First of all, the time and motion study analyst is handicapped because the results of his efforts are ordinarily gauged solely on the basis of increases in production. While he will not knowingly substitute a less safe motion for a more safe one, he nonetheless must devote his efforts toward increasing production, since that is his assigned task. The limited scope of activities forced upon him implies that full advantage is not being taken of his special training. Second, economy procedures are frequently confused with the "speed-up." While it is the purpose of time and motion economy to increase the amount of production, it is not the intent to do so simply by increasing the speed of the motions presently employed. Basically, time and motion economy seeks to eliminate slow movements and those that accomplish little work, and to substitute motions that are naturally more rapid and those that accomplish more work. Thus, while the speed at which items of work are completed is increased, this increase is not to be achieved through greater costs to the employee. Unfortunately, the principles of time and motion economy have not been developed with safety in mind, and, as a consequence, it cannot be said that the employment of this technique will *necessarily* result in a decrease in accidents.[2]

b. Analysis of Errors and Near Accidents. The job description itself may or may not indicate which types of activities are likely to lead to accidents. In some instances, unsafe acts are very obvious. Thus, following closely behind a vehicle while traveling at high speeds is clearly dangerous. In other cases, the danger might not be so obvious. The mangle, which requires the operator to support herself on one leg while operating a foot pedal with the other, would seem to have some elements of danger, yet one cannot be absolutely certain. Finally, some types of activities may be quite dangerous and yet go unsuspected. In certain situations, the application of the accepted principle in time and motion economy of opposite and symmetrical motions of both arms may be poor because it does not permit the simultaneous lateral movements to be well guarded by the eyes.

As a consequence, some attempts have been made to analyze case reports of accidents in order to determine mistakes made by the worker which led to the event.[7] The range of possible mistakes that an individual can make is great and the opportunity varies markedly from one occupation to another.[8] This means that there is little possibility of generalizing the findings with respect to unsafe acts from one occupation to another. Furthermore, if unsafe acts are described in very general terms, as in the American Standard Code for Compiling Accident Causes, important details will be lost. While it is of some help in the construction industry to know that a significant number of accidents are due to poor or faulty use of tools, it would be of immeasurably greater help to know that more accidents result when fixed or controlled movements are used in swinging a pick

[7] E. E. Ghiselli and C. W. Brown, *Personnel and Industrial Psychology*. McGraw-Hill, New York, 1948.

[8] R. P. Blake, ed., *Industrial Safety*. Prentice-Hall, New York, 1946.

than when ballistic movements are used. The value of an analysis of errors and unsafe acts will be in direct proportion to the specificity with which the error or act is described. As an aid in a preliminary analysis of unsafe acts in accident reports, and for the purposes of occupational and industrial comparisons, some system like the American Standard Code will be helpful.

The study of near accidents is a part of the critical incident technique, described by Flanagan. In this approach, incidents having a special significance or relevance to accidents are recorded with the aim of permitting inferences and predictions to be made about the person performing the act. Such data can assist in the advance elimination of the accident-repeating individual, just as analyses of near accidents can assist in the elimination of the accident-inducing situation or work method.[9]

II. Equipment Design in Relation to Human Body Size

Whenever the design engineer is concerned with the development of machinery to be operated by man, he must make decisions as to the dimensions and arrangements of the operator's control area and all of its components. In some instances, he is given general directions such as "all machine controls must be conveniently accessible"; or he is instructed to avoid arrangements that involve "reaching with hand, foot, or tool beyond range of clear vision," "off balance positions," "inadequate head room," "inadequate clearances," and "inadequate working space about machines or equipment."[10] He is rarely supplied with the detailed quantitative descriptions of man that will enable him to meet these specifications. The design engineer, then, has been obliged to work out required dimensions on the basis of general familiarity and experience with the operation, "educated guesses," measurements of trials with only a few subjects, and reference to previous design (which, in all likelihood, was established upon an equally tenuous basis). It is probable that in the great majority of cases where design deficiencies in fitting the machine to the man have occurred, the errors have resulted not from lack of concern for the operator but rather from the lack of adequate descriptions of his body measurements and other physical and physiological characteristics upon which equipment design must be based. Such a situation is clearly unacceptable from the point of view of industrial safety, since the extent and the success of the provisions that are made for the satisfaction of human requirements in any design or work situation will determine, to a considerable degree, both the safety and the over-all efficiency of the operating personnel.[2]

It is obvious, then, that designers must have access to descriptive data on the body size of the populations who are to use their machines. These data can

[9] J. C. Flanagan, The critical incident technique in the study of individuals. *Modern Educational Problems, Report of the 17th Educational Conference*. American Council on Education, Washington, 1952.

[10] Safety subjects, *Bull.* No. 67, Bur. Labor Standards, U. S. Dept. of Labor, 1944.