to determine the dimensions of seats for railway passengers.[12] He states that a seat depth of 20 inches would be sufficiently long to accommodate 90 per cent of the combined series including 85 per cent of the total males, and 95 per cent of the total females. However, this same 20-inch seat length would also mean that 15 per cent of the males and 40 per cent of the females would have to sit at least 2 inches forward from the back of the seat in order to bend their knees at right angles.[12]

Some selected static body dimensions for various groups are presented in Table 1.[11–15] Many of these values may be applied directly to industrial safety design. For example, the data are generally satisfactory for determining the sizes of protective clothing and equipment, as well as the resulting body clearances needed. Means (averages) and standard deviations are presented for each of the measurements (see below). Further information on the measurements, the points on the body from which they are made, as well as the instruments and techniques employed may be found by reference to such works as "Anthropometry of Flying Personnel"[13] or "Human Body Size and Capabilities in the Design and Operation of Vehicular Equipment."[11]

2. *Utilizing Anthropometric Data*

a. "Average" Values. The anthropometric data in Table 1 are presented in terms of average (arithmetic mean) values, a measure of central tendency that is quite familiar to everyone. However, in most problems of engineering design where the objective is to make the machine or the workspace fit the man, the average cannot be employed directly because this value gives no indication of the range at the top and bottom of the group. If only averages were used in the design of a vehicle, it is likely that as many as 50 per cent of the group would find many of the arrangements unsatisfactory for their use. For example, a knee clearance just large enough for the average man will be too small for the 50 per cent who are above average; and a control just reachable by the average man will be too far away for the 50 per cent who are below average.[16] As a further complication, the concept of the "average" man is unsatisfactory for design pur-

[12] E. A. Hooton, *et al., A Survey in Seating.* Heywood-Wakefield Corp., Gardner, Mass., 1945.

[13] H. T. E. Hertzberg and G. S. Daniels, Anthropometry of flying personnel—1950, *WADC Tech. Rept. 52-321,* Wright Air Development Center, Wright-Patterson Air Force Base, Ohio, 1954.

[14] R. W. Newman and R. M. White, Reference anthropometry of army men, *Report* No. **180,** Environmental Protection Section, Research and Development Branch, Military Planning Division, Office of the Quartermaster General, Dept. of the Army, 1951.

[15] G. S. Daniels, H. C. Meyers, and S. H. Worrall, Anthropometry of WAF basic trainees, *WADC Tech. Rept. 53-12,* Wright Air Development Center, Wright-Patterson Air Force Base, Ohio, 1953.

[16] B. G. King, Measurements of man for making machinery, *Am. J. Phys. Anthropol.* **6,** No. 3, 341–351 (1948).

TABLE 1. Some Selected Body Measurements Applicable to Equipment Design. (In inches)

	Males								Females			
	U. S. Army N = 24,465[14]		U. S. Air Force N = c. 4,000[13]		Civilian truck and bus drivers N = 271[11]		Civilians—general population[a] N = 1,950[12]		U. S. Air Force N = 852[13]		Civilians—general population[a] N = 1,908[12]	
	Mean	S.D. (σ)[b]	Mean	S.D. (σ)[b]	Mean	S.D. (σ)[b]	Median	Q.D.[c]	Mean	S.D. (σ)[b]	Median	Q.D.[c]
1. Age	c. 22		28.87	4.22	38.86	8.13	38.5		19.79	2.71	35.6	
2. Stature	68.47	2.51	69.11	2.44	68.33	2.41	69.0	1.95	64.07	2.34	64.9	1.70
3. Weight (lbs.)	154.76	20.49	163.66	20.86	166.90	27.93	166.7	16.95	123.27	14.54	133.1	14.50
4. Abdomen depth			7.94	.88	9.64	1.37						
5. Arm reach, anterior (maximum)			38.59	1.90	35.50	1.09						
6. Arm span			70.80	2.94	70.75	2.69						
7. Buttock-calf length (seated)							18.9	.65			18.2	.70
8. Buttock-knee length (seated)	23.40	1.12	23.62	1.06	23.72	1.12						
9. Buttock-leg length (seated)			42.70	2.04								
10. Chest depth			9.06	.75	8.94	.94						
11. Elbow height (seated)			9.12	1.04			9.6	.60			9.7	.60
12. Elbow breadth	17.54	1.54	17.28	1.42	17.91	1.68						
13. Eye ht. sitting erect			31.47	1.27								
14. Eye ht. sitting normal					29.36	1.20						
15. Eye ht. standing erect			64.69	2.38								
16. Foot breadth	3.87	.24	3.80	.19	3.98	.20			3.58	.20		
17. Foot length	10.43	.47	10.50	.45	10.49	.50			9.43	.46		
18. Forearm hand length	18.73	.87	18.86	.81	18.68	.89						
19. Hand breadth	3.42	.19	3.48	.16	3.44	.18			3.02	.19		
20. Hand length	7.58	.36	7.49	.34	7.55	.33			6.76	.34		
21. Hip breadth	13.95	.90	13.17	.73					13.80	.95		
22. Knee ht. (seated)	21.62	1.09	21.67	.99	21.64	.99						
23. Popliteal ht.[d]			16.97	.77			19.0	.60			18.1	.60
24. Seat breadth			13.97	.87	14.55	1.08	15.3	.75			14.6	.70
25. Shoulder breadth	17.95	.99	17.88	.91	18.33	.97	17.6	.45			15.7	.60
26. Shoulder ht. (seated)	23.01	1.17	23.26	1.14	23.67	1.00						
27. Shoulder-elbow length	14.28	.81	14.32	.69	14.67	.70						
28. Sitting ht., erect	35.77	1.34	35.94	1.29	36.22	1.16						
29. Sitting ht., normal					34.40	1.29						
30. Thigh clearance (seated)			5.61	.52								

[a] Dimensions include street clothes (minus topcoats) and shoes.
[b] S.D. (σ) = standard deviation: one S.D. above and below the mean will normally include 68 per cent of the population; two S.D.'s, 95 per cent; and three S.D.'s, over 99 per cent.
[c] Q.D. = quartile deviation: one Q.D. above and below the median will include 50 per cent of the population.
[d] Height from floor to underside of thigh behind knee.