# THE EVALUATION OF A PHOTOGRAPHIC RATIO-DELAY TECHNIQUE

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ABSTRACT

The photographic ratio-delay technique consists of using a camera, actuated by a time-lapse drive, triggered at random intervals to take a sequence of pictures of an operation or situation. In order to evaluate and compare this method with ratio-delay, two jobs were studied: (a) an incentive-paid shirt pressing laundry operation, and (b) an hourly-paid assembly operation. The time between the pictures varied from one to five minutes. Simultaneously with the taking of the picture, a visual observation was made. The camera analysis and the visual analysis were then compared.

It was found after analysis that unsatisfactory agreement was obtained, under the conditions of this study. However, it is the author's opinion that the method is usable for work other than ratio-delay. Agreement between data obtained from ratio-delay and photographic ratio-delay may be possible if a greater number of observations are made.

# CHAPTER I

# INTRODUCTION

## The Problem

It is the purpose of this thesis to determine if it is possible to use photographic ratio-delay procedures to obtain substantially the same information as that given by ratio-delay or production studies.

### What Are Allowances

Since the time of Taylor's inception of time study in 1881, time study men have been concerned with obtaining truly representative standard times for various tasks performed by the average person working at an average pace. With properly established standards it is relatively easy to estimate the time required to produce a specific number of finished products and, consequently, establish reliable delivery dates and prices.

To determine the standard time for a task, the task must be observed then broken down into elements. These elements are timed, and the representative time obtained for each is adjusted according to the observer's concept of normal pace. In order that the standard for a job be representative as well as attainable by the normal worker, it should contain adequate provision for the various delays and interruptions that will be encountered in the performance of the task. The adjustment for delays and interruptions is called an allowance.

Allowances are made for personal time required, fatigue, and unavoidable delays. (1) Many persons have broken the number of allowances down still more finely; however, for the most part the three divisions named are adequate.

Needs for Allowances

Taylor realized the need for allowances for unavoidable delays, and he obtained them by studying the operation over a long period of time. This is much the same as W. E. Curley wrote about in the Taylor Society Bulletin in 1935. His proposal for solving the problem of time study and allowances was to first be sure the persons being studied were skilled, experienced, and fast workers. Then the time studies should be made in a continuous, detailed manner, taking into account and measuring all elements including irregular elements and necessary and unnecessary delays. He proposed that sufficient time studies be made so the different operators could be checked against each other and all representative irregular delays would be covered. Mr. Curley then states that if the time studies are taken as continuous studies and in complete detail, then the matter of allowances, exclusive of fatigue, and personal, becomes a matter of the record and eliminates to a large extent the reliance upon judgment and experience. (2)

J. F. Campbell writes that allowances should be made for fatigue, preparations, set-ups, breakdowns, equipment attention, as well as processing or machine-cycles. (3) Of the allowances for preparations, set-ups, and breakdowns, he says they are all measurable, and consequently, a definite standard for their completion can be set. If they are minor in nature, or if they occur over a fixed productive output, they can be prorated and included in the standard values. If they are included, then they are a part of the direct-labor cost per unit of production. If the allowances are excluded, then they are classified as indirect and not included in the direct cost per unit. Campbell continues by saying that we "benefit from direct inclusion only when the inclusion of allowances may be made in the standard value or when the time required for such work is so short that calling a maintenance or machine repair man would be too costly."(4)

In support of his argument for the inclusion of allowances for preparation, set-up and breakdown in the standard time for a job, Campbell states:

1. Direct labor cost per unit produced becomes complete and fixed, cutting down on the work of cost clerks, estimators, etc.
2. All indirect charges are grouped and compact for proper overhead considerations.
3. Operators need do no complicated reporting as only units produced are then involved.
4. Production planning within a department is simplified since it is known what production is expected at each operation.
5. Production checking practically eliminated because of the first four reasons.
6. The claimed time for such work (which is an incentive system hazard) is eliminated.(5)

The allowance for equipment-attention, as mentioned before, consists of any function that tends to delay production for short time intervals, such as oiling and greasing machines, clean-ups, receiving instructions and adjusting machines. The processing or machine cycle allowances are "allowances for wait time required because of delays in the process of manufacture which are beyond an operator's control."(6)

Any legitimate interruption, delay or variation must be allowed for in computing a job standard. And in general when these delays will occur is unknown, and their length cannot be pre-determined. Every operation in every industry on which wage payment or cost standards are set must include these allowances.(7)

Why should we go to all the trouble to set correct allowances? F. H. Bellows at the National Motion and Time Study Clinic in 1945 gave several reasons for management's interest in correct allowances. The employees' morale is directly affected if they are dissatisfied with time standards, for it relates to their pay. It is a direct cost to management if the allowances set are too low because there will be inadequate incentive for the workers to produce, and as a result production suffers. If allowances are set too high, then the costs are unnecessarily high, for then costs go past the intended expenditure for a particular job. As a result, the workers are provided a means for increasing all other rates in the plant.(8)

As has been illustrated, there is a definite need for correct allowances.

## Present Methods for Establishing Allowances

Judgment.--One method for setting allowances which has been used in the past, and which is still being used, is the "judgment" or "experience" method. This method appeals to many for it is definitely the least expensive way to obtain allowances. It is extremely easy to arbitrarily set ten per cent as the allowance for necessary delays without trying to determine if that particular figure is within limits of being correct. Morrow states that many concerns resort to the judgment method of determining allowances for unavoidable delays because of the cost and personnel that would be involved in a production study.(9) The judgment method may seem the cheapest initially, however, as Mr. Bellows suggested, it could be very costly in the future if the judgment involved is not correct.

Production Study.--As has been mentioned before, production or all-day studies are another means of arriving at allowances. This type of study begins with the starting of the stop-watch at the morning whistle.(10) The observer records all movement and work, making notations of the total time per piece, the number of pieces per hour and per day, and all delays during the day. These delays are then classified as personal, unavoidable, special or unnecessary. The unnecessary or avoidable delays are not used to obtain the allowances. To determine the specific allowance being desired, the total time lost for that reason is divided by the total legitimate working time. The result when multiplied by one hundred is the percentage value of the desired allowance.(11)

Production studies should be made every day for several weeks so all the possible delays and interruptions will be encountered and recorded. This feature of the production study renders it an expensive undertaking. Many concerns have neither the personnel nor the money to finance such a study. Although it may be possible for one observer to watch several machines, these machines will of necessity be the same or similar type, and the number that can be observed will be dependent upon the individual problems concerned. Even though the production study is expensive, it is accepted as the most accurate method for determining allowances; and in testing other methods for accuracy, comparison is always made with the results obtained from a production study.

Ratio-Delay.--The third method used for determining allowances is called by its originator, L. H. C. Tippett, a "snap-reading method of making time studies."(12) Tippett originated his method of making time studies as a result of the British Cotton Industries' desire to get away from the subjective basis of assigning delay allowances.(13)

In considering the problem, Tippett assumed that it was desirable to know the amount of time an operator spends performing various duties. He also assumed that a rational attempt to increase the output of any machine can only be made if the amount of productive capacity lost for each of various causes is known. Tippett reasoned that the methods then used for obtaining the information needed had their difficulties. The stop-watch method requires time and the continued presence of the observer, which may affect the operators' performance because of their being possibly unwilling to be timed. Also, if the operator has a large number of miscallaneous duties and frequently changes his action, timing becomes difficult. The stoppage indicator is another method Tippett considered but quickly saw it would not give the complete information desired.(14)

The system Tippett finally devised consisted of taking a large number of snap-readings of machines at random intervals and recording their state, either working or not working, and if they were not working, the reason for their inactive state. Then, as Tippett says, "the percentage number of readings that record the machine as working will tend to equal the percentage time it is in that state."(15) Tippett goes on to say that if the readings "are randomly distributed over a sufficiently long time, this relationship holds whether the machine stoppages or operations of the operatives are short or long, many or few, regular or irregular."(16) Similar snap-readings may be taken recording what the operators are doing.

Preliminary to taking snap-readings of machines, the operations to be covered should be analyzed. The machine classifications should be listed, then subdivided into homogeneous groups for which a single delay per cent may be found. The determining factor in deciding the number of divisions into which a classification should be separated is the amount of variation in delay percentage which may be expected within the group itself. The groups should be divided into the smallest practical classification for which a single delay per cent will be calculated.(17)

In making a ratio-delay study, as Tippett's snap-reading method is called, there are several principles and procedures which should be followed.(18) The operation should be observed in a random manner, and at the exact instant that the observer notes the operator he should record the state of the operation. Taking irregular readings avoids machine stops that are regular and at uniform intervals. It may be helpful for the observer to mark a specific spot from which to observe in order to not anticipate the operator's movements. If the machine or person is "working," mark the check sheet in that manner. If the operator is "not working," then determine and record the cause.

The number of observations to be taken depends upon the occurrence and variation of the delays found; however, a large number is recommended to reduce the chances of error. Fewer than a thousand observations are of little value, with the best results being obtained with around three thousand readings.(19)

The observations should be made throughout the working day and during the different working days for at least two weeks. A log or record should be kept of the observations to be sure that adequate time is allowed between readings to give independent observations.(20) Before the study is begun, the time for the longest delay is determined and used as the minimum time between observations. Several different machines, either alike or totally different, should be observed each round so that the resulting studies cover more area and cost less.(21)

Barnes and Correll have listed in Advanced Management the precautions that should be taken with a ratio-delay study to avoid bias:

1. Clearly define productive and delay states; the decision regarding the state must be made instantly. Delays should not be anticipated.
2. Take the observations at true random intervals. Avoid periodic stops (rest periods, etc.).
3. Long delays should be recorded only once.
4. The use of the results should be considered in determining periods of observations. If they are to be applied to allowances for incentive work, then observations should be made while incentive work is being done.
5. Sufficient observations should be made to decrease the sampling error within acceptable limits. The greater the per cent delays, the greater the number of observations needed.
6. Production records should be checked for the period of the study to determine if results were obtained during a normal period.
7. Inform the operators that the study is being made, and instruct them to work as usual.
8. In calculating the results, only homogeneous groups of data should be combined.(22)

Tippett writes that operator self-consciousness is a serious source of error. The operator may turn on the machine on the approach of the observer and turn if off after he leaves. Therefore, it is necessary to gain the employee's confidence.(23)

Calculation of Allowances.--Care must be taken in calculating allowances to assure that they are calculated in the same manner they are to be applied. For example:

| | | |
|---|---|---|
| Productive observations | (P) | = 3000 |
| Delay observations | (D) | = 150 |
| Personal observations | (Per) | = 100 |
| Total observations | (N) | =3250 |
| Per cent delay allowance | $\frac{D}{P} \times 100 = \frac{150}{3000} \times 100 = 5\%$ | |

In the above example the allowance was to be applied to the productive or normal time, so the delay allowance was calculated as a percentage of production observations.(24)

In the event personal allowances are desired, then the study probably should be taken on a departmental or plant wide basis since personal time depends to a great extent upon individual operators. The calculation of the allowance should be made as follows:

| | |
|---|---|
| P = 3000 | Rest Period = 15 minutes per 480 minute day |
| Per = 100 | Number of personal delay observations in five 465 minute days = 100 |

Per cent personal delay in five 465 minute days = $\frac{Per}{P} = \frac{100}{3000} = 3.33\%$

Rest Periods $= \frac{5(15)}{5(480-15)} = 3.22\%$

Total personal allowance $3.33\% + 3.22\% = 6.55\%$(25)

Errors in Ratio-Delay.--Systematic errors may be present in the ratio-delay study due to the variations in actual conditions from time to time or to the workers working abnormally while under observation. These can be minimized by taking the readings at representative periods extended over a sufficient length of time and by gaining the confidence of the employees.

Other than systematic errors, even if all conditions that may affect the results remain constant, there are variations in repetitive determinations of the percentage snap-readings of a given kind. These variations are called random-errors of observation. When the systematic variations are eliminated, the random variations between repeated determinations of a percentage are usually only a little greater than may be expressed by the binomial law, which may therefore be used as a basis for calculating the standard error of the result.(26)

Although increasing the number of readings reduces random errors to a minimum, the systematic errors become relatively important. Unless exceptional precautions are used, the total error is not likely to be reduced much below about two per cent, except when the per cent measured is very high or very low (between zero and five per cent and ninety-five and one hundred per cent), or comparisons are being made under conditions where systematic errors are constant.

The magnitude of the sampling variations may be estimated by computing the standard error of the percentage. From this standard error it is possible to establish the number of observations necessary for desired accuracy. The formula for obtaining the standard error is:

$$SE = \sqrt{\frac{p(1-p)}{N}} \times 100$$

SE = standard error in per cent

p = percentage expressed as a decimal (based on the total number of observations)

N = total number of observations on which "p" is based

The desirable limits of accuracy used in industrial studies have been set at the five per cent level of confidence; therefore, the maximum variation is plus or minus two and one-half per cent. This amount of variation would not appreciably affect production, and higher accuracy is too costly. Using the previous example, we can compute the standard error.

$$p = \frac{D}{N} = \frac{150}{3250} = .046 \qquad S.E. = \sqrt{\frac{.046(1-.046)}{3250}} = .0037$$

At the five per cent level the error will not exceed 1.96 x S.E. or 1.96 x .0037 which is .0073.* Hence, the limits of accuracy are "p" $\pm$ .0073 which is .046 $\pm$ .007, or .039 to .053. Since the variation of .0073 is within the acceptable limits of $\pm$ .025, then sufficient observations have been made.(27)

Real variations occur in the quantities being measured from one time to another, from one machine to another, and from one operator to another. Since any data are effectively a limited sample of these variations, the ordinary sampling errors will be experienced. However, these variations can be reduced by extending the investigation over a sufficient length of time and over all the machines and operators in a plant. Common-sense application of the ordinary principles of good sampling will tend to overcome these difficulties.(28)

Barnes and Correll in their article on ratio-delay summed up the

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*From statistical tables showing the percentage of Total Area Under the Normal Curve between Mean Ordinate and Ordinate at any Given Sigma Distance from the Mean.

problems they encountered while using the method and gave their solutions.

1. The difficulty of ascertaining whether the worker was on incentive or not was solved by the observer's becoming more familiar with the operations.
2. The problem of getting a representative sample was solved by taking the same number of observations during each hour of the day.
3. In order to determine the cause or type of delay if the operator was gone, the observer had to wait for his return.
4. It was found that good judgment was needed to decide whether delays were avoidable or unavoidable.
5. No observations were made during the cyclical delays such as rest periods or lunch. These were added separately into the personal per cent allowance.
6. The time between observations was made long enough for independent readings. If the same delay was encountered the second time, it was not recorded.

No adverse reaction was encountered by Barnes and Correll. An explanation was given to the foremen and union stewards before hand, and if the operator questioned the observer during the study, an explanation was given him. Because no stop-watches were used, there was no unfavorable reaction. The workers performed normally after becoming accustomed to seeing the observer and production during the study was not affected.(29)

In a talk which was printed by Mechanical Engineering, R. L. Morrow pointed out the conclusions of three engineers who used the ratio-delay method while under his guidance. Those that have not been discussed before are:

1. The results from a few hundred observations may be used if the frequency distribution conforms to the binomial law.
2. The accuracy of the results may be determined in any case.
3. The ratio-delay study provides an opportunity to observe and evaluate operations of the department as a whole.
4. The observer's day may be interrupted at any time without affecting the study.
5. The cost of the studies is about one-third that of production studies.

<u>Other Uses of Ratio-Delay</u>.--Ratio-delay has been used for purposes other than determining allowances. Schaeffer found that the running time of the machines could be found. He also discovered by observing men doing materials-handling work and notating what they were doing that he could find the distribution of materials-handling time. Schaeffer also found that the distribution of office workers' time could be found by using ratio-delay.(29) P. D. Vincent used ratio-delay to determine the time spent in each part of a textile spinner's job in order to ascertain the "operative hours per unit of production."(30)

J. S. Petro has used ratio-delay as a means of observing and evaluating operators, methods, and machines, as well as detecting wasteful practices and excessive avoidable delays.(31)

Barnes and Correll comment that there are several adaptations for ratio-delay. It is a tool for increasing the efficiency by exposing the delay sources. It can be used to determine machine utility or operator utility percentages. Operation analysis by percentages may be found for purposes of cost control and accounting. Ratio-delay may be used to obtain plant or departmental efficiency, or productivity index, or to determine an inspector's utility percentage. The method has been used for a methods-and-delay allowance study on a twelve-man molding unit and to determine delay occurrences in laundry operations.(32)

<u>Use of Camera</u>.--Dwyer at Georgia Tech in 1950 was called upon by the school to make a study of the cashier's office to determine whether student claims of long waits for service were true.

Dwyer's problem was to find some device to make the study for him since it was impossible for him to be in attendance for a ratio-delay study. He devised a moving picture camera-timing device set-up which recorded the status of the office every five minutes. Using this technique, he obtained a study that approached a ratio-delay study, the difference being the time intervals.(33)

Dwyer's use of the camera and his suggestion that it could possibly be used for a ratio-delay technique are responsible for this thesis.

# CHAPTER II

# PROCEDURE

## Equipment

The camera used to make the pictures for the study was the Kodak-Cine Special II, utilizing the 15 millimeter, f-2.5 lens. This camera has a single frame release, so the operator may take a single picture.

Originally it was planned that a time lapse drive would be utilized in conjunction with a random triggering device to take the pictures for the study. However this device was not perfected in time for the study, and the pictures were taken at random intervals utilizing the single frame release.

## General Procedure

In order to obtain studies on both an incentive operation and and hourly paid operation, two different jobs were observed. The incentive operation was a shirt pressing and folding operation taken in a local laundry. The hourly paid operation was a fuel pump assembly operation in an automobile rebuilding plant. Studies were made in each case over a two-day period.

The random times at which the pictures were taken were chosen according to Tippett's listing of random sampling numbers.(34) These numbers were used as being twice the time increment between pictures, with a maximum time of five minutes and a minimum time of one minute.

In the laundry operation a large Telechron electric clock was hung on the wall behind the operators. This clock was used to determine the instant at which the picture and observations would be made, in accordance with the pre-established random time schedule. The clock appears in the photographs. A wrist watch was used to determine the photographing times for the fuel pump assembly.

Procedure-Pressing Operation

Selection.--Upon investigation of the possible operations that could be observed and photographed, the sleeve-pressing and folding operation in one of the local laundries seemed the best. The operators on this particular job were Negroes working under an incentive plan. They were paid a certain amount for each hundred shirts pressed. As a result of being on incentive, they were seldom away from their workplace, which made photographing fairly satisfactory.

Setup.--The camera was situated opposite the operation at a distance of about fifteen feet. Pictures were taken at the predetermined random times using the single frame release on the camera. At the same instant the picture was taken, the status of the operation was observed and recorded for later comparison with the film. Pictures were made each day beginning at eight o'clock in the morning and ending at 4:45 P.M..

During the day, the operators had no rest periods, and the lunch period was from twelve until twelve-thirty.

Operation Description.--After being washed the shirts were starched and shaken out preparatory to the pressing operation. In the actual pressing of the shirt, two operators were involved: a sleeve presser-folder,

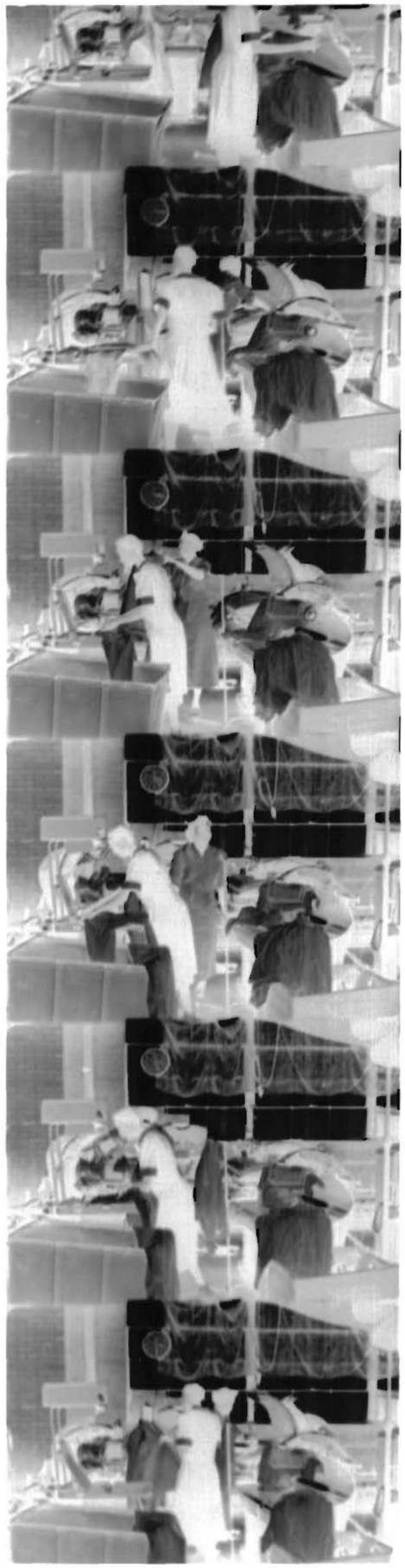

Fig. 1. Sample of Laundry Film

and a shirt, cuff and body presser, hereinafter called the folder and the presser respectively. For the purpose of this study only the folder was observed.

The folder's job consisted of taking one of the wet shirts from the bin on her right and putting a sleeve on the sleeve press. The cuff was held together, as if to be buttoned, on the end of the sleeve machine until the holding arm, which was actuated by a foot pedal, came into place to hold the cuff. This kept the cuff from dropping open until the U-shaped pressing head was in place. The holding arm then automatically withdrew. While one-half of a shirt sleeve was being pressed, the folder turned to the hot mandrel and buttoned the third button on the front. The shirt was then withdrawn and put, front down, on the folding table. By this time the shirt sleeve in the press was ready to be turned. The folder turned to the press, pressed two buttons, one with each hand, on the front of the machine in order to release the pressing head. After the head had risen from the work, the folder re-positioned the sleeve 180 degrees on the arm so the other side could be pressed. Then the pressing head was again lowered. The folder turned to the folding table, dropped the hinged folding plate on the back of the shirt, got a cardboard back and put on the shirt, folded the sleeves and made the two lengthwise folds in the shirt. The folder then turned to the press, released the head, changed the sleeves of the shirt on the press arm, positioned the cuff, lowered the holding arm and pressing head. The shirt on the folding table was then folded three times from the tail up, the gummed paper band joined, and the folded shirt taken off the hinged folding plate and put front up on the folding table. The folder turned to the press and repositioned the shirt sleeve to press the other side then turned back to the folding table. A collar board was obtained, prepared and assembled on the shirt collar, and the shirt was put in the finished shirt bin to the left of the folding table. The folder next turned back to the press, released the head, removed the shirt and put it on a hangar to the left of the pressing machine; then she proceeded to load another shirt.

The wet shirt supply at the machine was about thirty shirts. When that supply was exhausted, the folder had to find a canvas truck containing more wet shirts. At the end of every lot of production, the foreman came by and told the operators how many acceptable shirts they had pressed. This information was recorded by the folder on a production pad kept in the folding table.

Whenever the finished bin became full or the last few shirts from a lot came through, the operator would leave the workplace and take the shirts to the checking and packaging area.

Analysis.--Analysis of the film was made with a hand-crank projector. Each frame was examined closely to determine the nature of the work or activity being performed, and the job was broken down into as many parts as were discernable. During these processes, all data previously recorded by actual observation was disregarded.

Procedure-Assembly Operation

Selection.--In order to study an hourly paid operation, the fuel pump assembly operation was chosen. No time studies had been set for this job. The men employed at the plant where the pictures were made were all government employees.

The fuel pumps were removed from various government vehicles that were brought in for complete overhauling. The pumps were dismantled and all defective parts discarded. Then the pumps were cleaned, and rebuilt. Three men were involved in the assembly. One man assembled odd pumps, another made pumps for stock purposes, and the third man produced pumps for the shop assembly line. This last operator was the one observed in the study.

Setup.--The camera was situated approximately fifteen feet off of the working floor on the top of a plant office, thus giving an excellent view of the operation. The distance from the camera to the operation was about twenty-five feet.

Observations and pictures were again made simultaneously. The first day, pictures were taken beginning at ten o'clock in the morning and ending at four o'clock in the afternoon. The second day the photographing began at seven-thirty and ended at four o'clock. There were two fifteen-minute rest periods during the day, at nine-thirty and two-thirty. Lunch was from eleven-thirty to twelve-fifteen.

Operation Description.--The fuel pump assembly consisted of procuring the lower sections of the fuel pumps from a dump place near the cleaning vat, then placing them in a circular rotating rack situated in the center of the workplace. The rack held about a dozen pump bases. The operator next put an insert into the base of each pump and forced it into place, using a hammer and chisel. Springs were put on the pump arm and secured into place with a screw driver. A second spring was set on the top of

Fig. 2. Sample of Assembly Film

the insert. The pumping diaphram assemblies, previously assembled, were then removed from a five-gallon bucket sitting on the floor beside by operator and placed in the center of the circular rack. Using a large screw-driver, the operator assembled the diaphram, through the spring on the insert, to the base. The lower section of the pump was then complete.

From the dump place the operator secured the center or mid-section of the pump and placed them on top of the lower sections, which were still in the circular rack. The inner parts of the center section were then placed inside it and fastened into place with the air wrench which was suspended over the workplace. All the parts, bolts, and nuts were kept in a rotating circular bin that was underneath the work bench top in front of the seated operator.

The operator next obtained the tops for the pumps from the dump place and placed them on the mid-sections in the rack. He then assembled the bolts and washers used to hold the top in place and put them into the holes in the top section. With the air wrench the operator tightened the bolts.

The operator stood up and moved to his right about two feet to the test stand. He took each pump and connected it to the test apparatus. The operator cranked the apparatus and watched a dial that indicated whether or not the pump worked. The hose was removed from the first side, attached to the second side and the operation repeated. If the pump was good, it was laid to one side; if it was not good, it was put back on the circular rack. The good pumps were put into a cart at the left of the workplace. The rejected pumps were disassembled, repaired, reassembled, and tested until they functioned properly.

The nature of the operation was such that the operator assembled several different types of pumps, depending on what particular type of vehicle was going through the rebuilding phase. Ever so often then, the operator had to gather together the different selection of parts, depending on the type of pump. This phase of his operations was called a "change-over." A change-over was encountered in this study toward the end of the second day.

Analysis.--As in the analysis of the laundry operation, a hand-crank projector was used to examine the film. Again, as fine a breakdown of the job was possible was made during the film analysis, without any reference to the observation data.

# CHAPTER III

## DISCUSSION OF RESULTS

### Laundry Operation

The activities observed during the laundry operation are listed in the order of their appearance in Table 1. The observations obtained during the film analysis are given in Table 2. The matched analysis and observation items, with their descriptions, are given in Table 3. Table 4 shows the comparison of the two analyses by activity number and by the per cent occurrence of each matched group. The subtracted differences of the per cents is also shown as well as the percentage differences of the per cents, using the actual observation values as the base. The workplace layout is shown in Figure 3. During the two days of study, a total of 363 simultaneous film and actual observations were made.

Item Comparison.--In deriving the results shown in Table 3, as could be expected, the terminology used and the job breakdowns made were not exactly the same in the film analysis as in the actual observations. However, the first item under each analysis, "load sleeve press," was the same as far as terminology was concerned.

The second analysis item, "gone from workplace," corresponds to five difference classifications under the actual observation listing: four, "washroom"; twenty-six, "get drink"; twenty-seven, "get supply of wet shirts"; and twenty-nine, "sharpen pencil."

Table 1. Observed Laundry Activities

| Activity | | Frequency |
|---|---|---|
| 1. | Load sleeve press | 40 |
| 2. | Remove sleeve | 10 |
| 3. | Reposition sleeve | 29 |
| 4. | Washroom | 5 |
| 5. | Talk to supervisory persons | 5 |
| 6. | Fold shirt and tape | 77 |
| 7. | Pick up wet shirt | 9 |
| 8. | Write lot production on pad | 4 |
| 9. | Aside finished folded shirt | 10 |
| 10. | Aside shirt for repairs | 2 |
| 11. | Move to sleeve press | 13 |
| 12. | Move to folding table | 16 |
| 13. | Move to mandrel for shirt to fold | 3 |
| 14. | Adjust button or fix french cuffs on folding table | 12 |
| 15. | Remove folded shirt | 2 |
| 16. | Button shirt on mandrel | 26 |
| 17. | Get and prepare collar board | 9 |
| 18. | Insert collar board | 12 |
| 19. | Aside shirt from sleeve press | 9 |
| 20. | Insert cardboard in shirt | 7 |
| 21. | Position finished shirt bin | 2 |
| 22. | Talk - unnecessary | 14 |
| 23. | Talk to helper - necessary | 3 |
| 24. | Put shirt on folder | 23 |
| 25. | Gone for collar boards or cardboards | 1 |
| 26. | Get drink | 1 |
| 27. | Get supply of wet shirts | 2 |
| 28. | Remove shirt from mandrel | 2 |
| 29. | Sharpen pencil | 1 |
| 30. | Wipe hands | 1 |
| 31. | Flip up folder back | 1 |
| 32. | Aside extra collar board | 1 |
| 33. | Position fastening tapes in folder | 1 |
| 34. | Wait on helper for shirt | 1 |
| 35. | Deliver finished shirts (bin or singles) | 3 |
| 36. | Move to mandrel with short sleeve shirt | 1 |
| 37. | Get cardboard | 2 |
| 38. | Mark shirt with pencil | 1 |
| 39. | Eat orange | 2 |
| | | 363 |

Table 2. Film Analysis Laundry Activities

| Activity | | Frequency |
|---|---|---|
| 1. | Load sleeve press | 49 |
| 2. | Gone from workplace | 8 |
| 3. | Reposition sleeve on sleeve press or change sleeve | 17 |
| 4. | Talk to other employees | 4 |
| 5. | Fasten folded shirt | 12 |
| 6. | Fold shirt | 61 |
| 7. | Position wet shirts | 1 |
| 8. | Write on production pad or have pad in hand | 5 |
| 9. | Aside finished shirt | 11 |
| 10. | Button shirt on mandrel | 34 |
| 11. | Button shirt or french cuffs on folding table | 9 |
| 12. | Put shirt on pipe hanger | 10 |
| 13. | Put shirt on folder | 30 |
| 14. | Get collar board | 7 |
| 15. | Remove folded shirt | 3 |
| 16. | Get cardboard | 3 |
| 17. | Position bin for finished shirt | 1 |
| 18. | Press buttons for release or close of sleeve press | 26 |
| 19. | To sleeve press | 9 |
| 20. | To mandrel | 4 |
| 21. | Insert collar board | 15 |
| 22. | To folding table | 6 |
| 23. | Gone for collar inserts | 1 |
| 24. | Aside shirt for repairs (end of bin) | 1 |
| 25. | Insert cardboard | 7 |
| 26. | Pick up wet shirts | 11 |
| 27. | Talk to helper | 6 |
| 28. | Fix collar board | 5 |
| 29. | Count wet shirts | 1 |
| 30. | Talk to supervisor | 3 |
| 31. | Fix fastening strips | 1 |
| 32. | Idle | 1 |
| 33. | Work with folding table | 1 |
| | | 363 |

Table 3. Matched Analysis and Observation Laundry Activities

| Film Analysis Number and Description | Observation Analysis Number and Description |
|---|---|
| 1. Load sleeve press | 1. Load sleeve press |
| 2. Gone from workplace | 4. Washroom<br>26. Get drink<br>27. Get supply of wet shirts<br>29. Sharpen pencil<br>35. Deliver finished shirts |
| 3. Reposition sleeve or change sleeve<br>18. Press buttons on sleeve press | 2. Remove sleeve<br>3. Reposition sleeve |
| 4. Talk to other employees | 22. Talk - unnecessary |
| 5. Fasten folded shirt<br>6. Fold shirt | 6. Fold shirt and tape |
| 7. Position wet shirts<br>26. Pick up wet shirts<br>29. Count wet shirts | 7. Pick up wet shirts |
| 8. Write on production pad or have pencil in hand | 8. Write lot on production pad<br>38. Mark shirts with pencil |
| 9. Aside finished shirt | 9. Aside finished folded shirt |
| 10. Button shirt on mandrel | 16. Button shirt on mandrel<br>30. Wipe hands |
| 11. Button shirt or french cuffs on folding table | 14. Adjust button or fix french cuffs on folding table |
| 12. Put shirt on pipe hanger | 19. Aside shirt from sleeve press |
| 13. Put shirt on folder | 24. Put shirt on folder<br>28. Remove shirt from mandrel |
| 14. Get collar board<br>28. Fix collar board | 17. Get and prepare collar board<br>32. Aside extra collar board |
| 15. Remove folded shirt | 15. Remove folded shirt |
| 16. Get cardboard | 37. Get cardboard |

Table 3. Matched Analysis and Observation Laundry Activities (Continued)

| Film Analysis Number and Description | Observation Analysis Number and Description |
|---|---|
| 17. Position bin for finished work | 21. Position finished shirt bin |
| 19. To sleeve press | 11. Move to sleeve press |
| 20. To mandrel | 13. Move to mandrel for shirt to fold<br>36. Move to mandrel with short sleeve shirt |
| 21. Insert collar board | 18. Insert collar board |
| 22. To folding table | 12. Move to folding table |
| 23. Gone for collar boards | 25. Gone for collar boards or card-board |
| 24. Aside shirt for repairs | 10. Aside shirt for repairs |
| 25. Insert cardboard | 20. Insert cardboard |
| 27. Talk to helper | 23. Talk to helper - necessary<br>39. Eat orange |
| 30. Talk to supervisor | 5. Talk to supervisory persons |
| 31. Fix fastening strips | 33. Position fastening tapes in folder |
| 32. Idle | 34. Wait on helper for shirt |
| 33. Work with folding table | 31. Flip up folder back |

Table 4. Comparison of Laundry Operation Analyses

| Film Analysis | | Observation Analysis | | | |
|---|---|---|---|---|---|
| Item Number | Percentage Occurrence | Item Number | Percentage Occurrence | Subtracted Difference | Percentage Difference |
| 1 | 13.5 | 1 | 11.0 | 2.5 | 22.7 |
| 2 | 2.2 | 4,26,27,29,35 | 3.4 | -1.2 | -35.3 |
| 3 & 18 | 11.9 | 2,3 | 10.8 | 1.1 | 10.2 |
| 4 | 1.1 | 22 | 3.9 | -2.8 | -71.8 |
| 5 & 6 | 20.1 | 6 | 21.2 | - .9 | - 4.2 |
| 7,26,29 | 3.6 | 7 | 2.5 | 1.1 | 44.0 |
| 8 | 1.4 | 8,38 | 1.4 | 0 | 0 |
| 9 | 3.0 | 9 | 2.8 | .2 | 7.1 |
| 10 | 9.4 | 16,30 | 7.5 | 1.9 | 25.4 |
| 11 | 2.5 | 14 | 3.3 | - .8 | -24.2 |
| 12 | 2.8 | 19 | 2.5 | .3 | 12.0 |
| 13 | 8.3 | 24,28 | 6.9 | 1.4 | 20.3 |
| 14,28 | 3.3 | 17,32 | 2.8 | .5 | 17.9 |
| 15 | .8 | 15 | .6 | .2 | 33.3 |
| 16 | .8 | 37 | .6 | .2 | 33.3 |
| 17 | .3 | 21 | .6 | - .3 | -50.0 |
| 19 | 2.5 | 11 | 3.6 | -1.1 | -30.6 |
| 20 | 1.1 | 13,36 | 1.1 | 0 | 0 |
| 21 | 4.1 | 18 | 3.3 | .8 | 24.2 |
| 22 | 1.7 | 12 | 4.4 | -2.7 | -62.4 |
| 23 | .3 | 25 | .3 | 0 | 0 |
| 24 | .3 | 10 | .6 | - .3 | -50.0 |
| 25 | 1.9 | 20 | 1.9 | 0 | 0 |
| 27 | 1.7 | 23,39 | 1.4 | .3 | 21.4 |
| 30 | .8 | 5 | 1.4 | - .6 | -42.8 |
| 31 | .3 | 33 | .3 | 0 | 0 |
| 32 | .3 | 34 | .3 | 0 | 0 |
| 33 | .3 | 31 | .3 | 0 | 0 |
| | 100.3 | | 100.7 | | |

The third item of the analysis, "reposition sleeve on the sleeve press or change sleeve," was broken down more finely in the actual observations as: two, "remove sleeve," and three, "reposition sleeve." Since from the film it was difficult to tell whether a shirt was being loaded for the first time or only being repositioned for the second sleeve, it is possible that some of the readings listed in the analysis as "load sleeve press" should be "reposition sleeve." The eighteenth item on the film analysis, "press buttons for release or close of sleeve press," probably should go along with analysis item three since in observing the job the "remove sleeve" item was taken as starting as soon as the operator turned to the machine. In observing the job, the "push button" phase was very difficult to detect.

Analysis item four, "talk to other employees," was found to occur less than did the corresponding observation item twenty-two. In the film analysis it was difficult to tell when the employee was talking, especially if her back was toward the camera. When she did talk, she kept hold of her work and several times did not look at the person with whom she was talking.

The fifth and six analysis items, "fasten folded shirt" and "fold shirt," are the same as observation item six, "fold shirt and tape." Again, it was possible to detect two distinct phases of work more easily with the camera than with the eye.

Analysis item eight, "write on production pad," probably corresponds to items eight and thirty-eight, "write on production pad" and "mark shirt with pencil." When using a pencil, the operator leaned over the folding table; and although it was relatively easy to tell that she was writing, it was rather difficult to tell what the object was that was being marked.

"Button shirt on mandrel," analysis item ten, corresponds to observations sixteen, "button shirt on mandrel," and thirty, "wipe hands." When the operator wiped her hands, her back was toward the camera, and she was facing the mandrel. In the analysis this picture was probably called "button shirt at mandrel." The difference of 1.9 per cent, showing the film analysis higher, no doubt is affected by analysis item four. Several times when the operator talked to her helper she was at the mandrel working; she stopped work, but held the shirt in her hands and talked. This would have been recorded by film as "button shirt at mandrel" and probably accounts for the higher value of analysis item ten.

Analysis item thirteen, "put shirt on folder," most nearly matches items twenty-four and twenty-eight, "put shirt on folder" and "remove shirt from mandrel." The distance from the mandrel to the folding table is very short. Although in actual observation it was possible to tell when the two items were happening, it was not possible with the two-dimensional still picture.

"Get collar board" and "prepare collar board," analysis items fourteen and twenty-eight, coincide with actual observations of "get and prepare collard" and "aside extra collar board," items seventeen and thirty-two. From the film it was not possible to tell in what direction the operator's hand was moving, so the "aside" was not ascertainable.

The percentage difference in the per cents of analysis items fifteen, sixteen and seventeen and observed items fifteen, thirty-seven and twenty-one is rather large. However, there is actually only one observation difference between these values.

In the comparison of analysis item nineteen, "to sleeve press," and observation item eleven, "move to sleeve press," the film analysis showed less "moving." This could have been caused by the recording in analysis items three and eighteen, concerning the sleeve pressing, of some of the occurrences that should have been called in the "moving" category. This possibility is borne out by comparison of the actual differences between the per cents. This 1.1 of the sleeve pressing exactly balances the -1.1 of the moving operations, as seen in Table 4.

Analysis item twenty, "move to mandrel," probably contains the same information as observation items thirteen, "move to mandrel," and thirty-six, "move to mandrel with short sleeve shirt." The sleeves of the short-sleeve shirts were pressed by placing them on the mandrel.

The higher percentage for analysis item twenty-one, "insert collar board," than for observation item eighteen was probably caused by the interpretation of the film. If from the film it appeared that the operator was holding the cardboard on the shirt, it was assumed that she had just put the board on the shirt. However, by examining the "button shirt on table" phase of the analysis, item eleven, it is possible that due to the difficulty of discerning what the hands were doing, even though the operator was actually fixing french cuffs, it appeared she was holding the cardboard. Again by comparison of the actual difference of the per cents, the .8 balances the -.8 of the observation group, from Table 4.

Analysis item twenty-four and observation item ten, having to do with "putting aside shirt for repairs," do not compare exactly; the observed data showing the larger percentage. The operator put the shirts to be repaired in one of two locations: (a) on a shelf of the folding table, if the shirt was folded before discovery of needed repair, or (b) on the end of the bin, if the defect was found before folding. From the film analysis it was impossible to detect where the operator would put the folded shirt after she removed it from the folding table. It is possible that what was observed as "remove folded shirt" from the film analysis, could have been called "aside shirt for repairs" in actual observation. Examination shows that the comparison of the actual differences of per cent balances the .2 from "remove" against the -.3 from "aside for repairs."

Analysis item twenty-seven, "talk to helper," in all probability corresponds to items twenty-three and thirty-nine, "talk to helper" and "eat orange." As the operator ate the orange, she turned to the helper to talk. Thus her back was toward the camera, making it impossible to see the orange.

When the operator was talking to the supervisor, analysis item thirty, the supervisor was not always in the picture. The operator may have been looking in that direction, but, in the film analysis, if she appeared to be working, the proper "working" observation was made. This could possibly account for the difference in the two percentage figures of analysis item thirty and observation item five.

Group Comparison.--In order to determine whether a less detailed analysis than that made would have been beneficial, the items were grouped into similar activities and the groups compared. Table 5 shows the groupings

Table 5. Grouped Comparison of Laundry Operation Analyses

| Group Number | Film Analysis Item Number | Film Analysis Percentage Occurrence | Observation Analysis Item Number | Observation Analysis Percentage Occurrence | Subtracted Total Difference | Percentage Difference |
|---|---|---|---|---|---|---|
| (1) At Press | 1 | 13.5 | 1 | 13.5 | | |
| | 3,18 | 11.9 | 2,3 | 10.8 | | |
| | 7,26,29 | 3.6 | 7 | 2.5 | | |
| | | 29.0 | | 24.3 | 4.7 | 19.4 |
| (2) At Folder | 5,6 | 20.1 | 6 | 21.2 | | |
| | 8 | 1.4 | 8,39 | 1.4 | | |
| | 11 | 2.5 | 14 | 3.3 | | |
| | 13 | 8.3 | 24,28 | 6.9 | | |
| | 14,28 | 3.3 | 17,32 | 2.8 | | |
| | 15 | .8 | 15 | .6 | | |
| | 16 | .8 | 38 | .6 | | |
| | 21 | 4.1 | 18 | 3.3 | | |
| | 25 | 1.9 | 20 | 1.9 | | |
| | 31 | .3 | 33 | .3 | | |
| | 33 | .3 | 31 | .3 | | |
| | | 43.8 | | 42.6 | 1.2 | 2.8 |
| (3) At Mandrel | 10 | 9.4 | 16,30 | 7.5 | 1.9 | 25.4 |
| (4) Move | 9 | 3.0 | 9 | 2.8 | | |
| | 12 | 2.8 | 19 | 2.5 | | |
| | 17 | .3 | 21 | .6 | | |
| | 19 | 2.5 | 11 | 3.6 | | |
| | 20 | 1.1 | 13,36 | 1.1 | | |
| | 22 | 1.7 | 12 | 4.4 | | |
| | 24 | .3 | 10 | .6 | | |
| | | 11.7 | | 15.6 | -3.9 | -25.0 |
| (5) Talk | 4 | 1.1 | 22 | 3.9 | | |
| | 27 | 1.7 | 23,39 | 1.4 | | |
| | 30 | .8 | 5 | 1.4 | | |
| | | 3.6 | | 6.7 | -3.1 | -46.3 |
| (6) Gone from work place | 2 | 2.2 | 4,26,27,29,35 | 3.4 | | |
| | 23 | .3 | 25 | .3 | | |
| | | 2.5 | | 3.7 | -1.2 | -32.4 |
| (7) Idle | 32 | .3 | 34 | .3 | 0 | 0 |

used for comparison of the studies. The first group is called "at press" which is made up of all the activities performed predominantly at the sleeve press location. The analysis per cent figure is higher than the observed figure by 4.7, or a percentage of 19.4 per cent, using the observation per cent as the base. This difference is probably due to analysis item eighteen, as was discussed before.

The second grouping is called "at folder," which is made up of activities taking place at the folding table. The activities taking place at the folding table take almost half of the operator's time. The comparison shows a relatively high degree of agreement, since the per centage difference of the totals is only 2.8 per cent.

Third grouping, "at mandrel," contains only one item comparison, which has been discussed previously.

The fourth grouping is called the "move" group. All items that are predominantly "moving" items are included in this group. The difference between the per cents of -3.9 is probably affected by analysis item eighteen. This item, as has been discussed previously, was in part a move since the operator was turning and reaching toward the buttons at the same time. However, the operator moved so fast that it was impossible to detect the reaching by observation.

The comments made in the item comparison concerning the detection of talking by the operator apply also to the fifth or "talk" group.

The sixth or "gone from workplace" group is made up of the two-item comparison shown in Table 5. No plausible reason for the difference in per cents can be found other than the camera recorded the person in the picture when actually it was thought the operator was out of the field of view.

The seventh or "idle" group is made up of analysis item thirty-two and observation item twenty-four. These items compare exactly.

## Assembly Operation

The activities observed during the fuel pump assembly are given in Table 6. The observations obtained during the film analysis are given in Table 7. The matched analysis and observation items with their descriptions are given in Table 8. Table 9 shows the comparison of the two analyses by activity number and by the per cent occurrence of each matched group. The subtracted differences of the per cent are also shown as well as the percentage differences of the per cents, using the actual observation values as the base. The workplace layout is shown in Figure 4. During the two days of study, a total 282 simultaneous film and actual observations were made.

Item Comparison.--In deriving the results shown in Table 8, there were differences in the terminology and breakdown of the job. In order to obtain some similarity between the analysis data and the observation data, some groups had to be combined.

Analysis item one, "work with pump on test stand," corresponds to observed items: one, "put fuel pump on test stand"; two, "remove fuel pump from test stand"; four, "test pump"; eight, "put part on test apparatus hose"; and thirty-three, "inspect broken test crank knob and adjust."

"Use air wrench on center section," analysis item four, corre-

Table 6. Observed Assembly Activities

| Activity | Frequency |
|---|---|
| 1. Put fuel pump on test stand | 18 |
| 2. Remove fuel pump from test stand | 10 |
| 3. Return tested pump to assembly stand | 2 |
| 4. Test pump | 8 |
| 5. Put finished pumps into cart | 3 |
| 6. Change bits in air wrench | 2 |
| 7. Get parts from hands or bin to put on assembly | 11 |
| 8. Put part onto test apparatus hose | 2 |
| 9. Tighten arms on pumps bottom and assembly (second workplace) | 18 |
| 10. Gone to cleaning vat | 7 |
| 11. Put insert or springs in bottom section of pump | 2 |
| 12. Assembly diaphram to bottom section | 5 |
| 13. Get new mid-sections for pump | 3 |
| 14. Talk with friends - unnecessary | 6 |
| 15. Put parts into mid-section of pump | 21 |
| 16. Use air wrench on mid-section | 6 |
| 17. Make screw sub-assembly for top section | 20 |
| 18. Assemble gasket and top section | 5 |
| 19. Put assembly bolts in top section | 9 |
| 20. Use air wrench on top section bolts | 15 |
| 21. Get spring to put on arm of pump | 1 |
| 22. Return to workplace | 4 |
| 23. Adjust pump on bench or in hands | 11 |
| 24. Clean up workplace | 7 |
| 25. Gone for tools or parts | 13 |
| 26. Put base of pump in circular rack | 2 |
| 27. Remove diaphrams from gasoline bucket | 1 |
| 28. Straighten bent part | 1 |
| 29. Assemble mid-section to bottom of pump | 3 |
| 30. Gone for drink and to read bulletin board | 3 |
| 31. Get new top or bottom sections | 2 |
| 32. Gone to washroom | 2 |
| 33. Inspect broken test crank knob and adjust | 2 |
| 34. Adjust air wrench | 1 |
| 35. Put top on mid-section | 2 |
| 36. Inspect diaphrams or other parts | 3 |
| 37. Inspect tools | 1 |
| 38. Sort parts | 32 |
| 39. Talk to supervisory personnel | 1 |
| 40. Assemble top to mid-section | 2 |
| 41. Remove parts from rejected pump | 1 |
| 42. Gone to grinder | 1 |
| 43. Lay aside assembled sub-assembly | 1 |

Table 6. Observed Assembly Activities (Continued)

| Activity | Frequency |
|---|---|
| 44. Get parts for arm (second workplace) | 5 |
| 45. Drive insert into bottom section | 1 |
| 46. Get tool from tool box | 1 |
| 47. Wipe hands | 1 |
| 48. Gone with empty parts box | 4 |
| | 282 |

Table 7. Film Analysis Assembly Activities

| Activity | | Frequency |
|---|---|---|
| 1. | Work with pump on test stand | 38 |
| 2. | Put tested pump on circular rack | 2 |
| 3. | Put accepted pumps in cart | 3 |
| 4. | Use air wrench on counter section | 8 |
| 5. | Get parts from or put parts in circular bin or look in bin | 26 |
| 6. | Assemble small parts in hands | 6 |
| 7. | At body parts workplace | 35 |
| 8. | Gone from workplace | 31 |
| 9. | Put springs in bottom section | 2 |
| 10. | Put diaphrams on bottom and assemble | 6 |
| 11. | Put parts in center section | 18 |
| 12. | Preparatory work on top section | 5 |
| 13. | Use air wrench on top section | 16 |
| 14. | Adjust pump | 3 |
| 15. | Adjust chair at workplace | 1 |
| 16. | Inspect center section - parts | 13 |
| 17. | Put new parts on workplace | 2 |
| 18. | Put new bottom section in circular rack | 2 |
| 19. | Put diaphram in center of rack | 2 |
| 20. | Put screws in top section | 4 |
| 21. | Returning to workplace | 2 |
| 22. | Leaving workplace | 2 |
| 23. | Talk to other workers | 7 |
| 24. | Discard bad parts | 1 |
| 25. | Put on top section | 3 |
| 26. | Wipe hands | 1 |
| 27. | Assemble top section bolts and washers | 16 |
| 28. | Put center section on bottom section | 5 |
| 29. | Get tool box | 1 |
| 30. | Talk to other workers about work | 1 |
| 31. | Look for parts or material | 1 |
| 32. | Sort parts | 18 |
| 33. | Lay aside parts | 1 |
| | | 282 |

Table 8. Matched Analysis and Observations Assembly Activities

| Film Analysis Number and Description | Observation Analysis Number and Description |
|---|---|
| 1. Work with pump on test stand | 1. Put fuel pump on test stand<br>2. Remove fuel pump from test stand<br>4. Test pump<br>8. Put part onto test apparatus hose<br>33. Inspect broken test crank knob and adjust |
| 2. Put tested pump on circular stand | 3. Return tested pump to assembly stand |
| 3. Put accepted pump in cart | 5. Put finished pumps into cart |
| 4. Use air wrench on center section | 6. Change bits in air wrench<br>16. Use air wrench on mid-section |
| 5. Get parts from or put parts in bin or look in bin | 7. Get parts from hands or bin to put on assembly<br>34. Adjust air wrench<br>37. Inspect tools |
| 6. Assemble small parts in hands<br>27. Assemble top section bolts and washers | 17. Make screw sub-assembly |
| 7. At body parts workplace | 9. Tighten arms on pump bottom and assemble (second workplace)<br>13. Get new mid-section for pump<br>28. Straighten bent part<br>31. Get new top or bottom sections<br>44. Get parts for arm (second workplace) |
| 8. Gone from workplace | 10. Gone to cleaning vat<br>25. Gone for tools or parts<br>30. Gone for drink and to read bulletin board<br>32. Gone to washroom<br>42. Gone to grinder<br>48. Gone to empty parts box |
| 9. Put springs in bottom section | 11. Put insert or springs in bottom section of pump |
| 10. Put diaphrams on bottom and assemble | 12. Assemble diaphram to bottom section |

Table 8. Matched Analysis and Observations Assembly Activities (Continued)

| Film Analysis Number and Description | Observation Analysis Number and Description |
|---|---|
| 11. Put parts in center section<br>16. Inspect center section parts | 15. Put parts into mid-section of pump<br>34. Adjust air wrench<br>36. Inspect diaphrams or other parts<br>41. Remove parts from rejected pump |
| 12. Preparatory work on top section | 18. Assemble gasket and top section |
| 13. Use air wrench on top section | 20. Use air wrench on top section bolts |
| 14. Adjust pump | 23. Adjust pump on bench or in hands |
| 15. Adjust chair at workplace<br>17. Put new parts on workplace<br>21. Returning to workplace | 22. Return to workplace |
| 18. Put new bottom section in circular rack | 26. Put base of pump in circular rack |
| 19. Put diaphram in center of rack | 27. Remove diaphrams from gasoline bucket |
| 20. Put screws in top section | 19. Put assembly bolts in top section |
| 22. Leaving workplace<br>23. Talk to other workers<br>24. Discard bad parts | 14. Talk with friends - unnecessary |
| 25. Put on top section | 35. Put top on mid-section<br>40. Assemble top of mid-section |
| 26. Wipe hands | 47. Wipe hands |
| 28. Put center section on bottom section | 29. Assemble mid-section to bottom of pump |
| 29. Get tool box | 46. Get tool from tool box |
| 30. Talk to other workers about work | 39. Talk to supervisory personnel |
| 31. Look for parts on material | 21. Get spring to put on arm of pump |

Table 8. Matched Analysis and Observations Assembly Activities (Continued)

| | |
|---|---|
| 32. Sort parts | 38. Sort parts |
| 33. Lay aside parts | 43. Lay aside assembly sub-assembly<br>24. Clean up workplace<br>45. Drive insert into bottom section |

Table 9. Comparison of Assembly Analyses

| Film Analysis | | Observation Analysis | | | |
|---|---|---|---|---|---|
| Item Number | Percentage Occurrence | Item Number | Percentage Occurrence | Subtracted Difference | Percentage Difference |
| 1 | 13.5 | 1,2,4,8,33 | 14.1 | - .6 | - 4.3 |
| 2 | .7 | 3 | .7 | 0 | 0 |
| 3 | 1.1 | 5 | 1.1 | 0 | 0 |
| 4 | 2.8 | 6,16 | 3.5 | - .7 | -20.0 |
| 5 | 9.2 | 7,34,37 | 4.7 | 4.5 | 95.8 |
| 6,27 | 7.8 | 17 | 7.1 | .7 | 9.9 |
| 7 | 12.4 | 9,13,28,31,44 | 9.0 | 3.4 | 37.8 |
| 8 | 11.0 | 10,25,30,32,42,48 | 10.7 | .3 | 2.8 |
| 9 | .7 | 11 | .7 | 0 | 0 |
| 10 | 2.1 | 12 | 1.8 | .3 | 16.7 |
| 12 | 1.8 | 18 | 1.8 | 0 | 0 |
| 13 | 5.7 | 20 | 5.8 | .4 | 7.6 |
| 14 | 1.1 | 23 | 3.9 | -2.8 | -71.8 |
| 11,16 | 11.0 | 15,34,36,41 | 9.4 | 1.6 | 17.0 |
| 18 | .7 | 26 | .7 | 0 | 0 |
| 19 | .7 | 27 | .4 | .3 | 75.0 |
| 20 | 1.4 | 19 | 3.2 | -1.8 | 56.2 |
| 15,17,21 | 1.8 | 22 | 1.4 | .4 | 28.6 |
| 22 | .7 | - | 0 | .7 | 100.0 |
| 23 | 2.5 | 14 | 2.1 | .4 | 19.0 |
| 24 | .4 | - | 0 | .4 | 100.0 |
| 25 | 1.1 | 35,40 | 1.4 | - .3 | -21.4 |
| 26 | .4 | 47 | .4 | 0 | 0 |
| 28 | 1.8 | 29 | 1.1 | .7 | 63.6 |
| 29 | .4 | 46 | .4 | 0 | 0 |
| 30 | .4 | 39 | .4 | 0 | 0 |
| 31 | .4 | 21 | .4 | 0 | 0 |
| 32 | 6.4 | 38 | 11.3 | -4.9 | -43.4 |
| 33 | .4 | 43 | .4 | 0 | 0 |
| | | 24 | 2.5 | -2.4 | -100.0 |
| | | 45 | .4 | - .4 | -100.0 |
| | 100.4 | | 100.6 | | |

sponds to observation items six and sixteen, "change bits in air wrench" and "use air wrench on mid-section." The changing of bits is done by removing one bit and putting the new bit in -- then pressing the bit against the rack to lock it in place. From a distance, with the camera it was impossible to distinguish the change with the camera. The change could have happened during analysis item thirteen, "use air wrench on top section."

Analysis item five, "get parts from or put parts in circular bin, or look in bin," probably contains observation items seven, thirty-four, and thirty-seven, "get part from hand or bin to put on assembly," "adjust speed wrench," and "inspect tools." The last two items, thirty-four and thirty-seven, could have been easily interpreted as analysis item five, due to their nature. It is quite possible that some of the observations that were listed under observation item thirty-eight, "sort parts," should have gone under the "get parts" category. This seems especially true when the "over-observation" of sorting is noted.

"Assemble small parts in hands" and "assemble top section bolts and washers," analysis items six and twenty-seven, correspond almost exactly with observation item seventeen, "making screw sub-assembly for top section."

When the film was analyzed, it was found impossible to discern, because of the distance involved, what the operator was doing at the body parts or second workplace. Item seven, "at body parts workplace," then contains several of the observation items since by actual observation it was possible to detect the different operations. Observation items nine, thirteen, twenty-eight, thirty-one, and forty-four fall in the latter category.

Analysis item eight, "gone from workplace," corresponds to observation items ten, "gone to cleaning vat"; twenty-five, "gone for tools or parts"; thirty, "gone for drink and to read bulletin board"; thirty-two, "gone to washroom"; forty-two, "gone to grinder"; and forty-eight, "gone with empty parts box."

"Adjust pump," analysis item fourteen, was found less in the analysis than it was by observation, item twenty-three. It is very possible that some of the activities analyzed as "inspect center section," analysis item sixteen, or "put parts in center section," analysis item eleven, should have been called "adjusting." From the film, it was difficult to detect the "adjusting."

"Put parts in center section" and "inspect center section," analysis items eleven and sixteen, correspond to observation items fifteen, thirty-four, thirty-six, and forty-one; "put parts into mid-section of pump," "adjust air wrench," "inspect diaphram or other parts," and "remove parts from rejected pump."

The actual difference encountered between the percentages of analysis item nineteen and observation item twenty-seven, "put diaphram in center of rack" and "remove diaphrams from gasoline bucket," is very small. However, the large percentage difference is largely due to the small numbers involved.

Analysis item twenty, "put screws in top section," corresponds to observation item nineteen, "put assembly bolts in top section." The difference between the observations is probably due to inability of the observer to actually see what was happening the instant the picture was taken. If the observation was anticipated, which the camera could not do, by the observer then it is possible that the recording made under nineteen should actually have been under seventeen, "make screw sub-assembly for top section."

Under observation item twenty-two if the observer anticipated the timing instant, then the activity recorded as "return to workplace" may have been actually photographed as either "adjust chair at work-place," "put new parts on workplace," or "returning to workplace"; analysis items fifteen, seventeen and twenty-one respectively.

The difference encountered between the percentages of analysis item twenty-three and observation item fourteen, concerning unnecessary talking, is probably due to the job location. Since the job was located on the aisle, workers were continually passing the operation and several workers stopped and watched the operation. If one of the persons was very close to the operator and the operator's hands were not visible, it was assumed in the film analysis that the operator was talking to the person. This probably accounts for the "over-observation" of unnecessary talking.

Analysis item twenty-five, "put on top section," corresponds to observation items thirty-five and forty, "put top on mid-section" and "assemble top to mid-section."

With analysis item twenty-eight, "put center section on bottom section," a larger percentage was obtained than with the observed item twenty-nine, "assemble mid-section to bottom of pump." However, there is only two observations difference between the two.

While the operator was sorting parts, analysis item thirty-two and observation item thirty-eight, he frequently looked into the revolving bin for parts or a place to put sorted parts. This "looking" was not observed by the observer; however, it was distinctly noticed in the film analysis and listed as part of item five. By comparing the results of film analyses five and thirty-two, the large differences of 4.5 and -4.9 tend to compensate for the observation error.

During the film analysis two items were recorded that have no apparent corresponding observed item. These were items twenty-two and twenty-four, "leaving workplace" and "discard bad parts."

During actual observation two items were also recorded that have no comparable item in the film analysis. These were items twenty-four and forty-five, "clean up workplace" and "drive insert into bottom section."

Group Comparison.--In order to determine whether a less detailed analysis than that made would have been beneficial, the items were grouped into similar activities and the groups compared.

Group one is called the "at workplace" group. All activity performed predominantly at the workplace is grouped into this section. The difference between the total per cents is -4.5 or a percentage difference of -7.5 per cent. As can be seen in Table 10, group one comprises over half of the total time the operator spends on the job.

The operator's "work with finished pumps" is the second grouping. The comparison of total per cents of this group show a difference of only -.6 or -3.8 per cent, using the observed total as the base.

Table 10. Grouped Comparison of Assembly Operation Analyses

| Group Number | Film Analysis Item Number | Film Analysis Percentage Occurrence | Observation Analysis Item Number | Observation Analysis Percentage Occurrence | Subtracted Total Difference | Percentage Difference |
|---|---|---|---|---|---|---|
| (1) At Workplace | 4 | 2.8 | 6,16 | 3.5 | | |
| | 5 | 9.2 | 7,24,34,37 | 7.2 | | |
| | 6,27 | 7.8 | 17 | 7.1 | | |
| | 9 | .7 | 11,45 | 1.1 | | |
| | 10 | 2.1 | 12 | 1.8 | | |
| | 11,16 | 11.0 | 15,34,36,41 | 9.4 | | |
| | 12 | 1.8 | 18 | 1.8 | | |
| | 13 | 5.7 | 20 | 5.3 | | |
| | 14 | 1.1 | 23 | 3.9 | | |
| | 18 | .7 | 26 | .7 | | |
| | 19 | .7 | 27 | .4 | | |
| | 20 | 1.4 | 19 | 3.2 | | |
| | 24 | .4 | - | - | | |
| | 25 | 1.1 | 35,40 | 1.4 | | |
| | 28 | 1.8 | 29 | 1.1 | | |
| | 29 | .4 | 46 | .4 | | |
| | 31 | .4 | 21 | .4 | | |
| | 32 | 6.4 | 38 | 11.3 | | |
| | 33 | .4 | 43 | .4 | | |
| | | 55.9 | | 60.4 | -4.5 | - 7.5 |
| (2) Work with finished pumps | 1 | 13.5 | 1,2,4,8,33 | 14.1 | | |
| | 2 | .7 | 3 | .7 | | |
| | 3 | 1.1 | 5 | 1.1 | | |
| | | 15.3 | | 15.9 | - .6 | - 3.8 |
| (3) Moving | 15,17,21 | 1.8 | 22 | 1.4 | | |
| | 22 | .7 | - | - | | |
| | | 2.5 | | 1.4 | 1.1 | 78.5 |
| (4) Talk | 23 | 2.5 | 14 | 2.1 | | |
| | 30 | .4 | 39 | .4 | | |
| | | 2.9 | | 2.5 | .4 | 16.0 |
| (5) Gone from workplace | 8 | 11.0 | 10,25,30,32 42,48 | 10.7 | .3 | 2.8 |
| (6) At body parts workplace | 7 | 12.4 | 9,13,28,31 34 | 9.0 | 3.4 | 37.8 |
| (7) Wipe Hands | 26 | .4 | 47 | .4 | 0 | 0 |

Group three, "moving," indicates that there were more observations made of the moving in the film analysis than in the observation. This could be due to the observer not being able to record an impression of the job situation at the same instant the camera snapped. Any amount of anticipation or lag on the part of the observer in making the observations probably accounts for the error.

Unlike the laundry operation, more talking by the operator was observed from the film analysis than by actual observation, as shown in group four. As explained before, this is probably due to the "spectators" the operator drew as he worked.

Groups five, six, and seven -- "gone from workplace," "at body parts workplace," and "wipe hands" -- have been discussed under the individual item comparison. As seen in Table 10, there is only one comparison in each of these groups.

# CHAPTER IV

## CONCLUSIONS

The purpose of this thesis is to determine whether photographic ratio-delay procedures will yield substantially the same information as that obtained from a ratio-delay or production study, assuming that the production study and the ratio-delay study are simultaneously made. From the preceding data it is evident that photographic ratio-delay does not yield the same results as a ratio-delay study, under the conditions which this study was made. This negative conclusion is true for the following reasons:

1. As seen in Tables 4 and 9, the amount of variation of the analysis items from the observation items is beyond the level for satisfactory agreement.
2. Although the data is grouped into divisions of the job, the percentage difference of the group totals, as shown in Tables 5 and 10, is still too great for satisfactory agreement.
3. The fewer the number of observations on a particular activity, the greater the likelihood of a large percentage difference between the observed and the film analysis items.
4. The study was not of sufficient duration to give adequate coverage of the operations.
5. The human element made it difficult to get instantaneous readings of observer and camera. This is noticed particularly for the analysis items that had no apparent comparable observation item, and vice versa.

Although under the condition of this study the photographic ratio-delay procedure does not give the same information as the ratio-delay method, some conclusions were reached with regard to the photographic method:

1. The initial cost of the equipment for a photographic study is high. However, the use of the equipment in other work, such as micro-motion study, helps justify the cost.

2. The camera with the time-lapse drive would require mounting so that the camera would not be disturbed during the day.

3. The clock that appeared in the laundry operation pictures was helpful, for it showed when the picture was taken. If the time-lapse drive had been utilized, pictures would have been made during the rest periods and lunch. The clock would have been helpful in determining the cause of absence by the worker in these cases.

4. The amount of machine utilization can be very easily determined for a job regardless of the reason for which the study is being made, provided some sort of machine is being used.

5. A time-lapse drive actuated camera requires virtually no attention throughout the working day from the person making the study. A lens setting at the beginning of the day that is in accord with expected light condition, a check with an exposure meter at noon, and the removal of power at the end of the day are all that is required.

Several conclusions were reached regarding the operating as well as observing personnel involved in a photographic ratio-delay study:

1. The worker has no observer watching him at any time, and it is virtually impossible for him to anticipate the camera action. As a result, the worker performs in a more natural manner.

2. The analysis of the film is relatively easy, for the exact movement of the operator is completely stopped. Anticipation of movement by the observer is impossible.

3. The analyst should be familiar with the job being studied in order to make a good analysis. The scene of action can be mentally reconstructed by noting the location of various pieces of equipment and material, if the analyst has an adequate knowledge of the job.

4. If the person talking to the operator was not in the picture, talking by the operator was difficult, if not impossible, to detect.

5. Delay allowances could be set if the nature of the work is such that during the delay the operator remains at his workplace.

With regard to the job characteristics in this study, two conclusions were obtained:

1. The reason for the operator's absence from the picture was not ascertainable. Therefore, no personal allowances can be determined. However, if the operator was away from the workplace an undue amount of time, specific study of the job would be indicated.

2. The technique can be used only where one machine or group of machines that could be photographed together is being studied. Although the observer can move through the shop or plant, the camera is limited to one location.

# CHAPTER V

## RECOMMENDATIONS

Although under the conditions this study was made the results obtained were negative, it is the opinion of the observer that the photographic ratio-delay procedure has definite possibilities.

Dwyer's work in a cashier's office, which was mentioned earlier; suggests further work along that line. Another study made by Dwyer with the same camera triggering device was of a secretary. This study was made in an effort to determine the distribution of the secretary's duties. It is possible that similar studies using the single frame observation would be beneficial for determining work distribution on non-repetitive jobs.

In the event that simultaneous studies of crew work or the work of several persons on an assembly line are desired, the photographic method of ratio-delay has definite advantages over visual observation ratio-delay, since the camera can record all the persons at the same instant, assuming they are grouped so this is possible. It would be impossible visually to record the simultaneous work of several persons.

It is the author's opinion that if photographic ratio-delay is used to examine an operation, a substantial number of pictures should be taken. It seems that less than a thousand pictures would be inadequate; however, that depends upon the nature of the job.

If a considerable number of pictures were taken of a job and analyzed closely, it is the author's opinion that an approximation of a time-study could be obtained. Further study along this line is recommended. This information may be indeed helpful to the management if the conditions are such that stop-watches are not permitted in the plant.

It is possible that a photographic ratio-delay study could show the distribution of an operator's time for the purpose of methods improvements. If improvements are made, then "after" studies would be a means of checking the projected savings.

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# APPENDIX

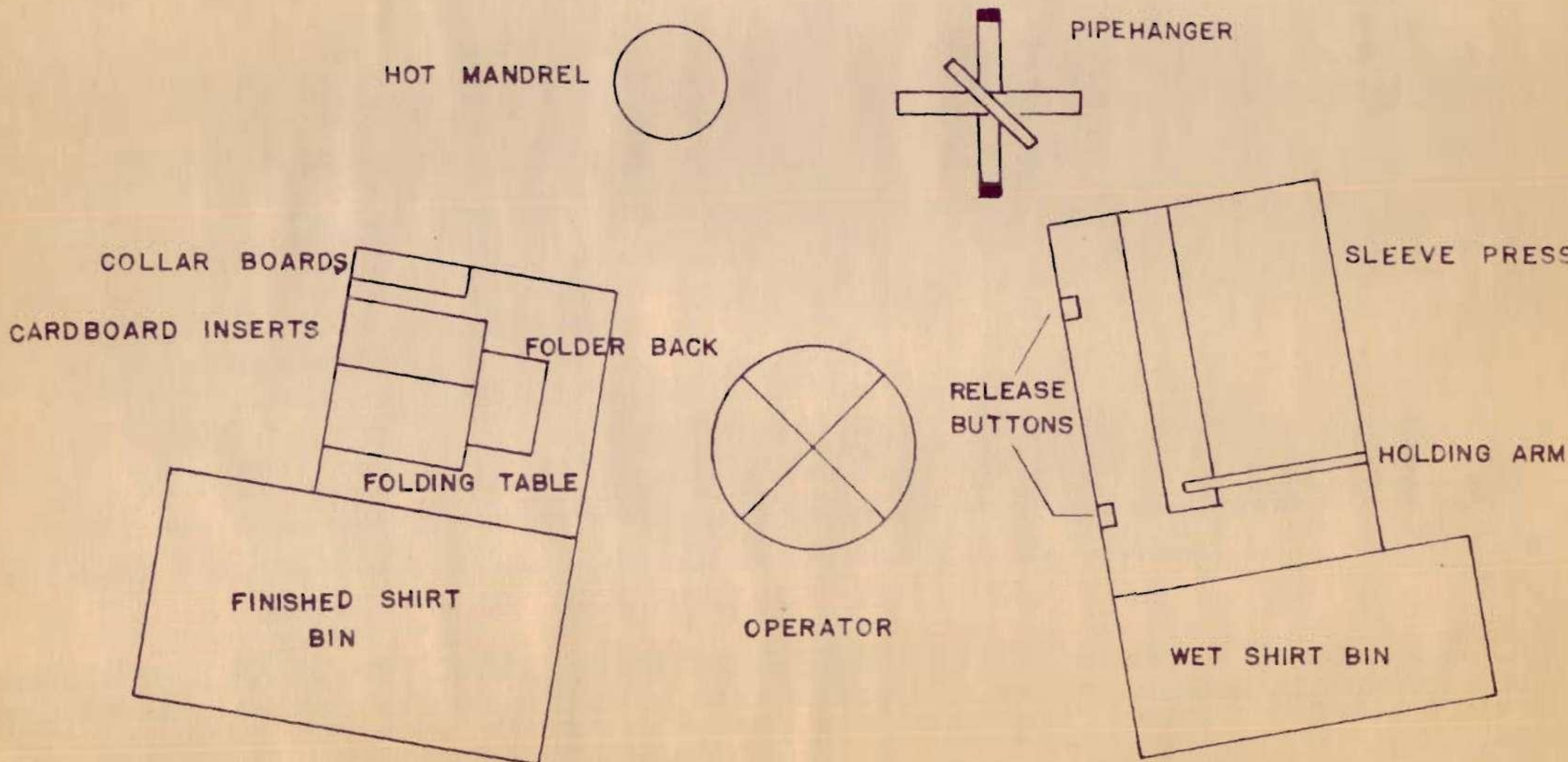


FIG. 3 WORKPLACE LAYOUT FOR LAUNDRY OPERATION

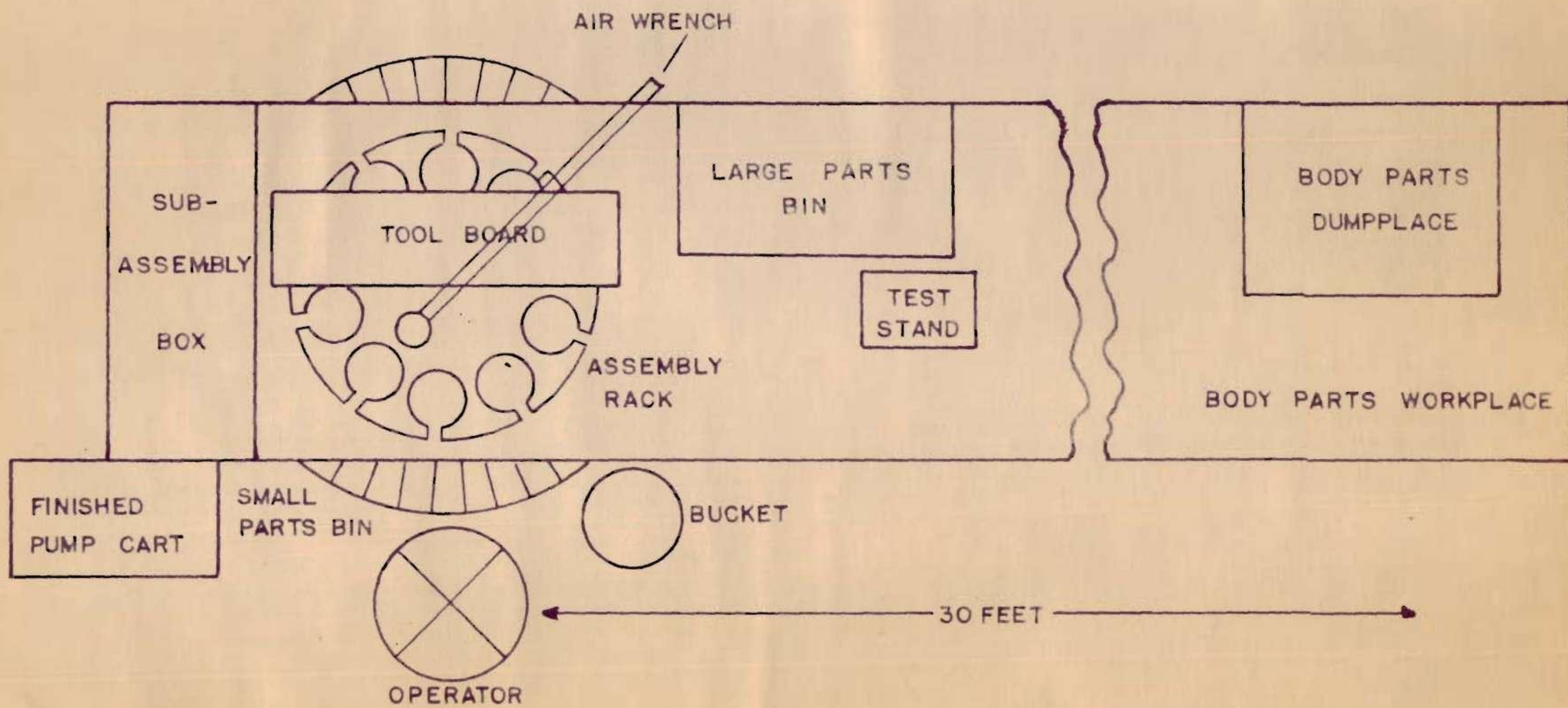


FIG. 4 WORKPLACE LAYOUT FOR ASSEMBLY OPERATION