up and the time required for performing the operation reduced to .28 minute.

2. Repairing what were commonly called "breaks" in strands of yarn composing the warp. This was not only time consuming but vexatious. Investigation showed that this was not in fact due to yarn breaking so much as to the loosening of knots where ends of two lengths had been tied with an ordinary weaver's knot. Various kinds of knots were tried without success. Finally, at the suggestion of a weaver, the expedient of tying in a short length of cotton yarn between the two ends of "camel hair" yarn was resorted to with the result that "breaks" practically disappeared. Not satisfied with this, however, weavers continued to experiment with different ways of tying one end of "camel hair" yarn to another until one of them devised a knot that would not come untied.

Production on these looms was increased from 60 per cent to about 90 per cent and at least half of the improvement was attributable to the workers' co-operation.

V. On Making Observations

Apparatus and Analysis

Almost every writer on the subject has called attention to misunderstandings of the term "time study" and the crimes that have been committed in its name. My colleague in Japan, Mr. Yoiti Ueno, told me at one time of an extreme case he had just encountered in the plant of a new client who, up to that point, had been proceeding "without benefit of counsel." The manager of this plant told Mr. Ueno that they had been making time studies. When asked how they went about it, he stated that in each department there had been placed a large electric clock which enabled the foreman to learn how long it took to perform any operation.

Gantt's comment in 1908 covers this very well. He said: "Inasmuch as, after a satisfactory method has been established, a large proportion of the work of the task setter is the study of the time in which operations can be performed, he is popularly known as the *time-study* man. This term has led to a misconception of his duties and has caused many honest people to claim that they were putting in our methods when they have put a stop watch in the hands of a bright clerk and told him to find out how quickly the best men were doing certain work. . . . Stop-watch observations on work done inefficiently, or with ill-adapted appliances, or by poor methods, is absurd and serves only to bring into disrepute all work in which the stop watch is used. Moreover, such use of the stop watch justly excites the contempt and opposition of the workman."[34]

The actual making of time-study observations has been so fully covered by others that I shall not go into it at length. Taylor devoted several pages to it in "Shop Management," Dwight V. Merrick, William O. Lichtner, Richard H. Lansburgh and Messrs. Lowry, Maynard and Stegemerten all give, in their respective books, excellent descriptions of how observations should be made and recorded, as well as descriptions of the implements and forms used.

Taylor was never satisfied with the stop watch or existing printed forms as the best implements. I recall his having frequently expressed the hope and belief that someone would invent a time-study machine that would be better. It was in response to this that Frank B. Gilbreth developed the use of the motion-picture camera and Henry H. Williams evolved a machine on which a pen records on a moving band of paper, measured off to correspond with units of time, the duration of each element of a cycle. I shall not at this time undertake a discussion of the relative merits of various devices. I believe, however, that more consideration should be given to the circumstances under which each may most advantageously be used. Some may be disposed to advocate the use of the stop watch because of its convenience and because it is the least expensive implement, or because they are familiar with it through long use and have not taken the trouble to acquaint themselves with the development and the merits of others. It would help if those who are successfully using time-measuring devices other than the stop watch would present to the Taylor Society papers based upon, and giving practical examples of, their experience.

Some years ago there came to my attention another device developed by a French engineer. It had been designed primarily to afford the advantage of recording, without subtraction, the time taken by each elementary operation in a sequence and at the same time to utilize the ordinary commercial stop watch, in which the hand is started

[34] "Training Workmen in Habits of Industry and Co-operation," *op. cit.*, p. 1043.

by the first pressure on the stem, stopped by the second and returned to zero by the third. Three watches were mounted on the time-study board with a device for depressing the stem of all watches simultaneously. The first pressure started Watch No. 1 from zero; the second stopped Watch No. 1, recorded the time of the element just concluded and started Watch No. 2 from zero; the third stopped Watch No. 2, returned Watch No. 1 to zero and started Watch No. 3 from zero. The next pressure started Watch No. 1 again, and so on. Each watch thus successively recorded the time for an element while another ran during the time consumed by the succeeding elementary operation. At the time I could see no advantage over the prevailing practice of reading and recording times from a continuously running watch, except that it recorded actual elapsed times without the necessity of securing them by a subtraction at the conclusion of a study. Apart from saving the trouble of computation, it might be helpful to the man making the study by making irregularity more evident at the time. It should also in some degree reduce inaccuracy and facilitate the recording of short elements, although it is doubtful how helpful it would be in recording small elements where the average of several successive elements was three-hundredths of a minute or less. The device mentioned lacked a means of stopping all three watches at a given point in case of an interruption. This, however, could easily be provided.

While I was in France, Mr. C. B. Thompson told me of an improvement that he had made in the standard time-study watch as developed by Colonel Sanford E. Thompson. This consists of fitting the watch with a double, or split, hand as is done with the type of watch used for timing horse races.

When the watch is started from zero, one-half of the hand remains stationary while the other half goes on. At the completion of an element the stem is pressed and the stationary hand jumps forward and stops at the place on the dial that marks the time of completion of the first element, while the moving hand continues. This is repeated in the case of each element. There is, of course, a considerable advantage in making readings from a stationary hand. One feature of the original time-study watch has been sacrificed, i.e., the ability to stop the watch at any given point and start it again from that point. An expert time-study man would almost invariably record delays rather than stop and start his watch, so that this is not an important omission.

Undoubtedly all of the measuring devices mentioned, as well as others with which I may not be familiar, have merits which, under appropriate circumstances, would make their use preferable to the old stop watch. Here is an opportunity for an impartial investigation which might be combined with, or incidental to, other research in the field of methods study.

One point that should be settled is whether we should use decimal divisions and sub-divisions of an hour or decimal divisions of a minute as the time unit. Ultimately, as greater interchange of data and experience comes about, this question will take on more importance than is attached to it at present. About 1905 Merrick, for a time, changed over to the use of a watch marked off in decimal parts of an hour. His only reason, as I recall it, was that it enabled him to compute the task time for jobs directly in hours and decimals thereof, in conformity with the time-keeping and pay system and eliminated the necessity of dividing the time in minutes by sixty. He shortly after went back to minutes and decimals of minutes and has, I believe, used this system ever since. S. E. Thompson and W. O. Lichtner use minutes and decimals thereof, as do a great majority of the leading practitioners. The only real advantage that I can see in using a watch marked off in decimal parts of an hour is that it may permit slightly finer direct readings because the hand makes one revolution in one one-hundredth of an hour, instead of in one-sixtieth of an hour, as in the case of a minute-decimal watch. The advantage of this, however, is problematical. Where elementary operations are so short as to make readings finer than .01 minute desirable, and where the system developed by Barth for the observation of two or more elementary operations together would not be satisfactory, I believe the use of some measuring device other than the stop watch should be considered. I have utilized with excellent results studies made by the Barth method mentioned above. In these the complete operation, composed of twelve elements, required only one-tenth of a minute to perform. By this expedient we obtained, with comparatively few studies, elementary unit times applicable to a great variety of jobs. It was not so satisfactory,