

have a front to rear downward slope, of perhaps 5 to 7°, although this too must remain a matter of experience.²⁹ It should be noted, of course, that the sloping of seats or back rests may be undesirable in jobs requiring special sitting positions or postures.

4. Sources of Anthropometric Data

It has been emphasized in this discussion that it is often necessary to measure directly the population that will operate a given machine or perform a certain task because anthropometric differences among various industrial groups may be quite marked. Unfortunately, relatively few anthropometric studies have been made of specific occupational groups. In many instances, therefore, surveys of this nature must be undertaken before the workers' equipment can be truly "human-engineered." In some cases, where less precise descriptive material may be sufficient, a rough approximation of human dimensions for a given group may be obtained by consulting published anthropometric data on different series of individuals, especially if use is made of the concept of correlations between the various body dimensions (see page 68). Much of the existing data for American males has been taken on military populations. Newman and White, working with the United States Army Quartermaster Corps, have published the results of a comprehensive survey of 24,000 men in their "Reference Anthropometry of Army Men."¹⁴ For the Air Force, two publications offer valuable data, "Human Body Size in Military Aircraft and Personal Equipment"¹⁷ and the comprehensive "Anthropometry of Flying Personnel."¹⁸

For the general civilian population, Hooton has presented data on 8 body measurements especially pertinent to seat design for 1,900 males and 1,900 females in his *A Survey in Seating*.¹⁹ Studies on the body dimensions of women are reported by O'Brien and Shelton in a United States Government publication, "Women's Measurements for Garment and Pattern Construction."²⁰ In this report, medians, means, standard deviations, and coefficients of variation for 59 measurements of over 10,000 women are given, together with tables of partial correlations of the various dimensions. Comprehensive anthropometric data directly pertinent to the design of desks, chairs, and other equipment for school children of all ages are available in *The Functional Body Measurements of School Age Children*.²⁴ For specific industrial occupational groups, data on the dimensions of commercial truck and bus drivers may be found in *Human Body Size and Capabilities in the Design and Operation of Vehicular Equipment*.¹¹

At all times, however, it should be remembered that it is always preferable, and sometimes mandatory, to measure the working population directly before applying the data to the design and layout of industrial equipment.

¹⁴ R. O'Brien and W. C. Shelton. Women's measurements for garment and pattern construction, Misc. Publication No. 454, Bur. Home Economics, U. S. Dept. of Agriculture, Washington, 1941.

²⁴ W. E. Martin and F. P. Thieme, *The Functional Body Measurements of School Age Children*. National School Service Institute, Chicago, 1954.

III. Equipment Design in Relation to Human Capabilities

Much of the equipment within the working area can be divided into two main classes: displays and controls. Controls are those devices that govern the operation of the machines, and the problems that are associated with them are fundamentally those of the physiology and psychology of bodily movements. Displays are those devices that tell how the machines are functioning. Display problems are primarily concerned with the normal functioning of man's senses. Controls direct the input of the machines; displays show the output.²⁵

A. VISUAL DISPLAYS

Accidents may occur because a worker has not clearly perceived the location or movement of the indicators, meters, or dials that relate to the functioning of his equipment. Very often one finds that special safety precautions have been taken with regard to one aspect of the working situation while little consideration has been given to other components of the job. Tasks may become uncomfortable and performance inefficient when an individual is required to perform a number of tasks successively or simultaneously, even though any single element of the job is easy to execute. The extent to which an employee receives clear and unambiguous information concerning all aspects of his job governs the way in which he exerts such controlling movements as the operation requires over long periods of time. Visual Presentation of Information²⁶ by Baker and Grether illustrates many of the principles of design of displays discussed below.

1. The Visual Field

In order to obtain the maximum information from the surroundings and from the displays, controls, and moving parts or materials within the immediate working area, a field of vision with the minimum of obstructions is necessary. The visual field of each eye, that is, the monocular field, ordinarily subtends a horizontal angle of about 160°, and a vertical angle of about 145°. In practice, the absolute size of the monocular field varies with the level of illumination, the size and color of the object viewed, and the age and condition of the viewer. The variations are described in a review by Hall and Greenbaum.²⁷ Owing to the considerable overlapping of the monocular fields the total field observed when both eyes are used subtends an angle approximately 200° in the horizontal axis; the use of both eyes does not, of course, influence the extent of the vertical axis. These limits apply when the eyes are fixed in their central position, as when looking straight ahead. Extreme movements of the eyes to one side and then to the other, with the head in its normal position, will enable a man to scan the surroundings to

²⁵ A. E. Javitz, ed., Human engineering in equipment design. *Electrical Manufacturing*, Combined Reprint. Gage Publishing Co., New York, 1956. C. H. Best and N. B. Taylor, *The Physiological Basis of Medical Practice*. 2nd ed., Williams and Wilkins, Baltimore, 1940.

²⁷ M. V. Hall and L. J. Greenbaum, Jr., Areas of vision and cockpit visibility, *Trans. Am. Acad. Ophthalmol. Otolaryngol.*, 55th Annual Meeting, 74-88 (1950).