Group: Conversation-personal

Dept. A

Day:	1st	2nd	3rd	4th	UCL (2s Limits)	LCL (2s Limits)	Ave. for worker	No. Obs.
Worker								
a	8.0	5.5	2.86	3.12	6.26	1.74	4.03	298
b	0.0	6.1	5.72	4.17	7.24	2.36	4.83	308
c	0.0	5.81	2.56	3.12	5.69	1.11	3.40	324
d	0.0	6.98	3.88	5.21	7.22	2.38	4.83	312
e	0.0	2.33	0.0	2.08	2.39	0.01	1.16	324
f	---	---	2.86	1.04	3.98	0.02	2.01	201
g	0.0	---	---	---	---	---	0.0	25
Ave. for the day	1.34	5.34	2.98	3.08			3.29	
UCL	5.78	4.68	4.33	4.42				
LCL	0.22	1.32	1.67	1.58				
No. Obs.	150	412	654	576				1792

TABLE 11H. AVERAGES FOR THE DAYS AND FOR THE WORKERS WITH DAILY PERCENTAGES AND CONTROL LIMITS AS SHOWN.

Element Group: Direct Work

Dept.B

Day:	1st	2nd	3rd	4th	UCL (3s Limits)	LCL (3s Limits)	Ave.for worker	No.Obs.
Worker								
a	83.85	87.2	82.0	79.1	94.93	69.07	82.4	318
b	64.47	67.5	68.9	62.0	82.4	49.6	65.6	314
c	86.85	96.16	88.7	85.4	99.17	78.83	88.9	341
d	84.22	80.5	89.8	81.8	95.8	72.2	83.9	346
e	84.22	83.75	85.4	---	97.2	70.8	84.5	207
f	89.48	80.0	85.4	76.0	93.9	68.1	81.0	332
g	84.22	81.39	80.5	78.6	92.7	67.3	80.3	356
h	88.96	68.58	---	---	89.1	54.9	71.8	124
Ave. for the day	82.5	80.5	82.7	77.6			80.4	
UCL	100.0	93.4	94.84	89.0				
LCL	62.8	66.6	71.16	67.0				
No. Obs.	290	645	634	769				2338

TABLE 12a. AVERAGES FOR THE DAYS AND FOR THE WORKERS WITH DAILY PERCENTAGES AND CONTROL LIMITS AS SHOWN.

Element Group: Supporting Delays

Dept. B

Day:	1st	2nd	3rd	4th	UCL (2s Limits)	LCL (2s Limits)	Ave. for worker	No. Obs.
Worker								
a	16.15	11.52	15.72	13.33	21.54	6.06	13.82	318
b	16.15	20.0	22.22	24.75	31.56	12.44	22.0	314
c	5.26	2.56	6.82	10.95	12.94	1.66	7.33	341
d	7.89	10.40	5.72	11.88	15.80	3.20	9.54	346
e	10.52	10.0	5.60	----	14.80	1.60	8.22	207
f	7.89	12.5	6.75	8.0	15.02	2.58	8.74	332
g	7.89	10.47	10.90	12.22	17.64	4.36	10.96	356
h	15.78	25.60	---	---	33.22	11.98	22.60	124
Ave. for the day	10.7	13.0	10.57	13.26			12.15	
UCL	21.0	20.5	17.06	19.32				
LCL	0.40	5.50	4.14	7.28				
No. Obs.	290	645	634	769				2338

TABLE 12b. AVERAGES FOR THE DAYS AND FOR THE WORKERS WITH DAILY PERCENTAGES AND CONTROL LIMITS AS SHOWN.

Element Group: Personal Delays

Dept. B

Day:	1st	2nd	3rd	4th	UCL (2s Limits)	LCL (2s Limits)	Ave. for worker	No. Obs.
Worker								
a	0.0	0.0	2.28	5.0	5.98	0.0	2.52	318
b	9.69	11.25	7.78	7.95	15.62	2.38	8.92	314
c	7.89	1.28	3.41	2.19	6.70	0.0	2.93	341
d	7.89	7.80	3.41	6.32	11.2	0.8	6.07	346
e	5.26	5.00	9.00	---	12.86	0.74	6.76	207
f	2.63	5.00	5.60	5.60	9.78	0.22	5.13	332
g	5.26	4.65	1.67	5.34	8.90	0.10	4.52	356
h	2.63	5.82	---	---	10.22	0.0	4.84	124
Ave. for the day	5.10	5.12	4.89	5.37			5.13	
UCL	12.44	10.0	9.42	9.42				
LCL	0.0	0.20	0.38	1.38				
No. Obs.	290	645	634	769				2338

TABLE 12c. AVERAGES FOR THE DAYS AND FOR THE WORKERS WITH DAILY PERCENTAGES AND CONTROL LIMITS AS SHOWN.

Element Group: Conversation-personal

Dept. B

Day:	1st	2nd	3rd	4th	UCL (2s Limits)	LCL (2s Limits)	Ave. for worker	No. Obs.
Worker								
a	0.0	1.28	0.0	2.5	2.55	0.05	1.26	318
b	9.69	1.25	1.1	5.3	5.86	1.14	3.48	314
c	0.0	0.0	1.07	1.46	1.83	0.00	0.84	341
d	0.0	1.3	1.07	0.0	1.04	0.00	0.49	346
e	0.0	1.25	0.0	----	1.20	0.00	0.52	207
f	0.0	2.5	2.25	10.4	7.40	2.60	5.13	332
g	2.63	3.49	6.93	3.84	6.70	2.30	4.52	356
h	2.63	0.0	----	----	2.09	0.00	0.76	124
Ave. for the day	1.70	1.38	1.84	3.77			2.32	
UCL	4.32	3.72	3.73	3.62				
LCL	0.68	1.28	1.27	1.38				
No. Obs.	290	645	634	769				2338

TABLE 12d. AVERAGES FOR THE DAYS AND FOR THE WORKERS WITH DAILY PERCENTAGES AND CONTROL LIMITS AS SHOWN.

Element Group: Direct Work

Dept. C Day:	1st	2nd	3rd	4th	5th	6th	7th	UCL (3s Limits)	LCL (3s Limits)	No,Obs.	Ave.for worker
Worker											
a	47.6	69.3	74.75	56.4	67.1	67.8	81.0	83.2	50.8	533	66.8
b	55.0	66.7	74.25	66.3	60.5	77.8	45.2	81.85	48.15	506	65.0
c	63.75	73.0	82.0	53.8	57.5	69.4	53.8	81.85	48.15	508	65.0
d	81.0	82.0	85.9	87.7	80.4	69.0	86.8	96.4	67.6	449	82.1
e	96.9	84.4	96.0	85.0	83.0	66.7	89.4	97.8	74.2	543	86.5
f	47.9	50.5	74.8	62.0	59.7	65.0	41.3	74.7	41.3	549	58.3
g	50.0	62.4	60.8	60.5	72.5	68.4	69.7	79.55	46.45	535	63.1
h	---	---	---	63.0	72.0	63.3	66.6	82.7	49.3	290	66.2
j	---	---	---	66.25	59.0	71.7	85.1	86.45	53.55	280	70.0
Ave. for the day	62.5	69.6	78.2	66.4	67.75	68.8	68.8				69.2
UCL	81.0	84.53	90.73	82.0	84.5	86.7	86.4				
LCL	43.0	55.47	65.27	50.0	51.5	51.3	51.6				
No. Obs.	410	628	667	713	649	556	571			4194	

TABLE 13a. AVERAGES FOR THE DAYS AND FOR THE WORKERS WITH DAILY PERCENTAGES AND CONTROL LIMITS AS SHOWN.

Element Group: Supporting Delays

Dept. C Day:	1st	2nd	3rd	4th	5th	6th	7th	UCL 2s Limits	LCL	No.Obs.	Ave.for worker
Worker											
a	49.2	27.5	20.4	35.9	21.9	17.7	11.1	36.06	15.94	533	26.1
b	45.0	25.5	18.5	22.9	22.5	12.7	24.2	32.9	13.1	506	23.1
c	29.0	16.8	8.34	35.9	27.4	17.7	30.8	33.6	13.6	508	23.6
d	11.9	12.8	9.79	9.23	11.4	19.0	7.55	19.5	3.5	449	11.55
e	1.55	11.4	1.0	6.25	3.85	26.7	4.55	13.34	1.46	543	7.36
f	34.8	26.4	15.1	23.0	31.2	23.8	41.3	37.0	17.0	549	26.9
g	37.5	21.5	19.6	21.0	10.1	20.0	16.7	30.3	11.7	535	21.1
h	---	---	---	19.8	20.0	29.4	27.3	33.8	13.8	290	23.8
j	---	---	---	15.0	27.4	11.7	3.0	6.42	6.42	280	14.63
Ave.for the day	30.0	20.4	13.8	21.2	19.7	20.0	18.6				20.0
UCL	41.96	28.9	20.88	30.4	29.0	30.2	28.4				
LCL	18.04	11.9	6.72	12.0	10.36	9.80	8.82				
No.Obs	410	628	667	713	649	556	571			4194	

TABLE 13b. AVERAGES FOR THE DAYS AND FOR THE WORKERS WITH DAILY PERCENTAGES AND CONTROL LIMITS AS SHOWN.

Element Group: Personal Delays

Dept. C Day: Worker	1st	2nd	3rd	4th	5th	6th	7th	UCL (2s Limits)	LCL (2s Limits)	No.Obs.	Ave. for worker
a	1.6	1.07	2.91	5.13	2.75	9.63	4.84	8.16	0.0	533	3.75
b	0.0	7.8	5.14	7.20	8.50	9.50	11.2	13.56	1.14	506	7.35
c	7.25	7.86	9.66	6.41	13.7	11.3	12.3	16.54	2.66	508	9.64
d	2.40	3.90	2.15	3.07	4.92	8.62	5.65	9.24	0.0	449	4.23
e	1.55	1.04	1.00	2.50	0.0	0.0	3.02	3.84	0.0	543	1.34
f	12.97	11.0	6.01	4.60	3.9	4.85	9.53	13.44	1.56	549	7.46
g	9.38	9.68	9.8	6.17	4.35	5.0	4.53	13.12	1.28	535	7.20
h	---	---	---	8.64	4.0	1.41	3.05	9.42	0.0	290	4.48
j	---	---	---	11.25	9.6	6.65	7.47	15.84	2.16	280	8.94
Ave. for the day	5.61	6.05	4.95	6.09	5.75	6.30	6.84				5.94
UCL	11.66	11.1	9.46	11.44	11.38	12.56	13.14				
LCL	0.0	0.90	0.54	0.56	0.22	0.04	0.46				
No. Obs.	410	628	667	713	649	556	571			4194	

TABLE 13c. AVERAGES FOR THE DAYS AND FOR THE WORKERS WITH DAILY PERCENTAGES AND CONTROL LIMITS AS SHOWN

Element Group: Conversation-personal

Dept. C Day:	1st	2nd	3rd	4th	5th	6th	7th	UCL (2s Limits)	LCL (2s Limits)	No.Obs.	Ave.for worker
Worker											
a	1.6	2.13	1.94	2.57	8.25	4.82	3.06	5.18	1.62	533	3.35
b	0.0	0.0	2.06	3.6	8.5	0.0	19.4	6.34	2.66	506	4.55
c	0.0	2.29	0.0	3.89	1.4	1.55	3.1	2.97	0.63	508	1.76
d	4.7	1.3	2.15	0.0	3.23	3.38	0.0	3.32	0.68	449	2.12
e	0.0	3.11	2.0	6.25	13.15	6.6	3.03	6.63	2.97	543	4.80
f	4.33	12.1	4.04	10.4	5.2	6.35	7.87	9.52	5.08	549	7.34
g	3.13	6.42	9.8	12.33	13.0	6.6	9.07	11.02	6.18	535	8.60
h	---	---	---	8.64	4.0	5.89	3.05	8.20	2.80	290	5.52
j	---	---	---	7.5	4.0	10.0	4.48	9.35	3.45	280	6.43
Ave.for the day	1.89	3.95	3.05	6.31	6.8	4.9	5.76				4.86
UCL	7.15	6.74	6.69	6.63	6.71	6.85	6.82				
LCL	2.85	3.26	3.31	3.37	3.29	3.15	3.18				
No.Obs.	410	628	667	713	649	556	571			4194	

TABLE 13d. AVERAGES FOR THE DAYS AND FOR THE WORKERS DAILY PERCENTAGES AND CONTROL LIMITS AS SHOWN.

Element Group: Direct Work

Dept. D

Day:	1st	2nd	3rd	4th	5th	UCL (3s Limits)	LCL (3s Limits)	Ave. for worker	No. Obs.
Worker									
a	57.8	77.0	70.4	67.4	80.0	88.2	51.8	69.6	286
b	54.4	34.6	58.8	55.4	71.1	76.5	37.5	56.7	291
c	75.5	46.7	67.1	79.1	83.7	89.5	54.5	72.5	295
d	47.0	53.4	44.9	59.0	60.0	73.0	31.0	52.4	256
e	15.0	50.0	49.4	45.5	66.1	66.2	27.8	46.9	303
f	71.1	80.5	45.7	43.2	65.25	75.7	36.3	56.5	285
g	57.5	66.6	76.4	77.7	90.0	91.65	58.35	75.5	305
Ave. for the day	54.75	59.1	59.8	61.1	74.4			61.6	
UCL	77.2	85.3	76.5	76.6	93.6				
LCL	32.8	32.7	43.4	45.4	54.4				
No. Obs.	314	220	552	620	315				2021

TABLE 14a. AVERAGES FOR THE DAYS AND FOR THE WORKERS WITH DAILY PERCENTAGES AND CONTROL LIMITS AS SHOWN.

Element Group: Supporting Delays

Dept. D

Days:	1st	2nd	3rd	4th	5th	UCL (2s Limits)	LCL (2s Limits)	Ave. for worker	No. Obs.
Worker									
a	42.0	15.4	28.4	29.2	20.0	39.86	16.14	28.3	286
b	43.5	61.6	35.0	40.4	26.7	51.78	26.22	39.2	291
c	16.33	33.3	29.3	13.2	11.62	30.42	9.58	20.3	295
d	53.0	40.0	52.2	33.3	40.0	57.88	30.12	43.8	256
e	82.5	44.5	48.2	48.9	32.2	62.36	36.64	49.5	303
f	8.9	5.5	27.15	29.5	19.6	31.8	10.2	21.0	285
g	40.0	30.6	19.1	12.2	2.0	27.84	8.16	18.35	305
Ave. for the day	40.4	32.3	33.7	29.5	20.9			61.6	
UCL	54.54	48.62	44.68	39.2	33.14				
LCL	25.46	15.38	23.32	19.8	8.86				
No. Obs.	314	220	552	620	315				2021

TABLE 14b. AVERAGES FOR THE DAYS AND FOR THE WORKERS WITH DAILY PERCENTAGES AND CONTROL LIMITS AS SHOWN.

Element Group: Personal Delays

Dept. D Day:	1st	2nd	3rd	4th	5th	UCL 2s Limits	LCL	Ave. for worker	No. Obs.
Worker									
a	0.0	3.8	0.0	1.13	0.0	---	---	0.7	286
b	2.1	2.5	2.5	1.05	0.0	4.44	0.0	1.37	291
c	0.0	1.16	1.16	1.1	2.34	5.24	0.0	1.77	295
d	0.0	1.45	1.45	3.85	0.0	5.70	0.0	1.9	256
e	2.5	1.2	1.2	0.0	0.0	4.16	0.0	1.29	303
f	15.55	24.3	24.3	26.2	15.15	30.6	9.4	20.7	285
g	2.5	4.5	4.5	10.1	8.0	12.18	0.0	6.15	305
Ave. for the day	3.23	5.46	4.71	6.13	3.81			4.85	
UCL	8.44	13.7	9.46	11.14	9.50				
LCL	0.0	0.0	0.0	0.86	0.0				
No. Obs.	314	220	552	620	315				2021

TABLE 14c. AVERAGES FOR THE DAYS AND FOR THE WORKERS WITH DAILY PERCENTAGES AND CONTROL LIMITS AS SHOWN.

Element Group: Conversation-personal

Dept. D Day:	1st	2nd	3rd	4th	5th	UCL (2s Limits)	LCL (2s Limits)	Ave. for worker	No. Obs.
Worker									
a	0.0	3.8	1.1	2.27	0.0	2.77	0.03	1.4	286
b	0.0	3.8	3.7	3.15	2.2	4.73	0.87	2.73	291
c	8.17	13.34	2.44	6.6	2.34	8.04	2.76	5.43	295
d	0.0	3.3	1.45	3.85	0.0	3.60	0.20	1.9	256
e	0.0	0.0	1.2	5.6	1.7	4.01	0.59	2.31	303
f	4.45	0.0	2.85	1.1	0.0	3.36	0.24	1.8	285
g	0.0	0.0	0.0	0.0	0.0	---	---	0.0	305
Ave. for the day	1.62	3.14	1.79	3.27	0.89			2.25	
UCL	3.58	3.89	3.19	3.12	3.58				
LCL	0.42	0.11	0.81	0.88	0.42				
No. Obs.	314	228	552	620	315				2021

TABLE 14d. AVERAGES FOR THE DAYS AND FOR THE WORKERS WITH DAILY PERCENTAGES AND CONTROL LIMITS AS SHOWN.

Element Group:		Direct Work	Supporting Delays	Personal Delays	Conversation Personal	Total	Out of
Dept. A	Points Beyond						
	Worker-Limits (All Days)	0	1	3	7	11	92
	Daily-Limits (All Workers)	2	13	4	14	33	
Dept. B		0	0	1	10	11	116
		3	4	2	20	29	
Dept. C		3	14	2	26	45	228
		10	18	4	38	70	
Dept. D		5	10	2	15	32	140
		4	14	6	21	45	

TABLE 14e. POINTS (REPRESENTING WORKERS' DAILY AVERAGES)

BEYOND CONTROL-LIMITS GIVEN IN TABLES 11-12-13-14 (a,b,c,d)

Element Group: Direct Work

	Dept. A		Dept. B		Dept. C		Dept. D	
	$\bar{p}$=74.0		$\bar{p}$=80.0		$\bar{p}$=69.0		$\bar{p}$=62.0	
DAY:	UCL	LCL	UCL	LCL	UCL	LCL	UCL	UCL
1st	*81.16	66.84	84.70	75.30	73.57	64.43*	67.46	56.54*
2nd	77.32	69.68*	83.15	76.85	72.69	65.31	68.55	55.45
3rd	77.43	70.57	83.17	76.83	*72.58	65.42	66.14	57.86
4th	77.66	70.34	82.88	77.12	72.46	65.54	65.90	58.10
5th					72.62	65.38	*67.46	56.54
6th					72.92	65.08		
7th					72.87	65.13		

95% Confidence Level

TABLE 15a. CONTROL-LIMITS, BASED ON GRAND AVERAGES ($\bar{p}$) AND TOTAL NUMBER OF OBSERVATIONS FOR THE DAY.

*Point beyond limit, on the side indicated.

Element Group: Supporting Delays

	Dept. A $\bar{p}$ =19.0		Dept. B $\bar{p}$=12.0		Dept. C $\bar{p}$=20.0		Dept. D $\bar{p}$=31.0	
DAY:	UCL	LCL	UCL	LCL	UCL	LCL	UCL	LCL
1st	26.04	11.96	15.82	8.18	*23.95	16.05	*36.5	25.5
2nd	22.86	15.14	14.56	9.44	23.19	16.81	37.57	24.43
3rd	22.06	15.94	14.58	9.42	23.10	16.9*	35.16	26.84
4th	22.27	15.73	14.34	9.66	23.0	17.0	34.92	27.08
5th					23.14	16.86	36.5	25.5*
6th					23.39	16.61		
7th					23.34	16.66		

95% Confidence Level

TABLE 15b. CONTROL-LIMITS, BASED ON GRAND AVERAGES ($\bar{p}$) AND TOTAL NUMBER OF OBSERVATIONS FOR THE DAY.

*Point beyond limit, on the side indicated.

Element Group: Personal Delays

	Dept. A		Dept. B		Dept. C		Dept. D	
	$\bar{p}$=4.0		$\bar{p}$=5.5		$\bar{p}$=6.0		$\bar{p}$=5.0	
DAY:	UCL	LCL	UCL	LCL	UCL	LCL	UCL	LCL
1st	7.20	0.80	8.20	2.80	8.39	3.61	7.45	2.55
2nd	5.93	2.07	7.31	3.69	7.93	4.07	7.94	2.06
3rd	5.53	2.47	7.32	3.68	7.87	4.13	6.86	3.14
4th	5.63	2.37	7.16	3.84	7.81	4.19	6.75	3.25
5th					7.89	4.11	7.45	2.55
6th					8.05	3.95		
7th					8.02	3.98		

95% Confidence Level

TABLE 15c. CONTROL-LIMITS, BASED ON GRAND AVERAGES ($\bar{p}$) AND TOTAL NUMBER OF OBSERVATIONS FOR THE DAY.

Element Group: Conversation-personal

DAY:	Dept. A $\bar{p}$=3.0 UCL	Dept. A LCL	Dept. B $\bar{p}$=2.5 UCL	Dept. B LCL	Dept. C $\bar{p}$=5.0 UCL	Dept. C LCL	Dept. D $\bar{p}$=2.0 UCL	Dept. D LCL
1st	5.78	0.22	4.32	0.68	7.15	2.85*	3.58	0.42
2nd	*4.68	1.32	3.72	1.28	6.74	3.26	3.89	0.11
3rd	4.33	1.67	3.73	1.27	6.69	3.31*	3.19	0.81
4th	4.42	1.58	*3.62	1.38	6.63	3.37	*3.12	0.88
5th					*6.71	3.29	3.58	0.42
6th					6.85	3.15		
7th					6.82	3.18		

95% Confidence Level

TABLE 15d. CONTROL-LIMITS, BASED ON GRAND AVERAGES ($\bar{p}$) AND TOTAL NUMBER OF OBSERVATIONS FOR THE DAY.

*Point beyond limit, on the side indicated

DEPT. A

95% Confidence Level

Element Group:		Direct Work Points		Supporting Delay Points		Personal Delay Points		Conversation-other Points	
Worker	Total Points	Above UCL	Below LCL	Above UCL	Below LCL	Above UCL	Below LCL	Above UCL	Below LCL
b	4	2	2	-	2	3	1	2	1
f	2	2	-	-	2	—	2	-	1
c	4	-	3	4	-	-	2	1	1
e	4	4	-	-	3	-	-	-	2
a	4	1	3	3	1	-	3	2	-
d	4	1	-	-	3	1	-	2	1
	Total:	10	8	7	11	4	8	7	6
		18		18		12		13	

TABLE 16a. POINTS (REPRESENTING WORKERS' DAILY AVERAGES)

BEYOND FLUCTUATING CONTROL LIMITS, GIVEN IN TABLE 15

DEPT. B

95% Confidence Level

Element Group:		Direct Work Points		Supporting Delay Points		Personal Delay Points		Conversation-other Points	
Worker	Total Points	Above UCL	Below LCL	Above UCL	Below LCL	Above UCL	Below LCL	Above UCL	Below UCL
h	2	1	1	1	-	-	1	-	1
e	3	2	-	-	1	1	-	-	3
b	4	-	4	4	-	4	-	2	2
c	4	4	-	-	3	-	3	-	3
a	4	1	-	2	-	-	3	-	2
g	4	-	-	-	1	-	1	2	-
d	4	1	-	-	2	1	1	-	3
f	4	2	1	-	3	-	1	1	1
	Total*	11	6	7	10	6	10	5	15
		17		17		16		20	

TABLE 16b. POINTS (REPRESENTING WORKERS' DAILY AVERAGES)

BEYOND FLUCTUATING CONTROL-LIMITS, GIVEN IN TABLE 15

DEPT. C

95% Confidence Level

Element Group:		Direct Work Points		Supporting Delays Points		Personal Delays Points		Conversation-other Points	
Worker	Total Points	Above UCL	Below LCL	Above UCL	Below LCL	Above UCL	Below LCL	Above UCL	Below LCL
d	7	6	-	-	6	1	4	-	5
h	4	-	2	2	-	1	3	1	1
b	7	2	3	3	1	3	1	2	4
a	7	2	2	3	1	1	4	1	5
g	7	-	4	1	1	3	-	4	-
j	4	1	1	1	3	2	-	2	-
f	7	1	6	5	1	3	1	3	-
c	7	2	4	4	1	4	-	-	6
e	7	6	-	1	6	-	7	1	4
	Total:	20	22	20	20	18	20	14	25
		42		40		38		39	

TABLE 16c. POINTS (REPRESENTING WORKERS' DAILY AVERAGES)

BEYOND FLUCTUATING CONTROL-LIMITS, GIVEN IN TABLE 15.

DEPT. D

Element Group:		Direct Work Points		Supporting Delays Points		Personal Delays Points		Conversation-other Points	
Worker	Total Points	Above UCL	Below LCL	Above UCL	Below LCL	Above UCL	Below LCL	Above UCL	Below LCL
e	5	-	4	4	-	-	4	1	2
g	5	3	-	1	2	2	1	-	5
d	5	-	3	4	-	-	3	1	2
f	5	2	2	-	4	5	-	1	2
a	5	4	-	1	2	-	4	-	2
b	5	1	3	3	-	-	5	2	1
c	5	4	1	-	3	-	4	3	-
	Total:	14	13	13	11	7	21	8	14
		27		24		28		22	

TABLE 16d. POINTS (REPRESENTING WORKERS' DAILY AVERAGES)

BEYOND FLUCTUATING CONTROL-LIMITS, GIVEN IN TABLE 15.

TABLE 17a. DAILY PERCENTAGES

<u>Dept. A</u>

Days:	1st	2nd	3rd	4th
<u>Element Groups</u>				
Productive	81.34	67.48	67.60	76.90
Absent	2.67	8.25	13.10	5.73
Delay	15.99	24.27	19.30	17.37
<u>Elements</u>				
1	12.67	8.26	11.65	12.72
2	26.67	26.92	22.80	26.12
3	16.67	13.12	12.20	13.72
4a	3.33	9.24	6.91	6.25
4b	1.33	5.33	2.93	3.12
5	6.00	4.63	5.45	9.72
6	4.00	3.15	3.28	2.95
7	2.67	8.25	13.10	5.73
8	0.67	0.74	0.35	0.36
12	2.66	3.15	3.83	2.43
13	19.33	14.55	15.50	14.62
14	4.00	2.66	549	2.26
No.Obs.	150	412		576

TABLE 17b. CUMULATIVE PERCENTAGES

Dept. A

Days:	1 day	2 days	3 days	4 days
Element Groups				
Productive	81.34	71.23	69.42	71.94
Absent	2.67	6.76	9.90	8.47
Delay	15.99	22.01	20.68	19.59
Elements				
1	12.67	9.45	10.54	11.25
2	26.67	26.90	24.85	25.22
3	16.67	14.10	13.15	13.32
4a	3.33	7.66	7.30	6.94
4b	1.33	4.27	3.60	3.44
5	6.00	4.98	5.23	6.82
6	4.00	3.38	3.33	3.23
7	2.67	6.76	9.90	8.47
8	0.67	0.70	0.51	0.47
12	2.66	3.00	3.42	3.08
13	19.33	15.80	15.65	15.33
14	4.00	3.00	2.52	2.43
No. Obs.		562	1111	1687

TABLE 18a. DAILY PERCENTAGES

Dept. B

Day:	1st	2nd	3rd	4th
Element Groups				
Productive	79.95	78.57	79.50	76.92
Absent	2.41	2.80	3.37	1.30
Delays	17.64	18.63	17.13	21.78
Elements				
1	13.80	12.40	11.40	13.50
2	23.10	21.50	28.30	23.40
3	20.30	17.20	14.05	12.85
4a	4.48	6.35	3.96	5.33
4b	1.72	1.40	1.90	3.77
5	6.90	5.29	7.02	3.77
6	3.79	3.10	5.27	5.06
7	2.41	2.80	3.37	1.30
8	1.04	1.55	1.61	0.74
9	6.20	8.08	4.98	10.40
12	2.41	3.59	2.78	2.86
13	11.05	14.41	13.75	13.00
14	2.76	2.33	1.61	4.02
No.Obs.	290	645	683	769

TABLE 18b. CUMULATIVE PERCENTAGES

Dept. B

Days:	1 day	2 days	3 days	4 days
Element Groups				
Productive	79.95	79.03	79.60	78.70
Absent	2.41	2.67	3.00	2.50
Delays	17.64	18.30	17.40	18.80
Elements				
1	13.80	12.84	12.25	12.62
2	23.10	22.00	24.63	24.25
3	20.30	18.20	16.43	15.28
4a	4.48	5.77	5.00	5.11
4b	1.72	1.50	1.66	2.34
5	6.90	5.77	6.32	5.51
6	3.79	3.32	4.14	4.44
7	2.41	2.67	3.00	2.50
8	1.04	1.39	1.48	1.22
9	6.20	7.50	6.43	7.70
12	2.41	3.22	3.02	2.97
13	11.05	13.36	13.54	13.34
14	2.76	2.46	2.10	2.72
No.Obs.	290	935	1618	2387

TABLE 19a. DAILY PERCENTAGES

Dept. C

Day:	1st	2nd	3rd	4th	5th	6th	7th
Element Groups							
Productive	62.5	69.5	78.1	66.4	67.8	69.0	68.7
Absent	19.5	11.25	5.00	7.50	9.40	8.00	9.10
Delays	18.0	19.25	16.9	26.1	22.8	23.0	22.2
Elements							
1	6.35	6.85	8.85	6.45	8.02	7.00	5.44
2	13.42	11.75	12.15	13.73	16.8	17.1	13.3
3	13.9	16.5	21.2	13.31	7.55	7.90	6.48
4a	5.13	4.93	3.90	5.60	4.93	6.11	4.21
4b	1.88	4.00	3.15	6.32	6.78	5.03	5.96
5	18.5	21.5	22.1	19.9	26.05	27.5	15.1
6	3.42	4.75	2.75	3.8	2.77	4.68	4.21
7w	19.0	9.97	3.50	6.87	8.32	5.75	7.18
7p	0.5	1.28	1.50	0.63	1.08	2.25	1.92
8	1.30	2.07	1.50	1.40	0.60	1.25	1.05
9	1.71	1.28	2.10	0.96	2.00	1.25	0.33
12	2.44	0.95	3.60	4.91	3.70	3.41	2.92
13	7.32	9.55	10.2	10.65	6.78	7.00	27.0
14	5.13	4.62	3.50	5.47	4.62	3.77	4.90
No.Obs.	410	628	667	713	649	556	571

TABLE 19b. CUMULATIVE PERCENTAGES

Dept. C

Days:	1 day	2 days	3 days	4 days	5 days	6 days	7 days
Element Groups							
Productive	62.5	66.7	71.2	69.7	69.4	69.4	69.2
Absent	19.5	14.5	10.8	9.8	9.7	9.5	9.4
Delays	18.0	18.8	18.8	20.5	20.9	21.1	21.4
Elements							
1	6.35	6.64	7.52	7.20	7.38	7.32	7.06
2	13.42	12.6	12.42	12.82	13.68	14.2	14.07
3	13.9	15.2	17.53	16.3	14.46	13.42	12.5
4a	5.13	5.01	4.57	4.88	4.90	5.08	4.96
4b	1.88	3.21	3.17	4.10	4.67	4.72	4.89
5	18.5	20.3	21.0	20.65	2184	22.7	21.63
6	3.42	4.23	3.7	3.72	3.52	3.70	3.77
7w	19.0	13.44	9.5	8.72	8.65	8.20	8.06
7p	0.5	1.06	1.25	1.08	1.08	1.25	1.34
8	1.3	1.76	1.69	1.57	1.34	1.44	1.31
9	1.71	1.54	1.82	1.53	1.63	1.57	1.42
12	2.44	1.54	2.28	3.12	3.14	3.14	3.23
13	7.32	8.66	9.27	9.68	9.07	8.75	11.21
14	5.13	4.81	4.28	4.63	4.64	4.51	4.55
No. Obs.	410	1038	1705	2418	3067	3623	4194

TABLE 20a. DAILY PERCENTAGES

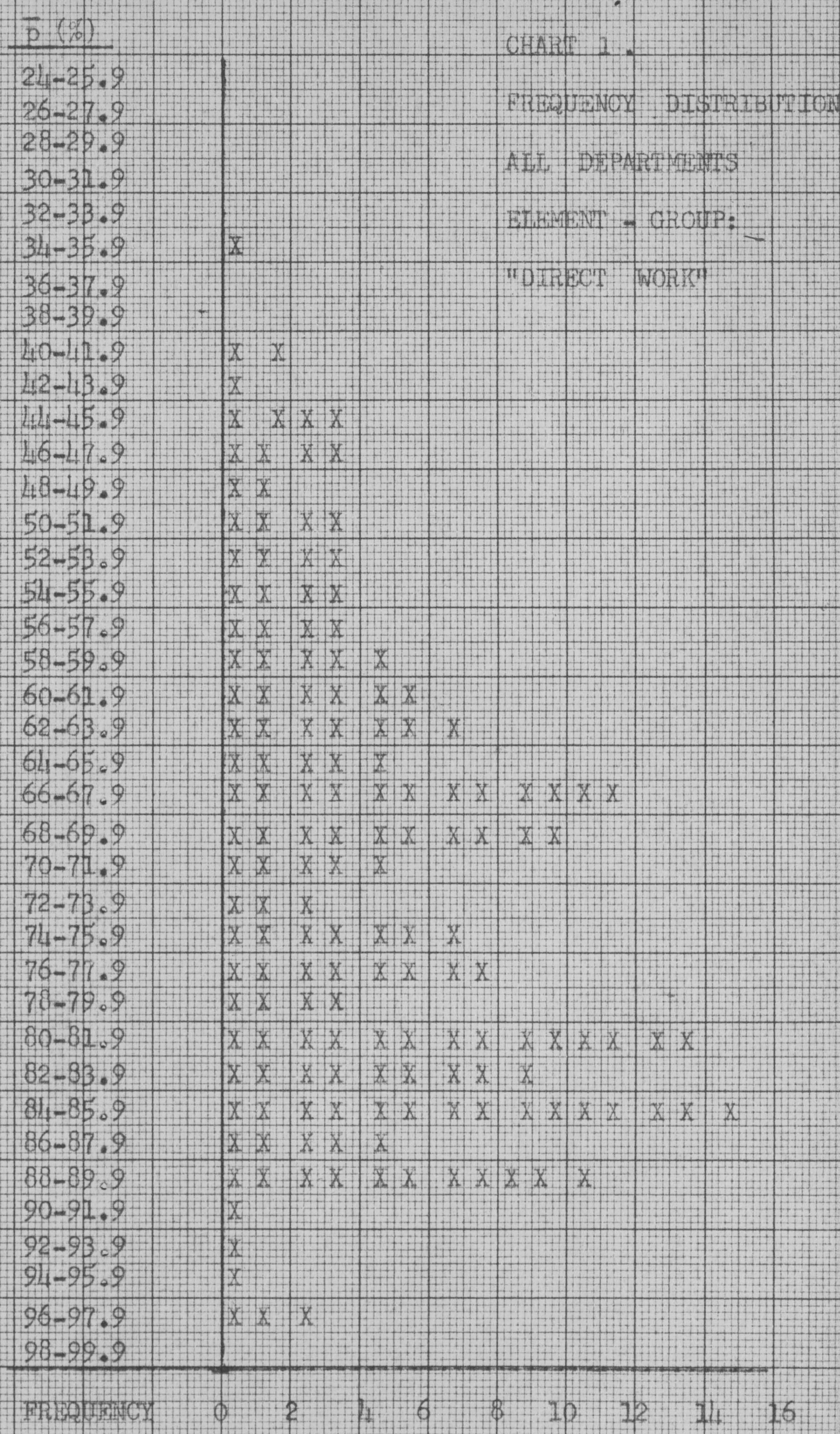
Dept. D

Day:	1st	2nd	3rd	4th	5th
Element Groups					
Productive	62.2	59.0	59.75	61.1	74.3
Absent	18.7	12.4	17.05	16.7	6.7
Delays	19.1	28.6	23.2	22.2	19.0
Elements					
1	7.84	6.82	12.7	9.2	13.0
2	13.45	15.45	16.3	19.2	21.25
3	14.7	0.0	4.7	6.61	12.4
4a	9.55	6.36	9.78	5.00	9.84
4b	1.95	3.13	1.84	3.16	0.91
5	9.55	4.09	6.70	4.84	8.25
6	2.45	4.09	2.90	3.39	2.54
7	18.7	12.4	17.05	16.7	6.7
8	4.90	3.13	2.90	1.27	0.68
9	2.21	5.91	2.15	2.58	3.17
12	2.70	9.39	3.98	4.51	1.90
13	9.55	23.6	14.3	17.4	15.55
14	2.45	5.63	4.70	6.14	3.81
No.Obs.	408	220	552	620	315

TABLE 20b. CUMULATIVE PERCENTAGES

Dept. D

Days:	1 day	2 days	3 days	4 days	5 days
Element Groups					
Productive	62.2	61.1	60.5	60.7	62.6
Absent	18.7	16.5	16.7	16.7	15.3
Delays	19.1	22.4	22.8	22.6	22.1
Elements					
1	7.84	7.49	9.92	9.67	10.15
2	13.45	14.15	15.17	16.55	17.25
3	14.7	9.55	7.29	7.05	7.85
4a	9.55	8.44	9.08	7.67	8.00
4b	1.95	2.34	2.12	2.49	2.29
5	9.55	7.65	7.20	6.40	6.66
6	2.45	3.02	2.96	3.11	3.02
7	18.70	16.5	16.7	16.7	15.3
8	4.90	4.30	3.64	2.80	2.40
9	2.21	3.50	2.88	2.78	2.84
12	2.70	5.10	4.57	4.55	4.16
13	9.55	14.46	14.4	15.45	15.45
14	2.45	3.50	4.07	4.78	4.63
No.Obs.	408	628	1180	1800	2115


p̄ (%)
24-25.9
26-27.9
28-29.9
30-31.9
32-33.9
34-35.9
36-37.9
38-39.9
40-41.9
42-43.9
44-45.9
46-47.9
48-49.9
50-51.9
52-53.9
54-55.9
56-57.9
58-59.9
60-61.9
62-63.9
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66-67.9
68-69.9
70-71.9
72-73.9
74-75.9
76-77.9
78-79.9
80-81.9
82-83.9
84-85.9
86-87.9
88-89.9
90-91.9
92-93.9
94-95.9
96-97.9
98-99.9
FREQUENCY
0
2
4
6
8
10
12
14
16
CHART 1.
FREQUENCY DISTRIBUTION
ALL DEPARTMENTS
ELEMENT - GROUP:
"DIRECT WORK"

CHART 2.

FREQUENCY DISTRIBUTION -

ALL DEPARTMENTS

ELEMENT GROUP: "SUPPORTING-DELAYS"

$\bar{p}$ (%)	
0-1.9	X X X
2-3.9	X X X X
4-5.9	X X X X X X
6-7.9	X X X X X X
8-9.9	X X X X X X
10-11.9	X X X X X X X X X X
12-13.9	X X X X X X X X
14-15.9	X X X X X X X X
16-17.9	X X X X X X X
18-19.9	X X X X X X X X
20-21.9	X X X X X X X X
22-23.9	X X X X
24-25.9	X X X X
26-27.9	X X X X X X X X
28-29.9	X X X X X X X X X
30-31.9	X X X X X
32-33.9	X X X
34-35.9	X X X X
36-37.9	X X X X
38-39.9	X
40-41.9	X X X X X X
42-43.9	X X
44-45.9	X X
46-47.9	
48-49.9	X X X
FREQUENCY	0 2 4 6 8 10

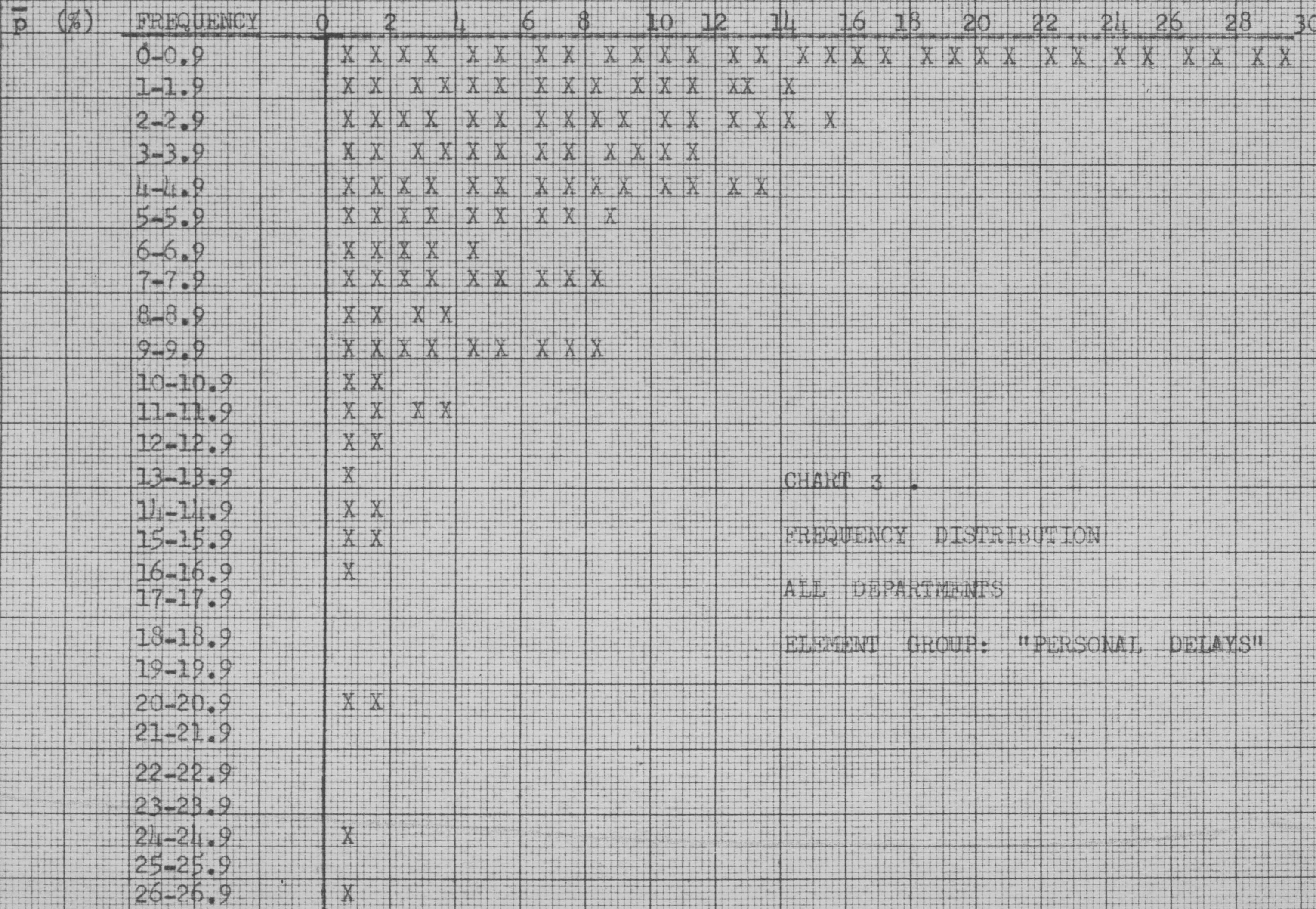


CHART 3 .

FREQUENCY DISTRIBUTION

ALL DEPARTMENTS

ELEMENT GROUP: "PERSONAL DELAYS"

$\bar{p}$ (%)	FREQUENCY (0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32)
0-0.9	X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X
1-1.9	X X X X X X X X X X X X
2-2.9	X X X X X X X X X X X X X X X X
3-3.9	X X X X X X X X X X X X X X X X X X
4-4.9	X X X X X X X X X
5-5.9	X X X X X X X X X
6-6.9	X X X X X X X
7-7.9	X X X X X X X
8-8.9	X X X X X
9-9.9	X X X X X X X X
10-10.9	X
11-11.9	X X X X
12-12.9	X X
13-13.9	X X
14-14.9	X

CHART 4.

FREQUENCY DISTRIBUTION

ALL DEPARTMENTS

ELEMENT GROUP: "CONVERSATION-PERSONAL"

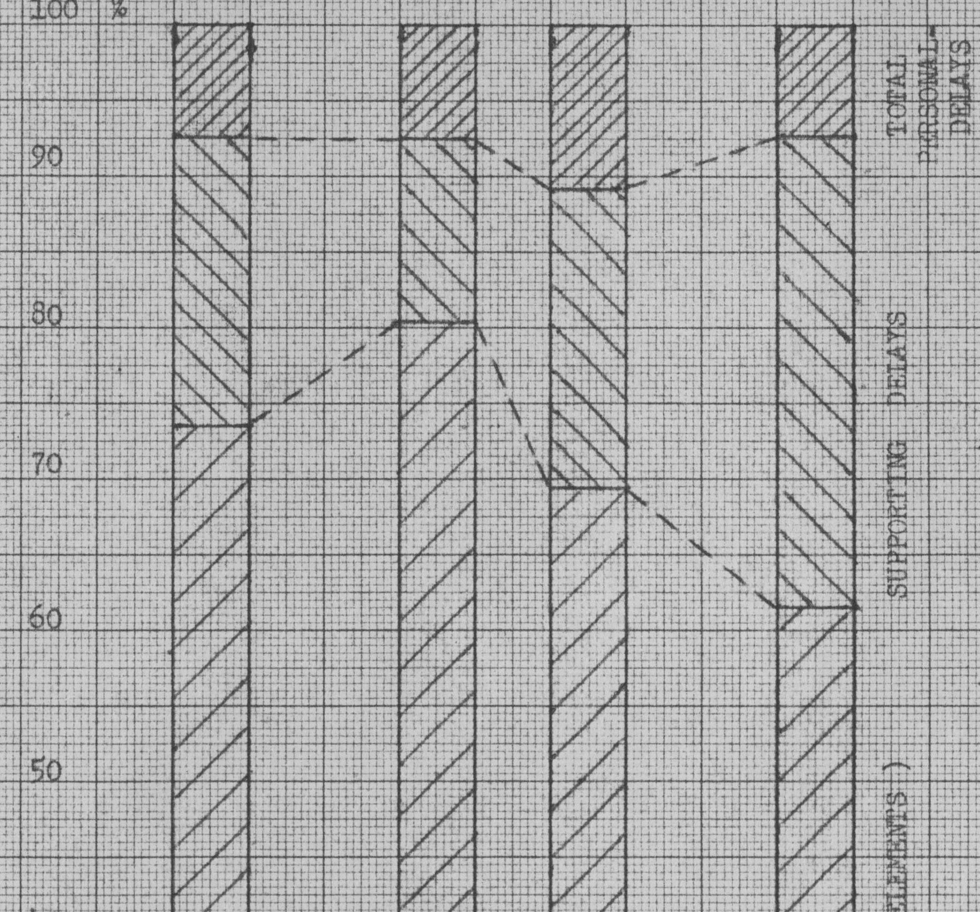


CHART 5 . DISTRIBUTION OF WORK ACTIVITIES (REF: TABLE 1)

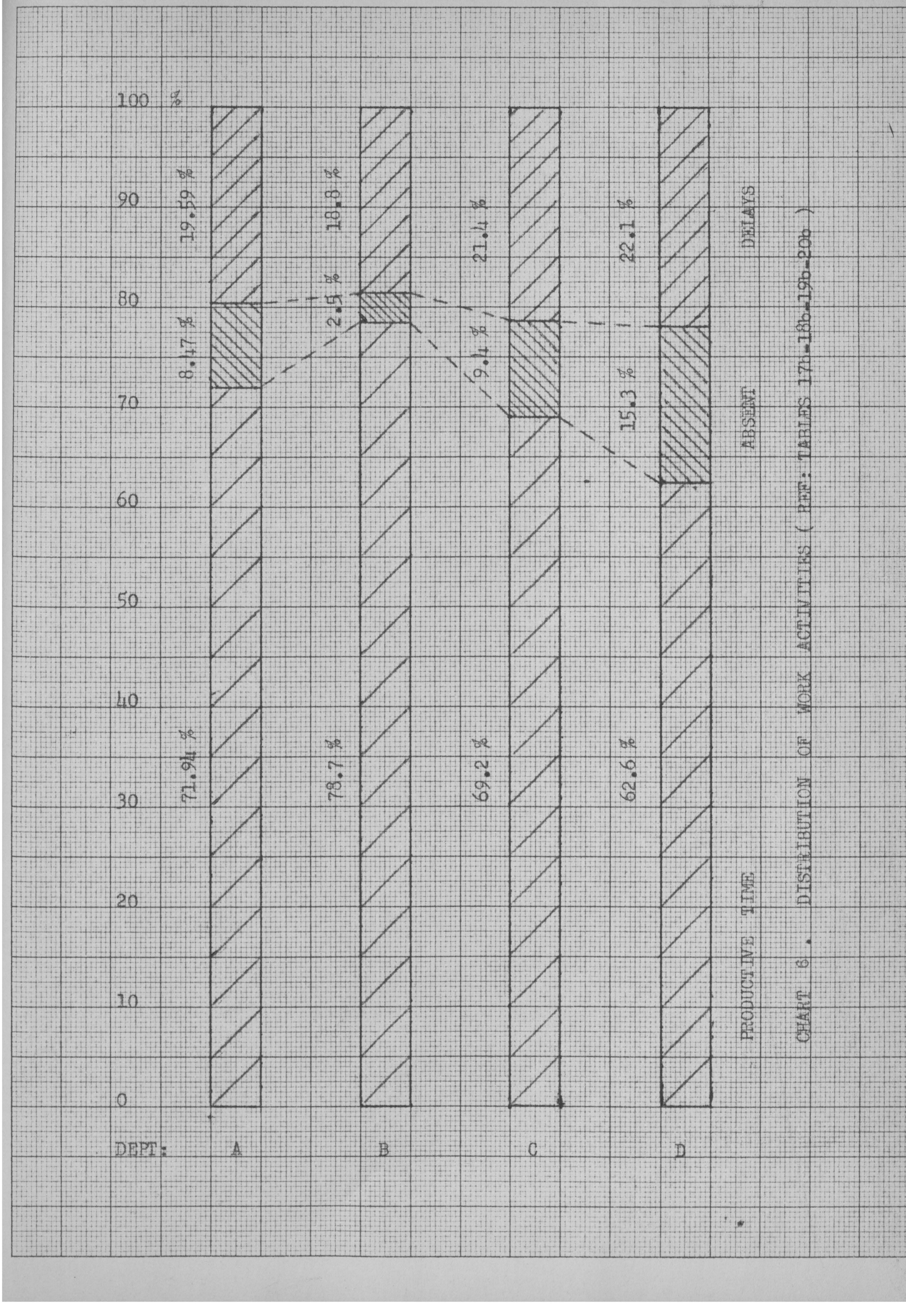


CHART 6 . DISTRIBUTION OF WORK ACTIVITIES (REF: TABLES 17b-18b-19b-20b)

CHART 7. CONTROL-CHARTS, 95% CONFIDENCE LEVEL

ELEMENT GROUP: PERSONAL DELAYS

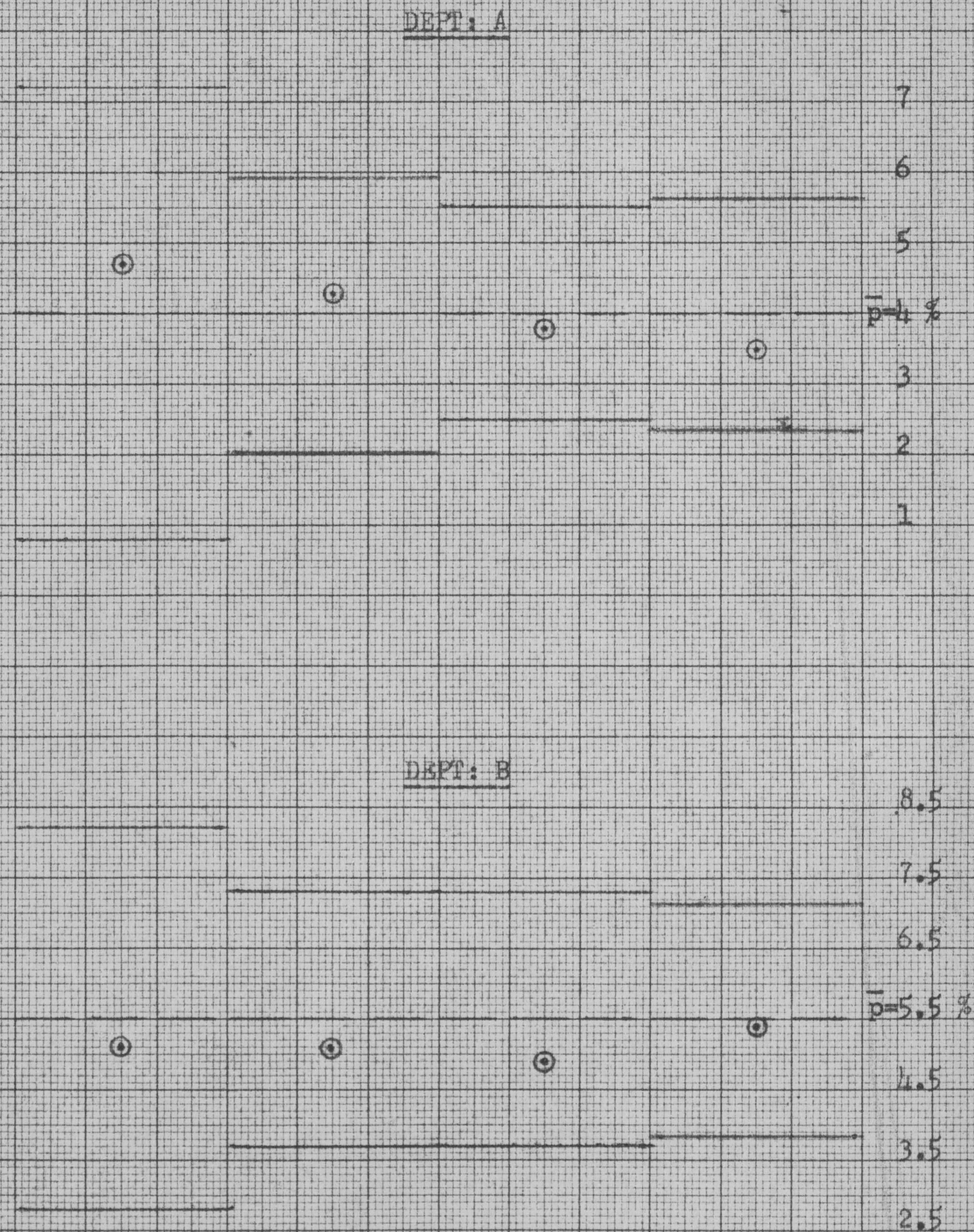


CHART 8. - CONTROL-CHARTS, 95% CONFIDENCE LEVEL

ELEMENT GROUP: PERSONAL DELAYS

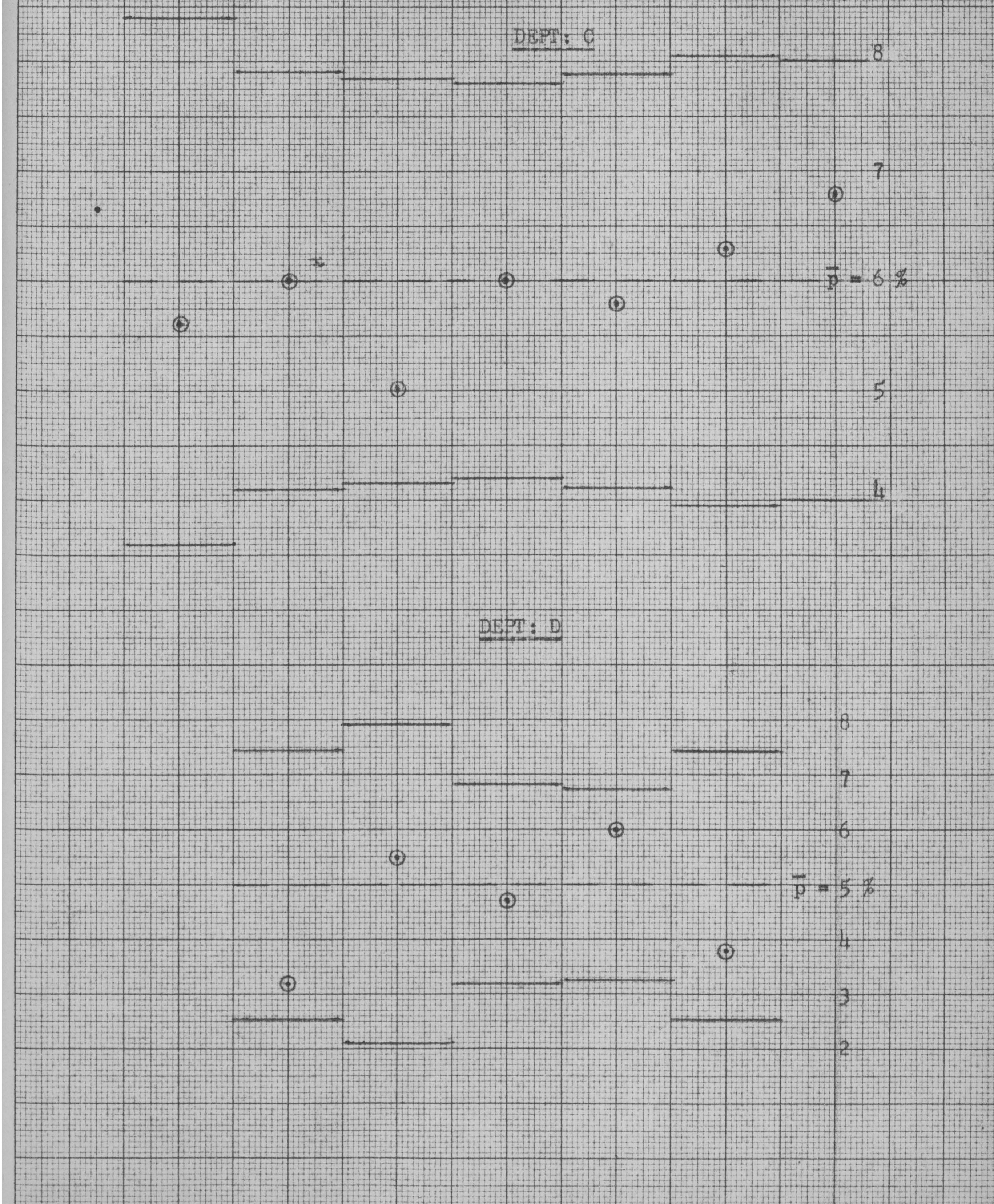
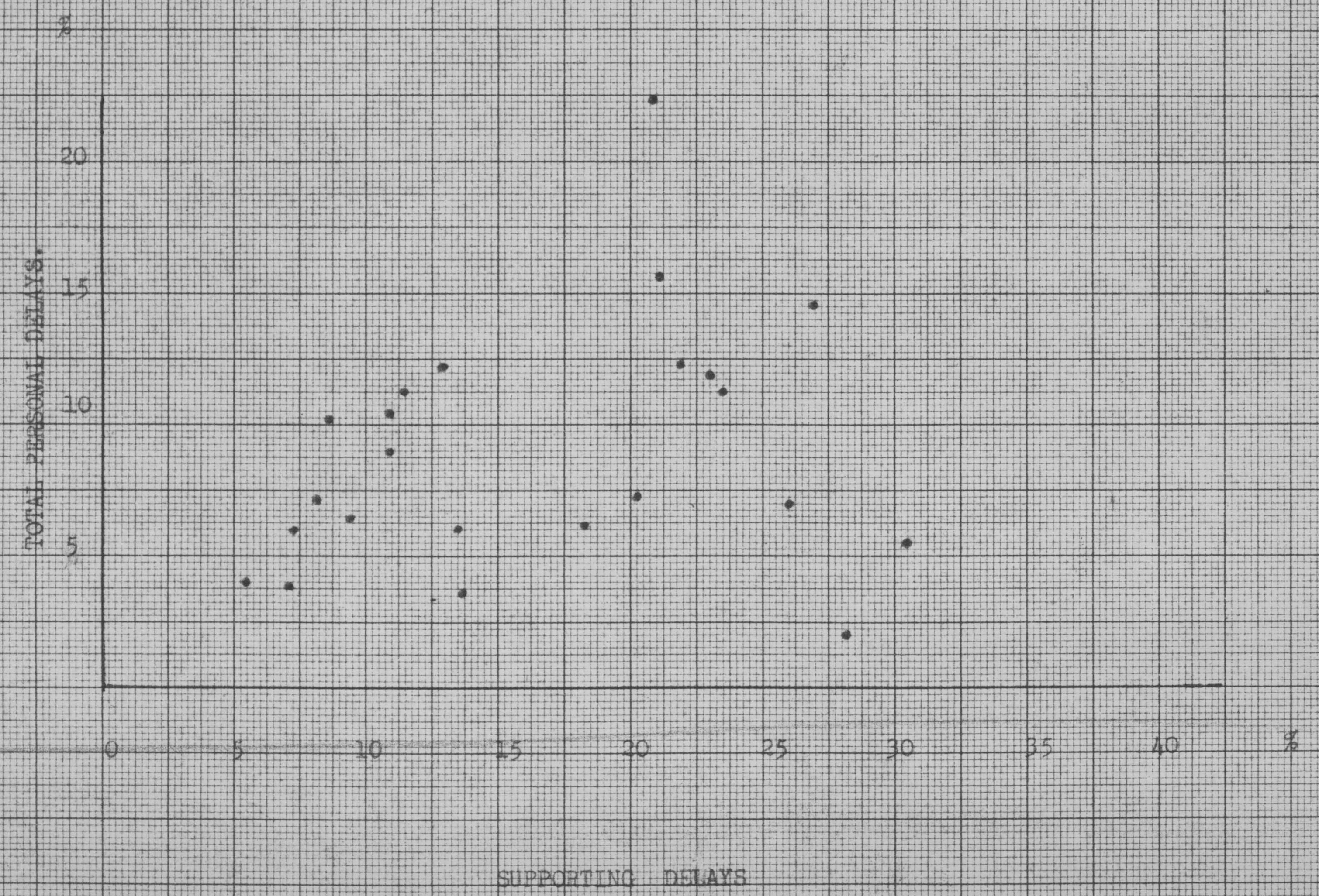


CHART 9. RELATIONSHIP BETWEEN THE SUPPORTING DELAYS AND THE TOTAL PERSONAL DELAYS.



APPENDIX

ACTIVITY KEY

DATE:

DEPARTMENT:

REMARKS:

1 Writing operations	8 Use telephone
2 Handle papers	9 Counter service
3 Operate office eqpt.	10 Wait on customer
4 Conversation	11 Make sale
5 Filing	12 Delay
6 Walking	13 Misc.
7 Absent	14 Relax

Worker	Cycle							

CONCLUSION

In the present investigation, the main attention was directed towards estimating the rates of different types of non-productive activities of a group of clerical workers, a field generally believed to be outside the domain of the time study analyst. For the first time, the qualitative approach of sampling has made it possible to obtain hitherto unknown detailed information about the work performance of white collar workers.

The findings of this study show that, as an average of the four departments, about 20 per cent of the working time was reported as "supporting delays." The total personal delays, including the official rest periods, constituted approximately another 15 per cent of the working time. The level of efficiency, by simple subtraction, was 65 per cent. This may represent a satisfactory level to some managements. The need for certain amount of non-productive activity for optimal results may also be recognized. But the fact still remains that a program of work simplification in the offices is as much of a necessity as the standard methods in industrial operations. This alone, without upsetting the delicate balance of human physiological limits, could lead to higher levels of efficiency so essential to an economy where electronic brains are threatening to replace human beings.

A few remarks in connection with the design and execution of the sampling plan and its effect on the results are in order. In the present study, a scheme of systematic sampling was employed, but this, by no means, rules out the use of random sampling in similar studies. In fact, if the study could be conducted over a longer period, a combination of systematic and random sampling would yield better results. The experience further dictates the necessity of observing a bigger group of workers with a better standardization of work methods and functions. This means an essentially homogeneous population, a condition not obtained in the present study. A single homogeneous population is also necessary if an analysis of variance is to be employed to study the variation among workers and among periods of time.

The correct determination of the cause of absence of a worker from the department is a problem that deserves greater attention, whenever such delays are frequent and long. In such a situation, a better understanding of the work procedures is necessary.

The frequency distribution curves are not binomially distributed, for reasons mentioned under "Discussion of Results." Rather than assume a binomial distribution, it is possible to take averages of sample groups and apply the central limit theorem which states that the averages will tend toward a normal distribution, regardless of the underlying distribution. One way to accomplish this would be to break down the working day into periods of suitable lengths of time. These periods would then represent sample groups which could be used for control charts. A stratified sampling should be employed where the probability of an event is suspected to vary from one period to another.

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