the controls, the manner in which they are operated, and their "feel" may differ significantly from one model to another. Even though the different models are equally effective in performing a given operation, the difference becomes important because it introduces novelty into a situation where uniformity is needed. In many industrial tasks, it is essential that the worker devote his whole attention to the result and not to the means. A good example is the operation of a motor vehicle through heavy traffic. Here the operator should be devoting his attention to his surrounds and to making judgments relative to distances, directions, and speeds, and not to the manner in which his controls are to be operated.

To be truly effective, equipment, insofar as possible, should be amenable to automatic operation. It should provide the opportunity for the utilization of habitual modes of action. This does not imply that the worker should never change his response as any change in the situation may require. Rather, the fundamental motions he employs should be so stabilized that in moments of stress and decision he should be able to devote himself to solving the problems so suddenly presented and not to the types of movements he is to make. When the worker is called upon to utilize different models of equipment, he must pause and consider the manner in which the particular equipment operates and is thus unable to give his entire attention to the larger problem confronting him. Furthermore, when the worker is confronted with different equipment from time to time, he may never be able to develop appropriate habitual responses because of the constant change. With standardized equipment, the worker can devote his entire attention to the situation confronting him and thereby can anticipate and deal more effectively with whatever hazardous circumstances develop.[2]

IV. Design of the Working Area in Relation to Environmental Variables

The way in which a worker carries out his job is influenced to a large extent by a group of physical variables consisting of temperature, humidity, noise, vibration, and so forth, and any other features especially characteristic of the working environment. The optimum integration of the man with the machine cannot be achieved, in a human engineering sense, unless these physical variables are taken into account in the initial design, or the redesign, of the worker's machines and equipment, as well as the whole of his immediate working area.[93] Many of the variables pertinent to this discussion are given detailed treatment in special chapters of this volume and hence will be treated here only briefly in regard to certain selected aspects.

Much of the research in human tolerances to physical variables has been based upon physiological hazards to man or upon sensory stimulation. However, another important kind of tolerance to consider is what may be called a performance tolerance where some definable impairment in performance serves as a criterion.

[93] R. A. McFarland, *Human Factors in Air Transportation—Occupational Health and Safety*. McGraw-Hill, New York, 1953.

One example might be the level of sound intensity at which a worker's co-ordination becomes measurably impaired; a specific feature of a man's behavior is thus examined rather than only possible damage to his ear.

Such tolerances are very significant for industrial safety because they refer to conditions in which an employee's performance may be below par and errors may be prevalent. This point of view takes account of those factors, such as illumination, sound, and temperature, which may have adverse effects upon an operator's performance and which may be controlled through human engineering techniques. An increased error rate is often one result of exceeding an operator's performance tolerances for one or more of these variables. Although there are many studies of the effects of environmental variables upon behavior, much of the information has not been gathered and systematized so as to specify performance tolerances. The best way to prevent accidents through control of the environment is to determine the appropriate tolerances of employees and then to provide working conditions in which these tolerances will not be exceeded. In Figure 11 the

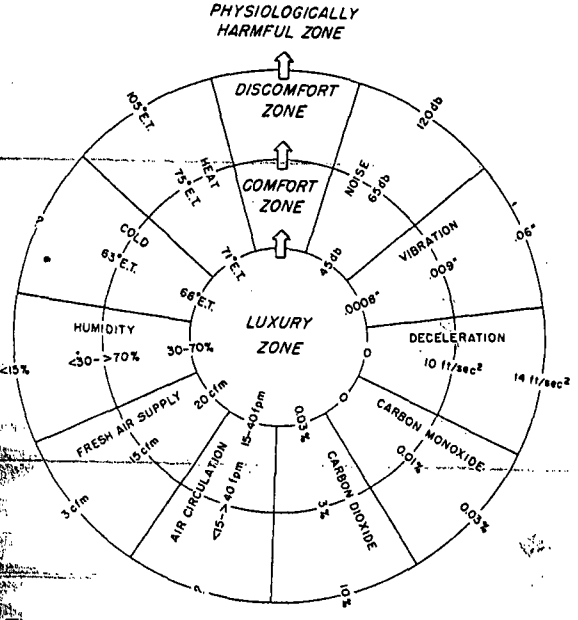

Figure 11. The physical variables of the environment and their influence on comfort, discomfort, and health. These figures were prepared specifically with reference to the operators and passengers of commercial vehicles, but could be applied in a general way to some other types of work. A schematic figure such as this can, of course, give only approximate values since each variable is interdependent with one or more additional factors. (After McFarland.[93])