ute. These cannot be timed directly by the running decimal watch, and the percentage of error in measurement by indirect methods is so large as to vitiate the results. For such a study the micromotion study apparatus is excellently adapted. I believe that by going at this subject persistently and systematically in a few years we could have for each of a hundred work elements a graphic chart, like those already attained for many elements at J. H. Williams Drop Forge Works, showing the range of the time of the element according to the size, shape, position and the like of any object to which it applies. Then we could realize our ideal of being able to analyze a new prospective job, write an instruction card for it, apply elementary time data and set a performance standard for it without leaving the desk in the planning department.

VII. TIME STUDY AND HUMAN STANDARDIZATION

By Reynold A. Spaeth[1]

1. In a paper delivered before the New York Section of The Taylor Society on December 16, 1920 by Mr. and Mrs. Frank Gilbreth, an indictment was advanced against stop-watch time study as it is customarily practiced. The validity and the scientific value both of the method and of the results were criticised. The method of stop-watch time study is believed by the Gilbreths to be too crude and they suggest substituting their motion picture technique for it.

2. After a careful reading of the Gilbreth's paper it seems to me that they have lost sight of the fact that the problem of time study is not one involving extraordinary accuracy in measuring time. In their motion picture technique they have concentrated upon a method that will give them a high order of absolute accuracy for the particular function measured, that is, motions in time intervals. This, however, is not the real problem.

3. In my opinion the stop watch, instead of being inaccurate, is already far too accurate. It is, in fact, of a different mathematical order of accuracy from that of the final result. The statistical arguments advanced by the Gilbreths are entirely correct, but they do not apply to stop-watch technique itself. The reliability of statistical data obviously does depend upon the accuracy of the individual components which constitute the final result. Most physiological experiments, however, probably have an error of about five per cent. Some of the real sources of serious error in stop-watch time study are unknown variables as allowances for delays and fatigue, variability of incentives and of individuals, and the mutual suitability of job and man—to mention only a few.

4. The time-study man's job is to set a fair wage on the basis of his observations not only of time intervals, but with the additional of allowances for fatigue, delays, etc. The final result, therefore, whether with a stop watch or with a moving picture technique, is made up of a combination of some very accurate measurements and some guesses. Consequently, your best guess necessarily determines the order of accuracy of the final result. If a chemist has to weigh a definite quantity of a particular substance and takes one fraction and weighs it to five decimal places on an extremely accurate chemical balance and then takes the remainder and "hefts" it with his hand and guesses it to weigh about a pound and a half, the final accuracy of his result depends not on the weighing that he did on the chemical balance but on his ability to guess accurately—whether in other words the other fraction really weighs a pound and a half or not.

5. It is important to bear in mind that the Gilbreths face exactly the same group of variables as the stop-watch time study man when they come to apply their observations on "the one best method" to other people than the particular expert studied. In other words, although the average man is not believed to exist by the Gilbreths, nevertheless it is average men and not exceptional experts with whom we are forced to work in practice. Whatever inspiration may come to the average workman from observing a five foot piece of film with a magnifying glass, I am frankly skeptical just how much such a study will contribute toward the learning of the expert's technique by the average workman.

6. I do not wish to be misunderstood in this criticism. As a research method and as a permanent record of the best way to do work there is much to be said in favor of the fascinating and highly ingenious technical appliances devised by Mr. Gilbreth. The possibility of synthesising a working method from the performances of different individuals is at least a theoretical argument in favor of the motion picture technique. In certain extremely

[1]Associate in Physiological Hygiene, School of Hygiene and Public Health, Department of Physiology, Johns Hopkins University, Baltimore.

rapid processes it may doubtless find an application also. However, when we are asked to abandon the stop-watch time study method and adopt the motion picture technique with the object of improving the accuracy of the final result, I believe this to be fundmentally incorrect and a step in precisely the wrong direction. As a general scientific problem, before increasing our refinements in one direction we should and must attempt to control some of the larger errors in another direction mentioned above. These errors are particularly concerned with the problem of the standardization of the individual.

7. All time-study men will agree that a fundamental preliminary step consists in a systematic standardization of equipment, methods and tools before any time studies are begun. Management engineers have made marvelous progress along these lines. I need not remind this group of the studies of Mr. Taylor and Mr. Barth on the art of cutting metals and the science of re-speeding machines. From reading Mr. Taylor's "Principles of Scientific Management" it is very clear that he appreciated the importance of standardizing the human beings who are to do the work, as well as the equipment. This phase of scientific management has, however, been almost totally neglected up to date. The reason seems to be that it has been nobody's job. Industrial physicians have been concerned with illness; industrial health has not yet been studied systematically. In fact, this work is in its earliest beginnings.

8. There are three general phases of human standardization: (1) physical standardization; (2) physiological standardization, and (3) psychological standardization. I wish to speak briefly about each of these three phases.

9. By a physical standardization of individuals we mean an inquiry into the total muscular strength required by a particular job. The method of measuring total muscular strength devised by Dr. E. G. Martin of Stanford University has already proved successful in industry. In a recent publication of the United States Public Health Service, Dr. Martin has shown that there is a definite correlation between total muscular strength and output. This correlation is not very high to be sure. It has a value of approximately —.50. However, statisticians consider such a value to be within the significant class. The practical value of physical standardization consists of establishing definite limits of strength required to do the particular work successfully. For example, if an individual has a total muscular strength of 3000 pounds on the Martin scale and the weakest individual who is successful at the job has a total strength of 2200 pounds the employment office would not consider engaging a man and placing him on this same job whose total strength did not come up to say 2000 pounds. Dr. Martin's method is extremely practical for it requires only some two minutes to make a single set of observations. Furthermore, the measurements are made with the individual completely clothed, which has obvious practical advantages. How far Martin's method may prove to be applicable in industry in the future I will not venture to predict. It is, however, important for management engineers to know that work is being done and has been done along the lines of physical standardization of industrial workers which has a great and important practical significance. Such standardization is obviously of use principally in jobs requiring a considerable expenditure of muscular effort.

10. The practicability of so-called physiological efficiency tests is less obvious. The physiological tests that have thus far been devised are principally concerned with the efficiency of the heart and circulatory system. You are familiar with the fact that after light exercise the heart rate increases. The time required for the heart to return to its normal rate is used as an index or measure of the heart's efficiency. This subject has been principally investigated in this country by Drs. C. Ward Crampton and Schneider of Wesleyan University. Dr. Schneider's test was used during the war in the selection of men who were especially fitted to become aviators. As in the case of the test for physical strengh the physiological efficiency test would be of greatest importance in jobs requiring much muscular effort. I have in mind women who work in sail lofts and dock workers who handle heavy loads at high speed. Other cases will occur to you.

11. Another group of investigations in which physiologists have been particularly interested has been concerned with the carbon dioxid output of the human machine during work. Without going into great detail in this fascinating subject I should like to call your attention to certain discrepancies or neglected points that occur in making out a so-called workingman's budget. According to the observations of Greenwood, Hudson and Tebb, the individual engaged in heavy labor must spend nearly five