Report
of
FIRST MOTION AND TIME STUDY INSTITUTE

University of California
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including

Papers presented by

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Institute Presented by

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THE SOCIETY OF INDUSTRIAL ENGINEERS
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Introduction

The University of California Motion & Time Study Institutes were originated in the attempt to render a needed service to West Coast Industrial Engineering. It is hoped that these Institutes will bring new and useful information and techniques to the attention of those interested in the scientific development of Motion & Time Study and other phases of Industrial Engineering. A part of each session will be participational for two reasons, first to focus attention on techniques in order to maximize the practical take-home of knowledge, and secondly, to enable investigation of some hypothesis offered which contributes to the scientific background of Motion & Time Study. Time Study Rating was chosen as the topic for the First Institute largely because this particular phase of time study receives the bulk of the criticism leveled at time study in general and also because it definitely seems to be handled in a less scientific manner than are other phases of time study. This is definitely one of the basic problems of Industrial Engineering.

This report attempts to present the results of the session in as brief a manner as possible, for it is felt that the individual is interested primarily in his own and his company's results and a comparison of these with the group and the nation.

Purpose of the First Motion & Time Study Institute

The program of the first Institute was formulated around several objectives:

1. To define the term "Industrial Engineering" and show the place of time study within that structure. Also, to present a few of the many reasons why work measurement is necessary to production planning in industry.

2. To present to a large majority for their first time the use of motion pictures as a training technique in time study.

3. To bring into sharp focus, the fact that rating requires the use of judgment at a highly complicated level and that the errors in rating are reflected directly into the time standards set for the job rated. Also, to show the deficiencies of current rating philosophies.

4. To allow individuals a means of checking their ability to rate consistently and accurately.

5. To obtain a rough measure of the level of work or average pace required of workers in the Bay Area and to permit comparison among companies and also to the national average.

6. To test the following hypothesis: "Untrained time study men are able to rate with greater consistency in a given period of time if the training film gives them known percentage values on both sides of 100% than if the training film depicts only the 100% point." This was tested by dividing the audience into two groups of approximately the same total experience. Men with odd numbers on their Work Book were called "ODDS" and were

given two values, one above 100% and one below 100%, during the course of the Walking Film (RB510) that the "EVEN" group did not have. This was done by writing the correct values into the Work Books of the ODD Group. These results were analyzed and will be discussed later.

7. To bring the status of research in progress to the attention of those participating and to indicate new techniques under development and where additional reading material may be found.

8. From the results of all the above to clearly point up the need for more training in the art of rating, the need for developmental work in time study theory and to inculcate an interest in attacking the problem through such sessions as these.

Statistics of Attendance and Experience of Audience

1.	Have personally made stop watch studies	yes	70%	
		no	30%	
2.	Rating system used	Point System	14%	13%*
		Westinghouse	30%	13%
		100% Plan	54%	73%
		Other	2%	4%
3.	Item usually rated	Overall Study	28%	
		Each Element	52%	
		Each S.W.Reading	20%	
4.	Time Study experience	3 mos. or less	13%	
		3 mos. to 1 yr.	15%	
		1 yr. to 2 yrs.	23%	
		over 2 yrs.	19%	
5.	Now spending the following amount of time in making time studies	Full time	8%	
		Approx. ½ time	14%	
		Only occasionally	34%	
		No studies in 2 yrs.	38%	
6.	Previous Participation in work measurement project	yes	14%	
		no	86%	
7.	Experience in use of film in rating	yes	30%	
		no	70%	

8. Attendance Statistics

Participated in Registrations	133
Participated in Morning Session	121
Participated in Afternoon Session	115

* from 1948 Study by R. M. Barnes, "Industrial Engineering--A Survey of Practices in 89 Plants," Factory Management & Maintenance, Vol. 107, No.6, June 1949, McGraw Hill.

The following interpretations have been given to these statistics:

1. It appears that Northern California has not followed the national trend towards greater use of the 100% plan in rating as reported by Barnes. Even the 54% figure as tabulated is high for comparison purposes. This is because figures for the Institute are on an individual basis while those of Barnes' are of companies only, and it can be shown that only the larger companies use the 100% plan and these companies usually had several men in attendance.

2. Since 72% of those in the audience having time study experience make time studies only occasionally or have not made any studies in the last two years, it appears that the group was made up largely of Industrial Engineers who have advanced to some supervisory capacity.

3. Only a very small number have previously participated in the Work Measurement project and the use of film as a training aid appears to have been accepted only on a very limited scale and here again only in the larger companies.

Results of Morning Rating Session

The Film "And In Return" from the Cooperative Wage Bureau, Pittsburgh, Pennsylvania, was shown.

This film develops the need for time study as necessary in determining a "Fair Day's Work" and in the second part requires the audience to rate four different operations which were performed at three rates of speed or effort. The rates shown were either 30% below normal, 30% above normal or normal---rather large and supposedly easily discernible increments of energy expenditure.

Film Sequence #	No Misses	% Accuracy
1	10	92
2	31	74
3	3	97
4	7	94
5	5	96
6	5	96
7	5	96
8	6	95
9	1	99
10	1	99
11	11	91
12	31	74
Total	116	92%

At the outset this appears to be a fairly high percentage of accuracy. However, when it is recalled that the ratings were made in the extremely large increments of 30% this accuracy appears rather low. Breakdown of the audience into groups of varied experience shows that those with more than one year time study experience and those who have had no previous time study experience both average 94% correct. The group with experience but less than one year averaged slightly less than 88% correct.

It should be noted in passing that the 70% of normal, normal, and 130% of normal levels of effort were shown and labeled for each of the four operations used in the test prior to the actual test. Also the test consisted of showing the twelve sequences in mixed or scrambled order.

Work Measurement Project Results

The Afternoon Session was devoted to the showing and discussion of the five films comprising the Work Measurement Project of Ralph M. Barnes.

Film #RB 510 required the audience to rate 12 sequences of a man walking across level ground in relation to a 100%, or normal value, of 3 mph. The hypothesis mentioned earlier was tested simultaneously during the showing of this film, the ODD group being given the extra values. After showing of the first two films the lights were turned on and the correct values were read to the audience. This permitted the audience to see the nature of their errors and accommodate their judgment. This procedure was followed after completion of each of the four films shown. It should be pointed out that only in the case of Walking and Card Dealing are exact true standards known, (even though these are considered arbitrary by many). These tasks had 100% points defined in terms of rate and amount which consequently allowed true ratings for other performances to be calculated by merely observing the time required for the particular sequence shown. This could not be done for the last two films in which "Miscellaneous Factory Operations" were shown since 100% points were not shown or even known. In these films the average of several hundred time study men's ratings of these same film sequences have been used as the "true" or standard value with which to make comparison.

The audience plotted their rating against the true ratings for both the Walking and Card Dealing films. There is a tendency for the inexperienced to rate low values too high and to rate high values too low. Correction for this involves expanding one's own personal judgment, i.e., deliberately rate high values a little higher and low values a little lower until this effect is cured. Experienced Time Study men seem to rate both fast and slow paces too low. This is probably a reaction to the common experience of having had rates set in practice turn out to be rather loose. Correction for this involves raising ratings given an amount equal to one's negative bias.

In presenting the results of the ratings made by individuals and groups the terms "accuracy" and "consistency" need a definition that can be expressed mathematically. For the purpose of this study Accuracy will be taken to mean a measure of how close the ratings made are to the true or standard ratings. The systematic error is a measure of accuracy. It is found by adding up all of the ratings made by an individual (or group as the case may be) during any one film and subtracting from this total the sum of all the correct or standard values for that film. This remainder when divided by the number of film sequences in the total represents the systematic error or average bias of the rater. If the remainder is negative this is a minus systematic error and indicates that on the average the rater is inaccurate in the low direction by the amount calculated.

Consistency is essentially a measure of the ability of the rater to repeatedly give the same rating to the same film sequence. This is perhaps best explained by saying that consistency is shown by how near the values of a given rater (or group) come to plotting in a straight line. The correlation coefficient found by correlating the values of the rater with the corresponding true values gives an excellent measure of consistency. The correlation coefficient was found by use of the following formula:

$$r = \frac{N\sum xy - \sum x \sum y}{\sqrt{N\sum x^2 - (\sum x)^2}\ \sqrt{N\sum y^2 - (\sum y)^2}}$$

where

x = rater's value (or group average) for a given sequence
y = true or standard value for a given sequence

TABLE NO. I
AVERAGE SYSTEMATIC ERRORS BY GROUPS (In Per Cent)

GROUP			FILM & NO.			
			Walking RB 510	Card Dealing RB 520	Misc. Factory RB 530	Operations RB 540
Experienced in Time Study	YES	Odd	-14.8	-2.8	+2.3	-2.1
		Even	-15.2	-3.5	+2.6	-4.1
	NO	Odd	-16.6	-2.0	-2.1	-6.0
		Even	-15.2	-0.7	-3.4	-7.6
Length of Experience	1 Yr. or Less	Odd	-17.9	-4.3	+2.5	-3.9
		Even	-16.7	-2.3	+2.8	-3.5
	More Than 1 Yr.	Odd	-12.9	-2.2	+2.1	-1.4
		Even	-14.6	-4.2	+2.6	-4.6
Total		Odd	-14.9	-2.5	+1.4	-3.3
		Even	-15.2	-2.3	+0.6	-5.2
Range		Odd	-29.6 to -.3	-16.1 to +9.7	-14.8 to +14.7	-17.7 to +16.8
		Even	-39.9 to +9.0	-13.7 to +12.2	-19.8 to +32.8	-19.9 to +9.0
Average Ratings for Film						
Standard			133.3	109.5	114	122.2
East						122.1
Middle West						120.3
West (This Study)						119.0

TABLE NO. II
CONSISTENCY STUDY (Correlation Coefficients)

FILM	ENTIRE GROUP		Experience in Time Study				Length of Experience			
			Yes		No		Less than 1 year		More than 1 year	
	Odd	Even	Odd	Even	Odd	Even	Odd	Even	Odd	Even
510 Walking	.989	.982	.990	.986	.991	.977	.988	.987	.972	.978
540 Misc. Factory Operations	.976	.981	.983	.989	.928	.933	.974	.961	.978	.958

Tables I and II give the results of the four films tabulated into various experience groups. The ODD group is the one that was given extra values in the Walking Film. Results indicate that the ODD group did better in regard to both consistency and accuracy. The correlation coefficient .991 was compared with .977 for statistical significance of difference. It was found that a difference this large might be expected to occur as often as 1 out of 3 by chance alone. A good strong tendency perhaps but not statistically significant. It appears that the ODD group rated more accurately as a group, judging by the smaller range experienced in systematic errors, 29.3% as compared to 48.9%. This all seems to lend much support to the hypothesis proffered. It appears that extra bench marks in the training film contribute to more consistent and accurate ratings, and it is therefore suggested that bench marks on each side of 100% be included in training films.

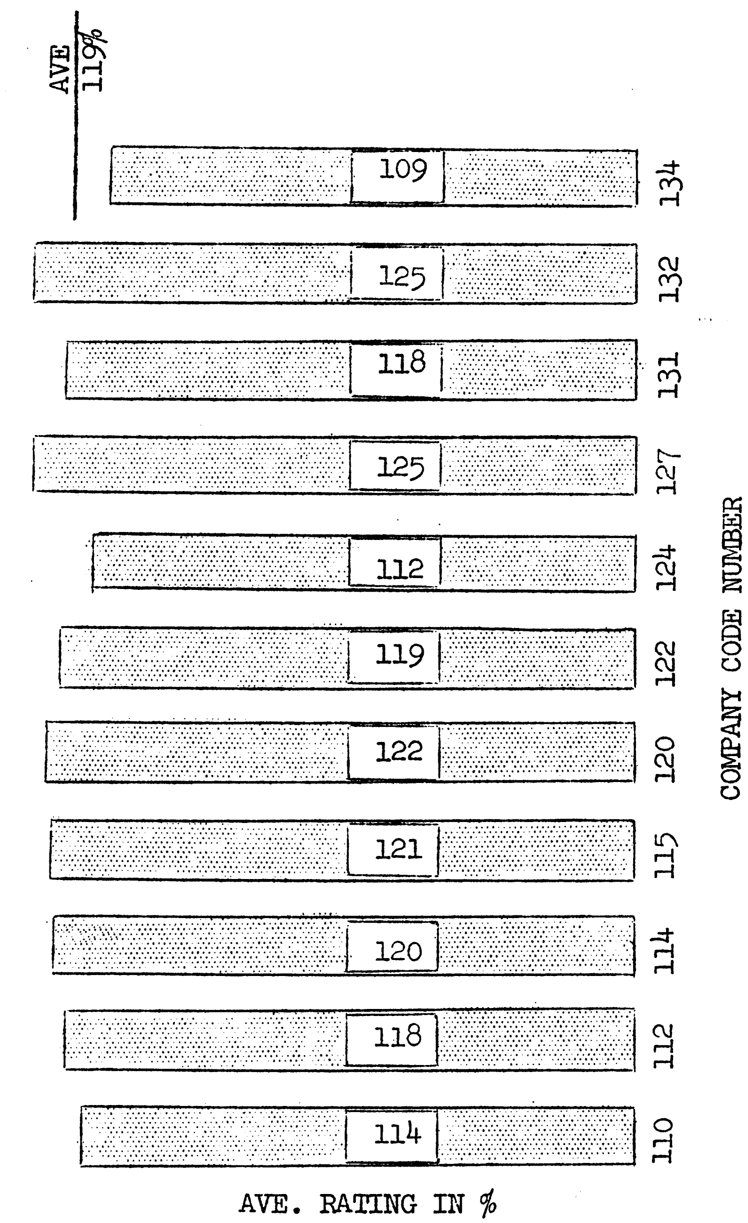
In Table II it is noted that while men with No Time Study Experience rated Walking nearly as well as those with experience did, the inexperienced groups are much poorer when it comes to rating the Miscellaneous Factory Operations. This is no doubt due to the fact that the latter film required the observer to adjust his concept of 100% speed to the levels of effort required by each of various operations shown. This added complication caused the inexperienced to become more erratic and argues for a simple rating philosophy. See "A Scientific Work Measurement Program" on Page 17 for further discussion.

In Table I the average of the entire audience for the last film is shown, and this figure can be compared with the average rating as given in the Middle West and in the East. If these results can be taken as significant, it appears that the West Coast collectively rates the same operations 2 - 3% lower than do the middle western and eastern sections of the country. There was no way to test these differences for statistical significance since the distributions of the middle western and eastern groups were not known.

TABLE III

Average Ratings of Companies with two or more men with more than 1 yr.time study experience participating. Film RB 540 - "Miscellaneous Factory Operations"

Company Code No.	Average Rating	Systematic Error	Range
110	114	-9.6	18.4
112	118	-4.4	16.7
114	120	-1.8	23.3
115	121	-1.4	8.5
120	122	+0.1	6.5
122	119	-3.0	20.5
124	112	-10.5	1.1
127	125	+2.7	12.8
131	118	-4.5	4.5
132	125	+3.2	11.7
134	109	-13.0	6.1
All Companies	119%	-3.2%	34%



AVERAGE RATING OF COMPANIES WITH TWO OR MORE EXPERIENCED TIME STUDY MEN PARTICIPATING FILM RB 540

FIGURE I.

Table III and Fig. I represent an estimate of the level of work found in the various companies and of the variations that might be found to exist between individual men in the company. Film RB 540 was used in this study. Company averages vary from 109% to 125% representing a rather large difference in work requirements. Individual time study men making up the study were found to have systematic errors ranging from -17.2% to +16.8%, a range of 34% in average rating for the nine operations shown in Film RB 540. These are experienced time study men. The range for all participants regardless of experience was 44%. It will be noted by comparison with Table II that both the experienced time study men comprising the results in Table III and the entire audience as in Table II averaged 119% for the film sequences in Film RB 540.

Individual Results

Table IV gives the systematic errors and correlation coefficients for individual raters and also the percentage correct in the morning session. In interpreting the relative consistency of an individual by use of the correlation coefficient, the actual figure should not be thought of as being, say 99% consistent if a figure of .990 appears. But rather it should be looked at as a measure of how much closer the values of the individual rater approach plotting in a perfect line because of his use of judgment than the values would have if he had merely guessed without looking at the film sequences.

The following table* allows one a better understanding of what the correlation coefficient indicates regarding consistency. The figure in the column headed K^1 indicates how much better (in %) the raters' values are than a mere guess would have been for different values of r -- the correlation coefficient. K^1 is referred to as the "Improvement Factor."

r	K^1 in %
.1	.5%
.2	2.0%
.3	4.6%
.4	8.3%
.5	13.4%
.6	20.0%
.7	28.6%
.8	40.0%
.9	56.4%
.92	60.8%
.94	65.9%
.96	72.0%
.98	81.1%
.99	85.9%
1.00	100.0%

Inspection of this table shows that quite high values of "r" are required for a measure of good consistency. An "r" of .99 is only 85.9% better than a mere guess and a correlation of .9 is only 56.4% better than a mere guess.

* Table 31, P 174, from Mathematics of Statistics, J. F. Kenney, D. Van Nostrand Company, NY 1945

Conclusion

Results of the session definitely seem to indicate an urgent need for more and continued detailed consideration of the problems involved in Time Study Rating by West Coast Industry. "Consistency" and "Accuracy" can definitely be improved by use of proper rating films and these should be used.

Results of the Interest Questionnaire are included and will serve as a guide in planning future institutes. Tentative plans are to hold an institute in the Fall concerning Work Simplification and another institute in the Spring with at least a part of the session devoted to Time Study Rating.

The cooperation extended by Professor R. M. Barnes of the University of Iowa (soon to be of UCLA) was quite instrumental to the success of the session and sincere thanks is extended.

FIRST INSTITUTE ON MOTION AND TIME STUDY

INTEREST QUESTIONNAIRE RECAPITULATION

Total Questionnaires Returned - 98

		No. of Replies
1. Was this Institute	a) Too technical	1
	b) Not technical enough	12
	c) Technically suitable	84
2. Did it cover your area of interest?		
	Yes..............................	79
	No	14
	Partially	2
3. In relation to industrial engineering, would you like the University to extend a service to industry?	Yes	88
	No	0
	a) In the form of rating films?	44
	b) Rating charts?	35
	c) Work simplification films	72
	d) Newsletter reporting new information	79
4. Would you like these Institutes to continue?	Yes	97
	No	0
	a) Topic of future Institutes	
	1. Rating	29
	2. Time study procedures	35
	3. New techniques in time study	66
	4. Work simplification techniques	79
	5. Wage incentives and job evaluation	70
	6. Others (See attached sheet)	
	b) How often would you like Institutes held?	
	1. Annually	15
	2. Semi-annually	83
	3. Quarterly (Not on questionnaire)	5

TABLE IV
INDIVIDUAL RATERS' RESULTS

ODD NUMBERS

Raters' Code No.	Systematic Errors				Correlation Co-efficients		% Correct Morning Sess.
	Film 510	Film 520	Film 530	Film 540	Film 510	Film 540	
118001	-25.5	-16.1	+ 6.5	- 7.1	.980	.923	83.3
128003	-13.8	+ 1.3	-12.3	+ 2.3	.981	.825	91.7
163005	-17.1	+ 8.8	- 5.4	-17.7	.953	.646	91.7
121007	-14.9	- 2.0	-13.4	- 3.8	.947	.880	91.7
159009	-13.2	-12.0	+ 7.8	+ 0.7	.979	.926	83.3
155011	- 0.3	- 1.2	- 0.4	+ 9.9	.984	.559	91.7
152013	- 8.2	- 4.5	-13.5	-11.0	.913	.693	100
126015	-22.8	- 0.3	+ 0.3	+20.1	.888	.354	66.6
							100
161021	-23.2		+ 7.1	- 9.9	.876	.615	100
148043	- 7.1	+ 7.2	+12.8	-10.4	.965	.740	100
102025	-16.6	- 7.0	- 7.3	+15.1	.980	.465	100
132027	-17.2	- 8.7	+ 9.6	+ 2.7	.929	.908	91.7
115029	-15.4	+ 4.7	- 6.6	+ 2.9	.954	.847	100
							100
137035	- 9.3	- 7.8	- 5.4	- 9.3	.973	.842	100
137037	- 6.0	- 4.5	+ 0.3	-12.1	.992	.786	83.3
137039	- 4.3	- 9.5	+ 2.1	- 1.0	.986	.919	66.6
138041	-28.0	- 8.7	+ 7.8	-13.8	.926	.786	100
110043	-10.7	- 9.5	+10.9	-11.8	.902	.869	100
110045	+ 5.7	- 0.3	- 1.0	+ 1.2	.962	.768	100
127049	-14.3	- 3.7	2.1	+ 0.7	.983	.791	100
127051	-20.4	- 1.7	7.9	10.1	.980	.960	83.3
116053	-12.8	- 0.3	- 2.6	-12.1	.976	.856	91.7
109055	-21.6	- 4.5	+ 0.9	+ 2.9	.946	.933	100
130059	-18.2	- 7.8	- 4.8	+ 5.1	.981	.733	75.0
138061	- 8.8	+ 7.2	- 5.4	- 7.1	.986	.935	100
117063	-19.4	+ 6.2	+ 4.6	+ 8.5	.802	.678	100
122065	-19.9	- 5.3	- 2.3	-16.5	.859	.958	91.7
122067	-24.9	- 8.7	- 9.8	- 8.2	.861	.869	83.3
122069	-21.0	- 4.5	+12.8	+ 4.0	.941	.891	91.7
112071	- 5.2	- 1.7	+ 9.6	- 6.0	.949	.797	100
112073	-14.9	+ 0.5	+12.1	+ 4.0	.983	.691	91.7
113075	-16.5	+ 3.8	+ 1.5	- 3.2	.966	.869	91.7
144077	-24.4	+ 3.0	- 5.4	- 9.9	.958	.924	100
145079	-14.9	- 7.8	- 8.3	+ 2.9	.954	.529	91.7
120081	- 7.7	- 6.2	+ 5.0	- 2.7	.990	.559	100
							100
141085	-20.7	- 4.5	- 3.5	+ 1.2	.977	.834	100
131087	-12.2	+ 3.0	+ 9.0	- 3.8	.980	.263	100
131089	- 6.6	+ 2.2	- 1.0	- 7.1	.987	.628	100
147091	-29.6	- 5.3	-16.0	-14.3	.827	.682	75.0
147093	- 9.3	-11.2	-14.8	-22.1	.830	.900	91.7
140095	-17.7	+ 0.5	- 5.4	- 9.0	.935	.549	25.0
119099	-18.8	- 2.0	- 4.1	-24.3	.891	.748	100
114101	-11.6	+ 2.8	+10.3	+16.8	.990	.772	100
123103	-23.2	- 7.0	+ 9.6	- 7.7	.928	.840	91.7

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TABLE IV (continued)

ODD NUMBERS

Raters' Code No.	Systematic Errors				Correlation Co-efficients		% Correct
	Film 510	Film 520	Film 530	Film 540	Film 510	Film 540	Morning Sess.
142107	- 8.8	- 2.0	+ 9.0	-12.7	.986	.809	100
124109	-17.1	- 4.5	- 4.8	-11.0	.967	.291	83.3
156111	-13.2	- 1.2	+ 0.9	+ 4.8	.956	.698	100
157117	-15.4	+ 9.7	+ 0.9	- 6.0	.959	.868	91.7
104119	-14.3	- 1.2	+ 9.0	- 6.0	.949	.891	91.7
122121	-25.5	- 6.2	+ 1.5	- 8.8	.982	.932	83.3
114123	-16.0	+ 9.7	+13.4	- 5.7	.974	.672	100
150125	-16.0	- 3.7	+ 3.4	-10.4	.939	.672	91.7
162127	-27.1	+ 1.3	+ 5.9	- 7.3	.898	.248	91.7
133131	-17.7	- 2.0	- 6.0	- 4.3	.965	.837	100
UC 133	-12.7	- 4.5	+14.7	+ 8.4	.934	.925	100

EVEN NUMBERS

Raters' Code No.	Systematic Errors				Correlation Co-efficients		% Correct (film)
	Film 510	Film 520	Film 530	Film 540	Film 510	Film 540	
113002	-15.5	+ 6.3	+32.8	-19.9	.963	.638	83.3
149004	- 9.9	+ 6.3	-14.8	-11.6	.944	.962	100
105006	-22.7	-10.3	-19.8	-12.1	.949	.137	91.7
134008	-16.0	- 2.8	- 4.6	- 1.0	.983	.222	83.3
107010	-15.5	+ 6.3	- 8.5	- 8.8	.963	.878	91.7
117012	-14.3	- 7.0	- 9.1	+ 2.3	.978	.866	100
164014	-14.3	- 1.2	- 5.4	- 3.8	.991	.803	100
143016	-39.9	-11.2	-14.1	+ 0.7	.945	.850	83.3
143018	-19.9	+12.2	+ 2.8	+ 0.1	.945	.849	100
161020	-19.4	- 3.7	+11.5	+15.7	.942	.865	100
148022	-21.6	-10.3	- 7.9	- 3.8	.953	.957	83.3
102024	+ 4.6	+ 1.3	-11.6	- 6.6	.965	.666	100
132026	-13.5	+ 2.8	+12.5	- 9.0	.983	.735	91.7
132028	+ 9.0	- 4.5	+25.9	+ 9.0	.973	.807	83.3
115030	-16.6	+ 1.3	+ 2.4	- 5.7	.971	.849	100
137032	- 4.9	- 5.3	- 7.3	- 7.1	.961	.655	100
137034	- 9.0	+ 1.3	-14.1	- 0.4	.930	.951	100
138036	-18.8	- 5.3	- 6.0	-18.2	.964	.655	58.3
~~138~~038							58.3
110040	-22.7	+ 5.5	+ 7.9	-12.6	.961	.893	100
110042	0.0	- 6.7	+ 1.5	- 9.9	.900	.617	75
110044	-22.7	+ 4.7	- 4.1	-17.2	.935	.754	91.7
127046	-19.4	+ 3.8	+ 2.1	- 2.7	.924	.778	91.7
114050	-17.1	- 8.7	+ 7.8	+ 0.1	.960	.913	100
							100

TABLE IV (continued)

EVEN NUMBERS

Raters' Code No.	Systematic Errors				Correlation Co-efficients		% Correct (film)
	Film 510	Film 520	Film 530	Film 540	Film 510	Film 540	
108054	-13.8	- 2.0	-20.0	-13.8	.947	.939	100
123058	-17.1	+ 2.2	+17.8	-11.6	.945	.840	91.7
153060	-10.4	- 3.7	+ 2.1	+ 2.3	.988	.456	75
103062	-12.1	+ 4.7	- 7.8	-13.2	.956	.930	83.3
115064	-19.9	- 1.2	- 3.5	-11.0	.868	.690	100
122066	-18.8	- 3.7	+ 9.6	- 4.3	.958	.720	91.7
122068	-27.1	- 6.2	+ 6.5	+ 6.2	.968	.858	75
122070	-22.1	- 6.2	+ 4.0	- 1.0	.935	.864	91.7
122072	-19.9	- 3.7	+ 0.3	- 2.1	.974	.740	100
112074	-30.5	-15.3	- 9.1	-12.7	.940	.853	91.7
144076	-17.7	-10.3	- 5.4	-11.0	.967	.877	100
145078	-17.1	- 6.2	+ 2.1	-16.5	.954	.929	91.7
145080	-16.6	- 8.7	- 9.1	-13.2	.864	.792	100
120082	-17.7	- 8.7	+ 3.4	- 8.2	.949	.578	91.7
120084	-13.2	- 0.7	+10.3	+ 2.9	.963	.904	100
146086	-19.9	+ 5.5	- 7.9	- 4.3	.974	.860	91.7
141088	- 6.6	- 0.3	- 4.8	+ 8.9	.953	.994	91.7
131090	- 8.2	+ 2.1	+ 5.3	- 2.7	.985	.776	100
147094	- 5.4	- 7.8	+ 9.0	-15.1	.983	.805	100
140096	+ 5.7	- 2.8	+ 8.4	+ 4.0	.986	.693	100
111098	-21.0	- 4.5	+ 7.8	- 2.7	.981	.853	100
165100	-20.3	- 9.7	+ 4.6	-11.6	.925	.790	91.7
129102	- 9.9	-13.7	+ 4.6	+ 0.1	.989	.513	100
157104	-21.6	- 6.2	+ 4.6	- 4.3	.928	.955	100
152106	-15.4	- 1.2	+ 0.9	-11.0	.968	.595	100
154108	- 1.6	+ 2.2	-16.0	-13.8	.909	.709	91.7
136110	-18.2	- 6.2	- 5.1	- 2.7	.937	.599	91.7
							100
114114	-11.0	- 6.2	+ 6.5	- 6.6	.985	.858	100
114116	-21.0	- 2.0	+21.5	+ 2.4	.961	.572	100
103118	- 9.9	+ 0.5	+ 4.0	- 7.1	.914	.570	91.7
166120	-22.7	-10.3	- 1.0	-11.6	.975	.908	91.7
160122	-11.0	- 4.7	+10.9	-12.7	.976	.911	91.7
114124	-14.9	+ 2.1	- 1.6	+ 2.8	.986	.842	91.7
124126	-18.8	+ 3.0	-10.4	- 9.9	.956	.663	100
101128	-16.6	- 2.8	+ 9.6	+ 7.3	.976	.823	66.6
142130	-20.4	- 1.2	+ 7.1	-11.6	.941	.890	100
134132	-14.9	- 5.3	- 9.1	- 9.9	.983	.896	100

A SCIENTIFIC WORK MEASUREMENT SYSTEM[1]

by

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In the athletic world no team does consistently well when most of the load must be carried by one player. We all know that balanced team play makes for a winning combination. Yet in Motion and Time Study we have a team wherein one member is carrying the load.

It is a fact that while Motion Study is not universally applied and does need refinement still, it has achieved considerable attention, and its techniques of application have improved to the point where it is a highly successful and accepted managerial control. On the other hand, we have not progressed nearly as far with our Time Study systems as we have with Motion Study. In fact, in most plants so little thought is given to the philosophy and development of Time Study that the success of both Motion and Time Study as a team is seriously imperiled.

For example let me relate to you the story of one Indiana plant which was quite interested in having some methods work performed in an attempt to increase its output efficiency. Looking into this plant, I found that the rates were set by the foreman who "knew" how much work to expect from a workman. As he put it, he had experience. His time study consisted of watching the worker from his glass enclosed office and at the same time reading a clock overhead in the office. Then, as he confidentially told me, he cut the time he observed in order to have leeway to give in some when bargaining with the Union Steward. "You have to be cagey in dealing with those guys," he said.

I believe that he sincerely thought he was being quite shrewd in handling his labor situation and that he was extracting at least a fair day's work from his employees. However, a simple look at the production floor in mid-afternoon might give one a different perspective. Around 2:00 o'clock nearly everyone in the plant had made his production quota and was spending a rather arduous two to three hours in cleaning up and in general milling around. Of course, this activity was being disguised by the workers as machine breakdowns or material shortages, and was either being ignored or rationalized by the foreman. I've never seen so many machines that wouldn't run in the afternoon. To make the story complete, a piece rate wage incentive was being used, and the union steward told each worker how much he could produce over standard performance. The workers would not produce over this figure for fear of a rate cut and also because of the more effective force - that of being called a scab.

Now comes top management suggesting a work simplification program. Regarding time study, they felt that relations were going along smoothly with the union - their rates were being set by foremen who had worked in many of the jobs, and well, since they just weren't having any trouble with rates now, perhaps sleeping dogs should be allowed to lie. So management was actually suggesting that better methods alone would give them the increased efficiency desired. They forgot one thing - how could they quantitatively measure the amount of improvement given by a methods program and relate these improvements to time values? They were in essence expecting methods improvements to carry along poor rate setting and get more production.

[1] Presented at a meeting of the Society of Industrial Engineers, Oakland, San Francisco, Bay Area, California, April 7, 1949

Some time later I visited the plant again after considerable methods work had been done. On the whole it was quite a recommendable installation. However, the production efficiency hadn't gone up anywhere near the amount that top management had been led to expect. True, the union had allowed token decreases in standard times, but these were nowhere near commensurate with the amount of improvement installed. Perhaps the most notable effect of the program was that the working part of the day now ended at around 1:30 instead of 2:00.

As a natural result, the plant manager was convinced that Motion Study had been overpublicized and he lost interest in the Work Simplification Program. Examples such as this would be amusing if there weren't so many of them.

It has become axiomatic to say that Motion Study must precede Time Study. We've even changed the name from Time and Motion Study to Motion and Time Study to better emphasize that fact. It should be just as important a principle to state that Motion Study and Time Study must be developed mutually if either is to succeed. It is my opinion that most of our Time Study Systems are much more inaccurate than the results would lead us to believe. How many of our Time Study Systems work because their logic is irrefutable, and how many work because they are made to work?

Let us analyze Time Study to see what it is, what is wrong with it, and finally what, if anything, can be done about it. The first part of the question can best be answered by stating the objective or goal of an individual time study. A stop-watch time study is made to determine the amount of time an average operator requires to perform a certain operation on the average. This time is called the standard time. Many Time Study Systems stop right here with just such a definition and throw the problem of procedure and judgment into the lap of the time study man, arguing that experience is needed to estimate what "average" is. Delving deeper, we see that there are several factors which must be carefully scrutinized. First, when we are talking about a "certain" operation, we must know what method of work was followed and under what conditions it was performed. Our time values obtained certainly are only good for the method observed and under the same working conditions. The "average operator" concept necessitates our determining whether the operator's skill, aptitude and motivation are average. Finally, "on the average" brings in the idea that the worker should be working at a reasonable and maintainable pace.

One of the main faults of Time Study is that we never define completely what a Time Study is, i.e., what its goal is. Of course, we know that the goal is to find standard times, but what is standard time? I propose, therefore, that we tie all of these concepts up into one concise definition of what standard time is. Standard time is the amount of time required to do a unit of work, using a given method, and under given conditions of work by a worker possessing sufficient skill to do the job properly and is as physically fit for the job, after adjustment to it, as the average worker who can be expected to be put on the job, and working at a pace which is 30% below the maximum pace that can be maintained day in and day out without harmful physical effects. Finding this standard time for each operation is the goal of Time Study.

Now we have our work cut out for us. We have a definition of standard time and now must set up procedures for adequately considering each section of this definition. Each section we do not cover completely or we slide over will definitely contribute to the inaccuracies of Time Study.

The Given Method - the method must be recorded in detail. Time values are good only for the method that is used during the time study. Changes in the method essentially make an entirely new operation and therefore require a new time study. The importance of recording what is done in great detail cannot be overemphasized.

Given Conditions of Work - The light, heat and other working conditions affect output. Therefore, standard time is good for only like conditions as observed during the time study. Working conditions as well as method must be recorded on the time study sheet in such detail that the job could be reproduced in the future exactly as it was during the time study.

The remainder of the definition deals with the worker observed and not the job itself. Evaluation of his skill, aptitude and motivation must be determined by a "rating" made by the time study engineer. As pointed out in our last meeting, variations in skill, aptitude and motivation of the operator are reflected by variations in the pace at which he works, and that this rate of activity or pace is the only thing that is observable and capable of being judged by another human being. Therefore all we need now is to have some physical representation of a worker performing at a pace 30% below the pace that can be maintained day after day without harmful physical effects. This pace will be called standard pace or 100% and does allow the average worker a chance to obtain full incentive pay without harmful physical effects. A film loop should be made of a worker working at a pace that all parties involved, labor and management, agree is 30% below the maximum maintainable pace. This loop of film and the speed at which it was taken can be made a part of the union contract and should be known as standard pace for all jobs.

Now we have a meeting of the minds on what constitutes normal pace. However, you are probably saying that all jobs cannot be done as fast as in the film. How is this fact taken care of? You will note that rating was made of only the operator and not of the job in this system. These differences in jobs are exactly what cause the jobs to be performed at these different rates of activity.

Therefore, all we need to evaluate is how much the differences in jobs affect the normal pace and apply this as an allowance. The table of allowances (Table I) is merely a table of job differences showing how much each of these differences slow down the pace from that of the film loop. For example, the table shows that a certain job requiring "Fine and Close" Eye Hand Coordination (Reference Letter Q) will require a 6% allowance to correct for the slower pace caused by this needed coordination. The other allowances may be thought of in the same way. If the method has been described in sufficient detail, the time study engineer can determine these allowances and apply them to the base time at any time later. The biggest improvement to Time Study by this system is that rating is now on a basis that requires a concept of only one standard and that judgment is needed only to the extent of being able to put percentage values on changes in pace observed. Time Study has been given a definition and now a way to measure performance. Equally important is the fact that standard pace has now been brought completely out into the open and all parties concerned can see and acquire the same concept of standard pace.

How does the system operate?

1. The method is recorded in great detail - this cannot be overemphasized.

2. The operation is broken down into time study elements. There are definite criteria to be followed in the breakdown into elements, but time does not permit a discussion at this time.

3. The time of a particular operator is observed by the continuous method of stop watch reading.

4. Each element of the operation must be given a rating. It would be desirable to rate each and every reading, but since this becomes too complicated, an average rating for each element is often used.

5. The Selected Time is found in the usual manner. The average of the values observed is the most common way to determine Selected Time.

6. The rating factor multiplied times this Selected Time still gives us Base Time, but it now has a new concept. It represents the time the observed operator would have taken for the particular element if he had worked at the standard pace as shown in the film loop.

7. The allowances for each element are determined and added up. To be sure that each one of the allowances is considered, it is recommended that the allowances be written on the Time Study Sheet in the following manner: A-3 or D-0 or P-3. Take (100 + the sum of the allowances) and multiply this times the Base Time and the Standard Time is found. Now we have the time the operator observed would have taken if he were working at a rate of energy expenditure comparable to the film loop. These are the only allowances that need be made.

8. In order to train time study men in this system, it is necessary to use the standard loop and loops of known variation in pace from this standard. By repeating these different films and allowing the time study man to correct his errors, he soon becomes proficient at pace rating. Stop watch technique is the same and application of allowances may be done at leisure.

I want to caution you in a few more details of the system. The allowance table was compiled for a simple operation involving only wrist and finger motion, practically no weights handled, and the material could be handled roughly. This was done so that allowances would always be positive, which is of great psychological value in explaining the allowances to the workers. This fact must be borne in mind if use of this particular table is contemplated.

Cooperation of the union must be sincerely solicited and a mutual understanding of the system must be effected if this or any Time Study System is to be successful. Concerning reaction to this system by a union official, I quote from a letter by Mr. William Gomberg, Director of the Management Engineering Department of the International Ladies Garment Workers Union to a Mr. Smith in Urbana, Illinois. "Mundel has developed a series of films in which he attempts to define a norm on the basis of common agreement between the two parties. Mundel, of course, has published material indicating limitation in the use of movies for leveling purposes. Within these limitations, I would say that this is the method I would advocate at the present time."

Knowing and understanding the union's viewpoint is certainly necessary if satisfactory relations are to exist. A booklet by the UAW-CIO titled "UAW-CIO Looks at Time Study" lists what this union believes are the "Six Shortcomings of Time Study." With the exception of two of the shortcomings listed - errors in merely reading the stop watch and the fact that there is no standardized policy on how many cycles should be observed in the time study - we have touched on these shortcomings tonight and have given suggestions for their improvement.

Finally, you may well be questioning my statement that no other allowances are necessary by asking how about allowances for Unavoidable Delay and for Fatigue? Unavoidable Delays should be timed as irregular elements and prorated over the number of cycles observed. True, this does involve a rather long time study period in order to be sure that all possible unavoidable delays have been accounted for. Many companies do make blanket allowances for this and some refer to it as an allowance for Managerial Delays which perhaps gives this allowance a more realistic title. This blanket allowance is not as accurate of course as a longer time study would be.

In regard to the fatigue allowance, I believe that this is one point where we must really dig in and analyze our basic time study philosophy. Ask yourself this question - Does our Time Study System have as its concept of standard performance a rate of effort that is maintainable throughout the working day? Answer this question carefully, but I must warn you that I have you whether you answer yes or no. If your answer is no, you are then open to the rather serious charge of operating a sweat shop in which the workers are required to work at such a rate that it cannot be maintained throughout the day. If your answer is no, and this is probably not your answer, you then do need an allowance for fatigue. More likely your answer is yes. If you are rating against a standard that can be maintained all day, then obviously you have already accounted or allowed for fatigue and any further allowance for it would be merely a duplication.

In conclusion I should like to suggest that we be quite critical of our time study philosophy and be extremely sure that our system allows us to fulfill the primary purpose of Time Study - that we are accurately determining what consttutes a fair days work.

MOTION & TIME STUDY
ALLOWANCES FOR STOP WATCH TIME STUDIES

No.	Description	Ref. Letter	Condition	Per Cent Allowance
1	Personal	A	Comfortable Room	3
		B	Warm or Slightly Disagreeble	5
		C	Hot, Dusty, Noisy, etc.	10
2	Amount of Body Used	D	Fingers Used Loosely	0
		E	Wrist & Fingers	1
		F	Elbow, Wrist & Fingers	2
		G	Arm,Elbow, Wrist & Fingers	5
		H	Trunk, Arm, etc.	8
3	Foot Pedals	I	None or One Pedal	0
		J	Two Pedals	1
4	Bimanualness	K	Hands Help Each Other, or Alternate	0
		L	Work Simultaneously Doing the Same Work on Duplicate Parts	10
5	Eye-hand Coordination	M	Rough Work Mainly Feel	0
		N	Moderate Vision	1
		O	Constant but not Close	2
		P	Watchful, Fairly Close	3
		Q	Fine & Close	6
6	Handling Requirements	R	Can be Handled Roughly	0
		S	May be Squeezed but Must be Controlled	1
		T	Must be Handled Carefully	3
		U	Fragile	5
7	Per cent of cycle controlled by machine	Use letter V followed by %	100 per cent machine time	30
			95 per cent machine time	25
			90 per cent machine time	21
			85 per cent machine time	18
			80 per cent machine time	15
			75 per cent machine time	12
			70 per cent machine time	10
			65 per cent machine time	6
			60 per cent machine time	7
			55 per cent machine time	4
			50 per cent machine time	2
			45 per cent & less, machine time	0
8	Weight Handled	Use the letter W followed by actual weight of resistance on lever or wheel	Actual weight or resistance Overcome up to 70 lbs. Maximum for Not More Than 50 per cent of cycle From M.E.Mundel "Systematic Motion & Time Study" with Alterations Prentice Hall Inc., New York, 1947.	.5 per lb.

A FAIR DAY'S WORK [1]

by
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Historically the measurement of the work content of a job was undertaken for technical purposes requisite to the proper planning of production. The early approach made by F. W. Taylor was lacking in the concept of tieing measurement to control of production through payment of incentives. As long as the concept of control through payment was lacking, the techniques of measurement did not need to contain the reliability and validity now demanded of them. They were not subjected to sharply critical examination or to the wear and tear experienced by all techniques falling in the area of labor-management relations.

Our early predecessors quickly removed themselves from the area of academic interest by relating take home pay to productivity determined by measurement. They were then interested in answering the question of what constitutes a fair day's work, and after 65 years we are still attempting to answer this question. The early association of money paid with work measurement placed the techniques of measurement into an area of conflict, an area emotionally charged, and unfortunately, highly dominated by opinion. Add to this the early abuses practiced by so called efficiency experts, after Taylor's time, who were incapable or otherwise did not make the transition from the mechanical aspects of measurement to the social setting in which it takes place. These people did not realize that they were measuring, for measurement presupposed standardization. They did not realize that they were using measurements for prediction purposes which presupposed control of the situation in which the predictions were to operate. All of these added together served merely to move Time Study further away from the area of accurate measurement towards the area of opinion.

The originators and early users of Time Study had a background in engineering and in the application of scientific principles. Reflecting their skills and predictions and in the face of the then unknown social sciences, a highly technical, mechanistic approach was taken towards work measurement. "Scientific" and mathematical laws were sought and rigid procedures and tables of data were established which presumed that adequate and proper measurements had been undertaken. It is needless to belabor this approach further for it has long since been abandoned, although its ghost reappears every so often.

In establishing the Time Study procedure, Taylor instructed users of the technique to study a well qualified worker. This rule was laid down to provide a known anchor point in a sea of unknowns. The questions, what constitutes a fair day's work, what kind of worker can be expected to produce this quantity, what qualifications must the worker have, how shall measurements be made, how can predictions be made in the face of a varying work situation, were those confronting Taylor and the questions are still largely with us today. The establishment of work standards through Time Study means the setting of goals, not merely goals of production but personal, social, and financial goals as well.

[1] Presented at the First Motion & Time Study Institute.

The practitioner today as in Taylor's day is not cognizant of the social, biological, physiological, and psychological implications of work measurement. A number of research studies outstanding of which is the Hawthorne study,[1] clearly point out the vital interrelationship and inseparability of all these effects. The research worker today, and there are few of them, is approaching the problems of work methods and work measurement by relating and applying the biological, physiological, social and psychological sciences to that of engineering.[2]

In his use of these bordering sciences, the research industrial engineer is retarded by the existing state of knowledge. The problem of the application of known information and established principles is difficult, and in the face of missing information and untested principles it is sometimes impossible. The status of physiology today is such that a definition of the extremes has been begun. A good deal is known concerning man's reaction to and performance under extreme environmental conditions. Unfortunately little is known concerning adaptation, performance, and fatigue effects under the ordinary demands of daily working conditions.

In the field of psychology a large amount is known about small bits of human behavior. There are many theories describing behavior which are as yet in the hypothesis stage. Knowledge of "total behavior" and integration of the known small bits is lacking. Excellent approaches are being made by social psychologists in describing, predicting, and adjusting group actions. During and since the last war a new branch of psychology has gotten under way and is doing a job most closely related to industrial problems. This new work called experimental applied psychology, and sometimes referred to as human engineering, is acquiring experimental information of the same type that the research industrial engineer is attempting to acquire. The purpose of this approach is to learn everything about the subject of man at work.[3] The field of sociology has been busy preparing itself for work to be undertaken, and there are not as yet many readily available tools for the engineer to use. Some important starts have been made in industrial sociology which give promise of rich results.[4]

The engineer has to, and is, bridging the gap between these sciences and his own work and he is learning to apply the related information to the problems of industry. However only a beginning has been made, a long uphill road is ahead.

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[1] Rothlesberger & Dickson, Management and the Worker, Harvard Press, 1939
Mayo, Human Problems of an Industrial Civilization, Macmillan, 1933.
Whitehead, The Industrial Worker, Harvard Press, 1938.

[2] Malcolm, D. G., "The Optimum Speeds of Indexing Devices," ASME, paper No. 49SA34, July, 1949.
Davis, Louis E., "The Human Factors in the Design of Manual Machine Controls," ASME paper No. 49SA30, July, 1949.

[3] Fitts, P. M., Psychological Research in Equipment Design, Report No. 19 Army Air Forces Aviation Psychology Program, Washington, '47.
Morgan, C. T., Human Factors in Engineering Design, Wiley, 1949(pub.in Fall)

[4] Moore, W., Industrial Relations and the Social Order, Macmillan, 1946
Merton, R. K., "The Machine, Worker, and Engineer," Science, vol.105, p.79, '47.
Mills, John, The Engineer in Society, Van Nostrand, 1946.

Work measurement is an inseparable part of techniques used by progressive management. It serves as the basis for production planning, control, and management. The engineer's approach to the problem of work measurement has been practical, in the face of the large unknown areas affecting his work. The ideal solution might have been for him to wait until sufficient information was available before proceeding with measurement. However, the pressure at first from management, and now from labor too, was so great that action had to be taken. The approach taken at first was over-confident and dogmatic. Today, past schemes, inflexible formulae, and the know-it-all attitude are giving way to the recognition of working in an area that is largely uncharted. Dogmatic action has to be avoided by both management and labor. Management does not have the answer but has claimed on many occasions that it was right in its approach. Labor does not have the answer either and has taken the attitude that it was right, or wanted no part of work measurement.

The trends of the approaches to the solution of the problems involved in work measurement are proceeding along three lines. First, research is being carried on by industrial concerns to develop an immediate solution. At universities, research of a more fundamental nature is also in progress. Second, work measurement projects which constitute a practical approach are under way in various parts of the country and nationally to gather the experience of practicing engineers in their handling of the question of rate of work. Third, managements, notably in the steel industry are taking the lead in promulgating the concept of a "fair day's work for a fair day's pay." The basis of the concept is to be fairness and a working agreement with labor.

The concept is an empirical practical one set forth and negotiated between management and labor. Management is undertaking a selling program to disabuse labor of the idea that it is the quantity of product that is the sole determinant of the work performed. The techniques for determining a fair day's pay are well established and used. These involve the use of the area wage survey, job evaluation, and merit rating.

The determination of a fair day's work has been worked out by management and the union and is based upon the following definition: "A fair day's work is that amount of work that can be produced by a qualified employee when working at a normal pace and effectively utilizing his time where work is not restricted by process limitations."

To change the definition from a statement of policy to a working tool, it was necessary to define normal pace, which has also been done as follows: "A normal pace is equivalent to that exhibited by a man walking without load on smooth level ground at a rate of three miles per hour."

This approach introduces the concept of, and need for, rating to transfer the definition of normal pace from job to job and to evaluate it on a scale. The use of motion pictures is introduced as the medium for recording agreed upon pace scales used as bench marks and reference sources for key jobs.

The approach taken by these managements in agreement with their unions is not one that the research engineer would take. But then again, the researcher is not being pressed for results. This approach represents a step in the practical solution of the problem. It appears to wash over the detailed research work currently in progress, but the true answer is years in the future.