



PRINCIPLES OF MOTION ECONOMY

IENG 301
FUNDAMENTALS OF
WORK STUDY AND
ERGONOMICS

Principles of Motion Economy

A Check Sheet for Motion Economy and Fatigue Reduction

These 22 rules or principles of motion economy may be profitably applied to many kinds of work. Although not all are applicable to every operation, they do form a basis or a code for improving the efficiency and reducing fatigue in manual work.

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<i>Use of the Human Body</i>	<i>Arrangement of the Work Place</i>	<i>Design of Tools and Equipment</i>
<ol style="list-style-type: none">1. The two hands should begin as well as complete their motions at the same time. (Page 175.)2. The two hands should not be idle at the same time except during rest periods. (Page 175.)3. Motions of the arms should be made in opposite and symmetrical directions, and should be made simultaneously. (Page 175.)4. Hand and body motions should be confined to the lowest classification with which it is possible to perform the work satisfactorily. (Page 186.)5. Momentum should be employed to assist the worker wherever possible, and it should be reduced to a minimum if it must be overcome by muscular effort. (Page 189.)6. Smooth continuous curved motions of the hands are preferable to straight-line motions involving sudden and sharp changes in direction. (Page 190.)7. Ballistic movements are faster, easier, and more accurate than restricted (fixation) or "controlled" movements. (Page 194.)8. Work should be arranged to permit easy and natural rhythm wherever possible. (Page 195.)9. Eye fixations should be as few and as close together as possible. (Page 197.)	<ol style="list-style-type: none">10. There should be a definite and fixed place for all tools and materials. (Page 202.)11. Tools, materials, and controls should be located close to the point of use. (Page 202.)12. Gravity feed bins and containers should be used to deliver material close to the point of use. (Page 207.)13. Drop deliveries should be used wherever possible. (Page 210.)14. Materials and tools should be located to permit the best sequence of motions. (Page 211.)15. Provisions should be made for adequate conditions for seeing. Good illumination is the first requirement for satisfactory visual perception. (Page 211.)16. The height of the work place and the chair should preferably be arranged so that alternate sitting and standing at work are easily possible. (Page 219.)17. A chair of the type and height to permit good posture should be provided for every worker. (Page 220.)	<ol style="list-style-type: none">18. The hands should be relieved of all work that can be done more advantageously by a jig, a fixture, or a foot-operated device. (Page 223.)19. Two or more tools should be combined wherever possible. (Page 228.)20. Tools and materials should be pre-positioned whenever possible. (Page 231.)21. Where each finger performs some specific movement, such as in typewriting, the load should be distributed in accordance with the inherent capacities of the fingers. (Page 231.)22. Levers, hand wheels and other controls should be located in such positions that the operator can manipulate them with the least change in body position and with the greatest speed and ease. (Page 233.)

As Related To The Use Of The Human Body

1. The two hands should begin as well as complete their motions at the same time.
2. The two hands should not be idle at the same time except during rest periods.
3. Motions of the arms should be made in opposite and symmetrical directions, and should be made simultaneously.

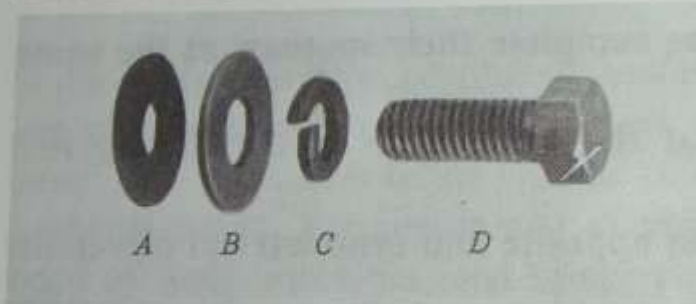
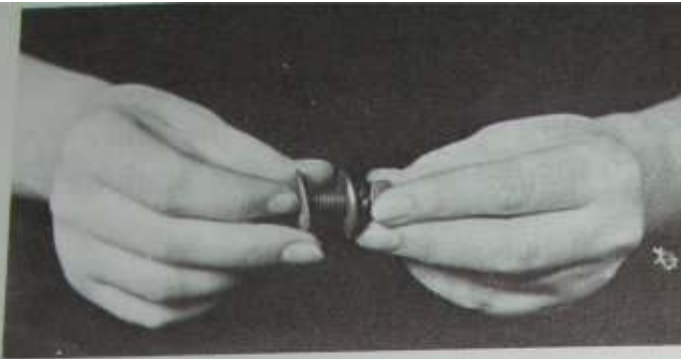


Figure 109 Bolt and washer assembly: A, special rubber washer; B, flat steel washer; C, lock washer; D, $\frac{3}{8}$ -inch \times 1-inch bolt.

Figure 110 The hole in the rubber washer is slightly smaller than the outside diameter of the bolt so that when the bolt is forced through the hole it is gripped, thus preventing the washers from falling off the bolt.

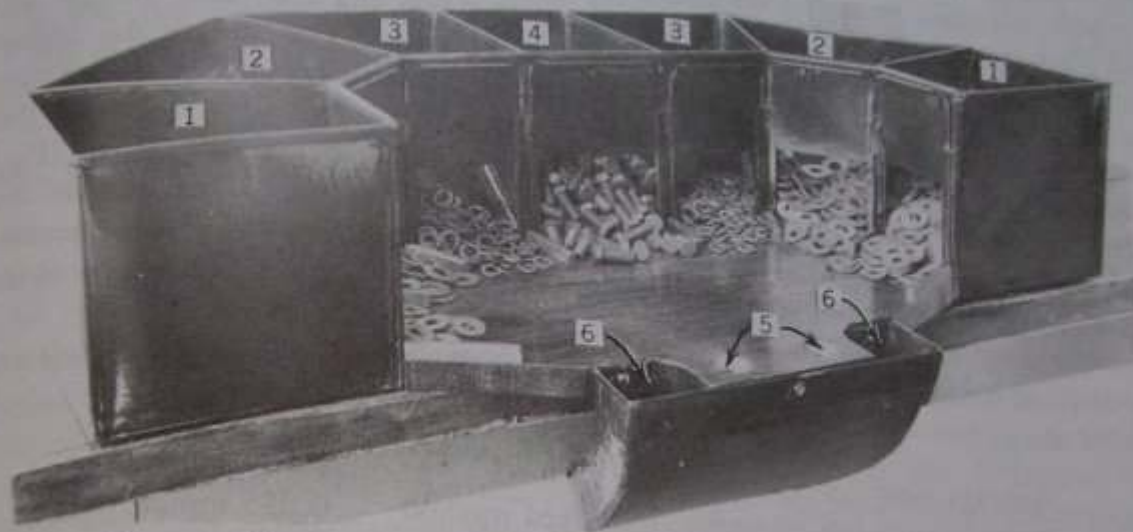


Figure 111 Bins, fixture, and chute for bolt and washer assembly.

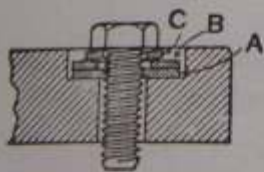


Figure 112 Enlarged view of recess in wood fixture for assembling bolt and washers: *A*, rubber washer; *B*, steel washer; *C*, lock washer.

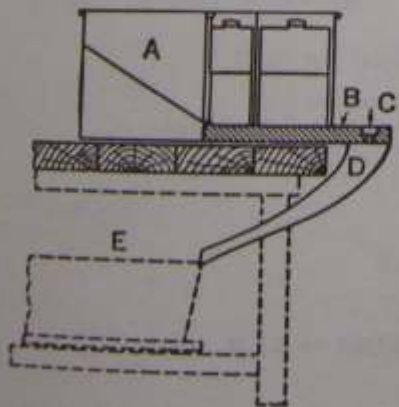


Figure 113 Cross-section of bins showing chute for drop delivery: *A*, bins with sloping bottom; *B*, top of fixture; *C*, countersunk holes in top of fixture; *D*, chute; *E*, container for finished assemblies.

[Bolt & Washer Example]

- Average time per assembly, old method 0.084 min
- Average time per assembly, new method 0.055 min

- Time saved 0.029 min
 - Increased in output = 53%

- Increase in Output in Percent

$$\frac{\left[\begin{array}{l} \text{Pieces produced} \\ \text{per min, new method} \end{array} \right] - \left[\begin{array}{l} \text{Pieces produces} \\ \text{per min, old method} \end{array} \right]}{\left[\begin{array}{l} \text{Pieces produced per min,} \\ \text{old method} \end{array} \right]}$$

As Related To The Use Of The Human Body

4. Hand and body motions should be confined to the lowest classification with which it is possible to perform the work satisfactorily.

Table 9. Physiological Costs of Two Different Methods of Handling Brick

Operator	Method A Major Body Bending								
	Energy Expenditure in Calories per Minute				Heart Rate in Beats per Minute				
	Number of Bricks Moved per Minute				Number of Bricks Moved per Minute				
	16	22	28	34	16	22	28	34	
1	5.4	5.7	6.8	8.5	102	104	109	131	
2	5.4	6.8	7.9	10.2	110	126	134	155	
3	5.3	6.8	8.5	11.7	102	113	126	159	
Average	5.4	6.4	7.7	10.1	105	114	123	148	
	Method B Minor Body Movements								
	1	2.8	3.1	3.3	5.8	92	92	92	113
	2	2.3	2.6	3.3	3.8	100	97	107	109
	3	2.5	2.7	3.0	3.8	90	97	97	95
Average	2.5	2.8	3.2	4.5	94	95	99	106	

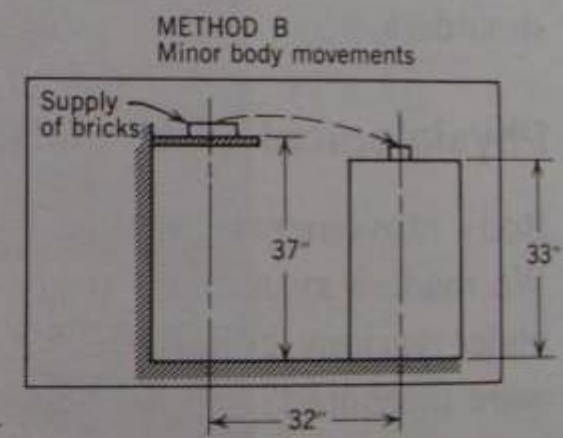
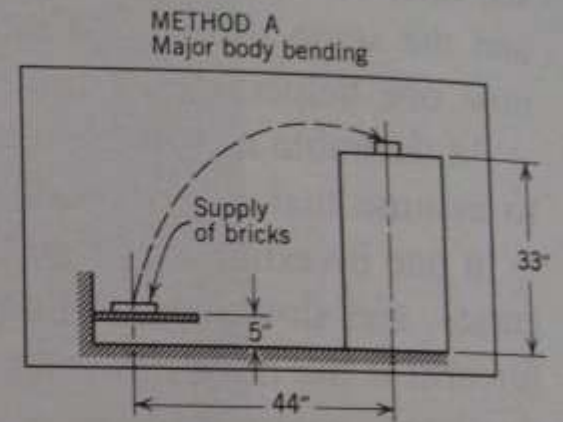
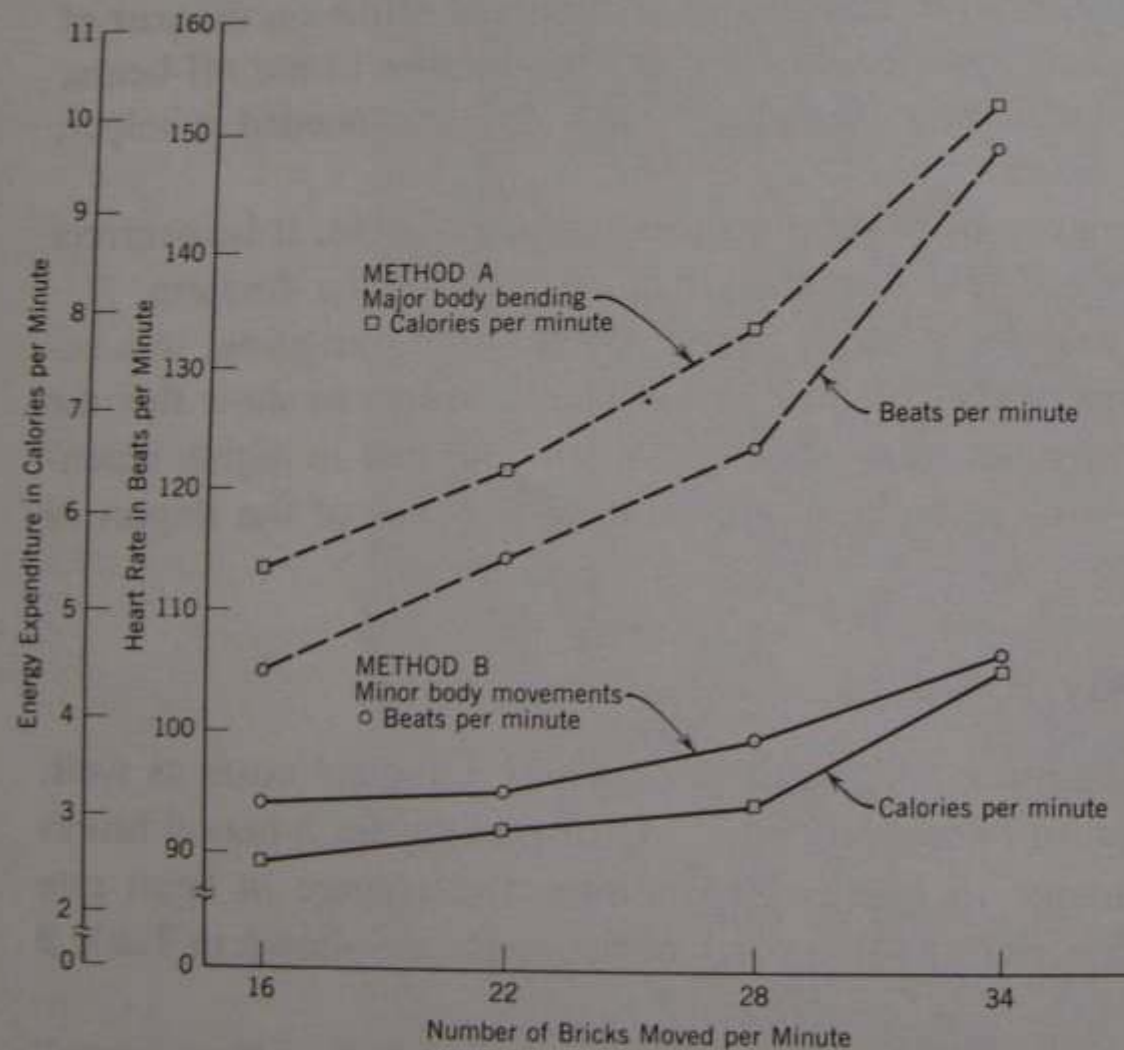


Figure 122 Physiological cost of two different methods of handling brick. Method A, major body bending; Method B, minor body bending.

As Related To The Use Of The Human Body

5. Momentum should be employed to assist the worker whenever possible, and it should be reduced to a minimum if it must be overcome by muscular effort.
6. Smooth continuous curved motions of the hands are preferable to straight-line motions involving sudden and sharp changes in direction.

As Related To The Use Of The Human Body

7. Ballistic movements are faster, easier, and more accurate than restricted (fixation) or “controlled” movements.
8. Work should be arranged to permit easy and natural rhythm wherever possible.
9. Eye fixations should be as few and as close together as possible.

As Related To The Work Place

10. There should be a definite and fixed place for all tools and materials.

11. Tools, materials, and controls should be located close to the point of use.

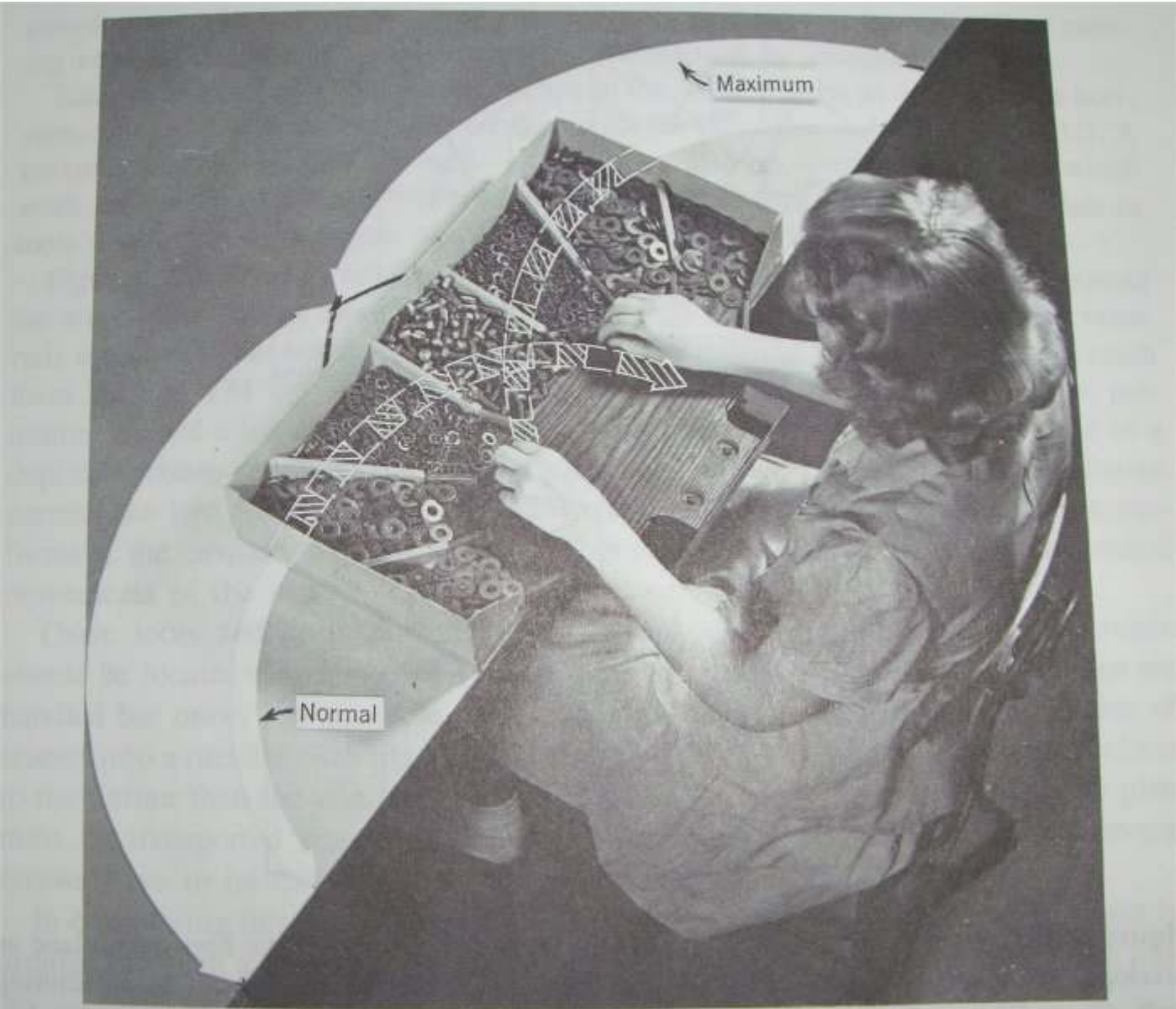


Figure 130 Normal and maximum working areas in the horizontal plane.

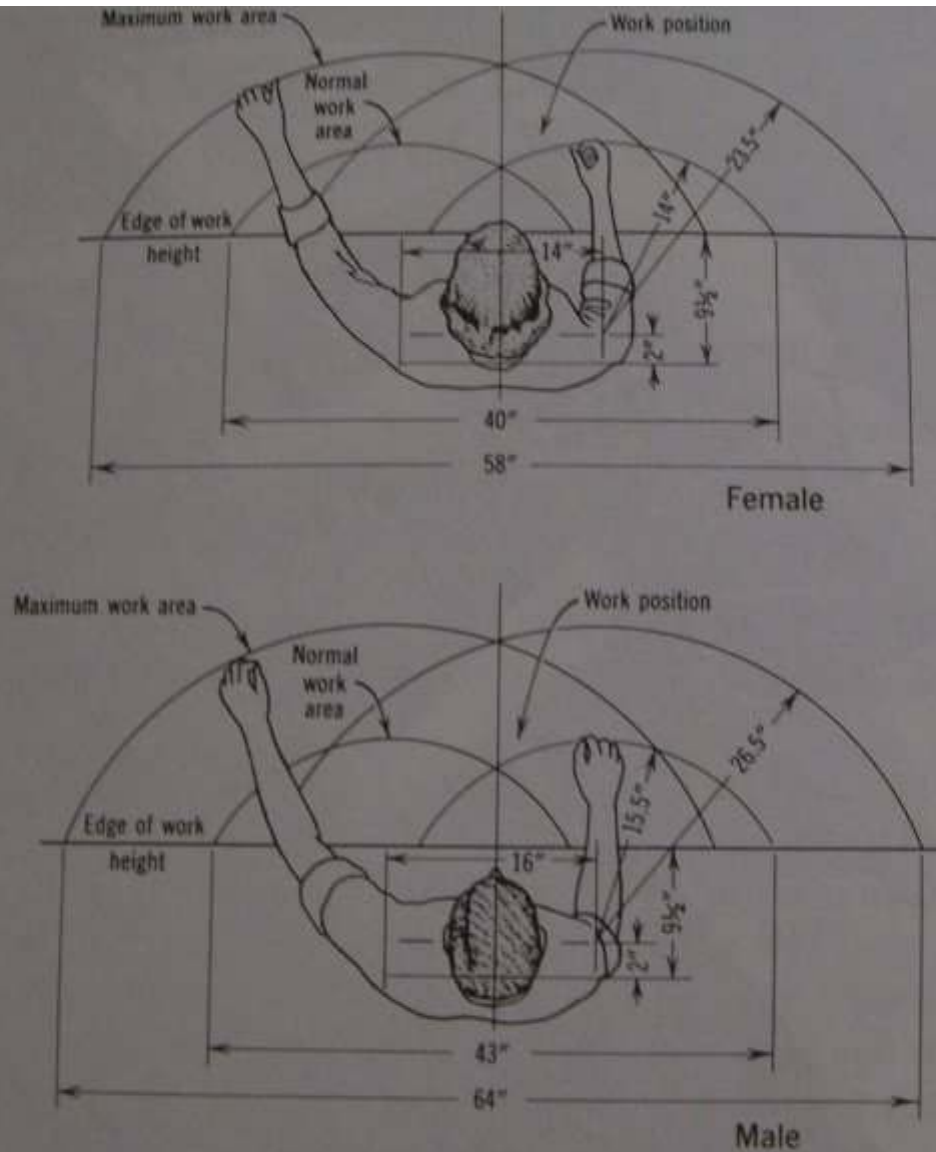


Figure 131 Dimensions of normal and maximum working areas in the horizontal plane as developed and used by the Process Development Section of the General Motors Manufacturing Staff. (From Richard R. Farley, "Some Principles of Methods and Motion Study as Used in Development Work," *General Motors Engineering Journal*, Vol. 2, No. 6, pp. 20-25.)

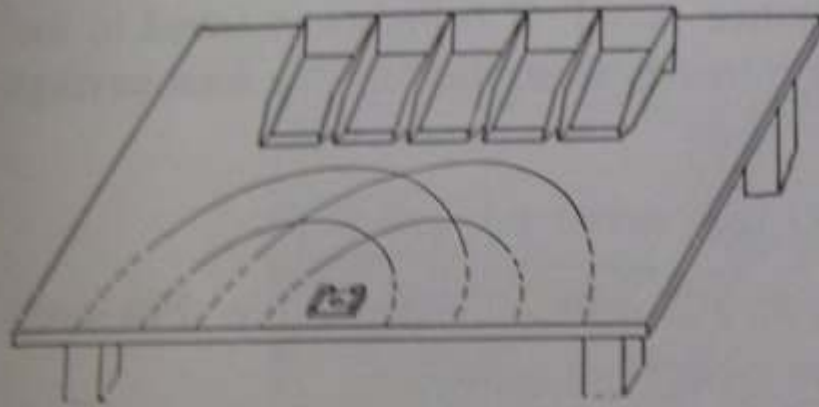


Figure 133 Incorrect work-place layout. Bins are located too far from the assembly fixture. The operator must bend forward to get the parts from bins.

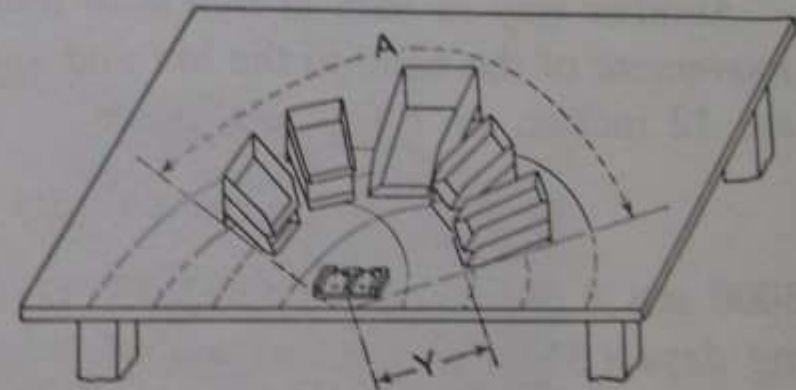


Figure 134 Correct work-place layout. Bins are located close to the fixture. In many kinds of work the eyes must direct the hands. In such cases the work area should be located directly in front of the operator so that eye fixations will be as few and as close together as possible. Angle A should be as small as possible, and distance Y should be as short as the nature of the work will permit.

As Related To The Work Place

12. Gravity feed bins and containers should be used to deliver material close to the point of use.



As Related To The Work Place

13. Drop deliveries should be used whenever possible.
14. Materials and tools should be located to permit the best sequence of motions.
15. Provision should be made for adequate conditions for seeing. Good illumination is the first requirement for satisfactory visual perception.

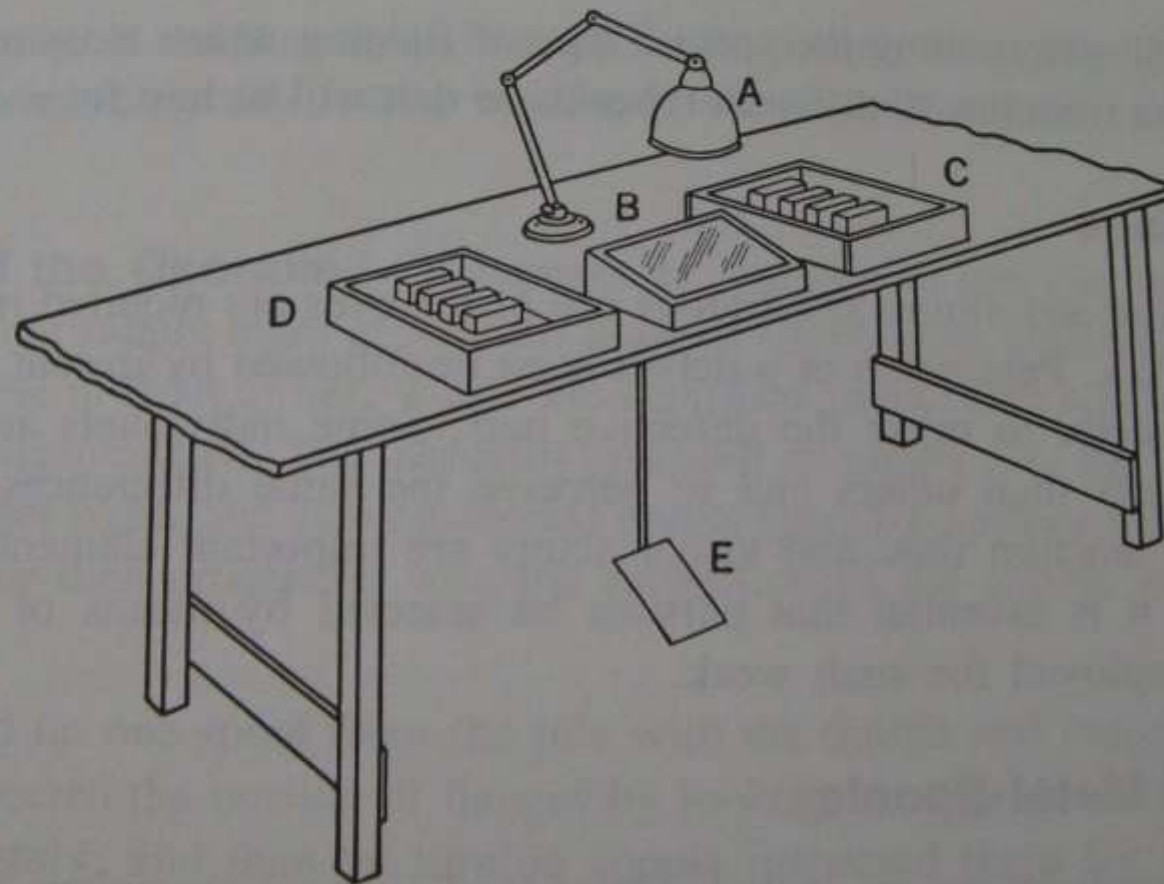


Figure 139 Improved lighting unit: *A*, adjustable lamp for direct light; *B*, background light; *C*, finished work; *D*, work awaiting adjustment; *E*, foot-operated switch for adjustable lamp

As Related To The Work Place

16. The height of the work place and the chair should preferably be arranged so that alternate sitting and standing at work are easily possible.

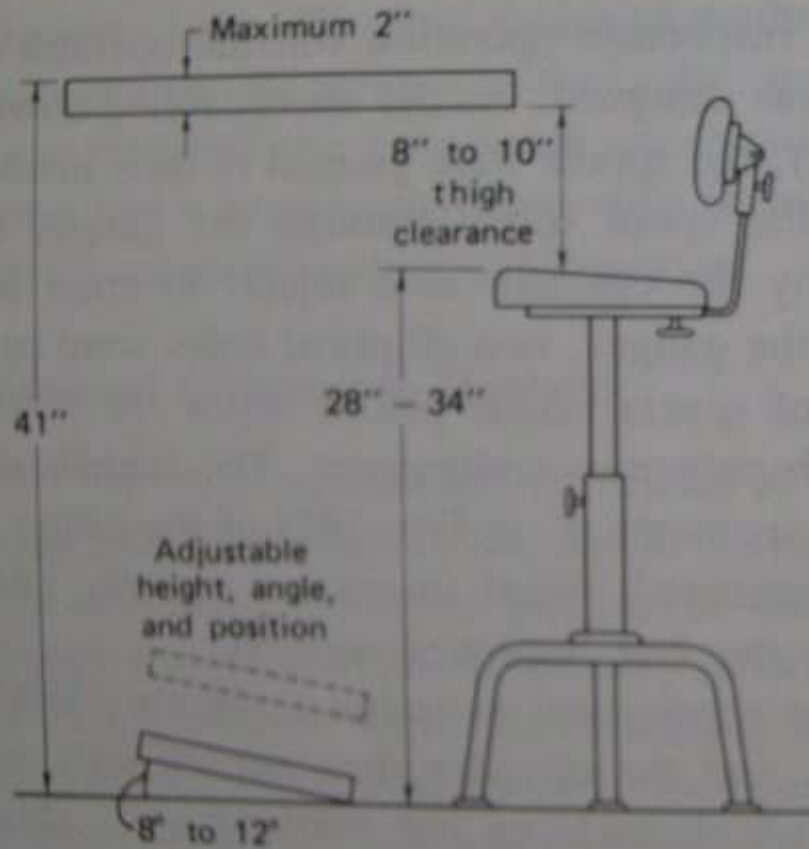


Figure 143 Sitting-standing work place for males.

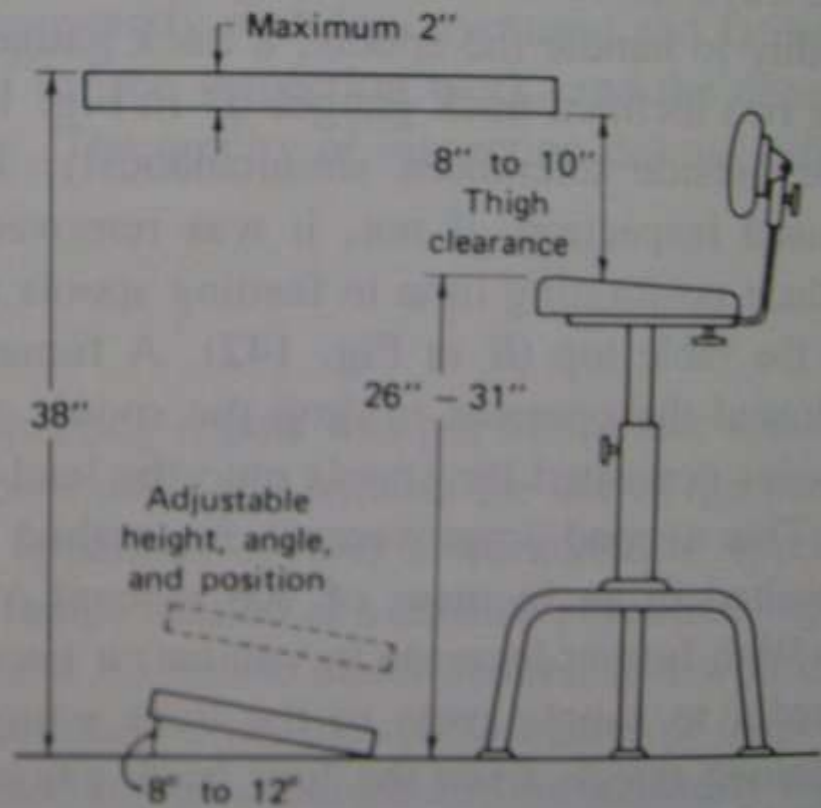


Figure 144 Sitting-standing work place for females.

As Related To The Work Place

17. A chair of the type and height to permit good posture should be provided for every worker.

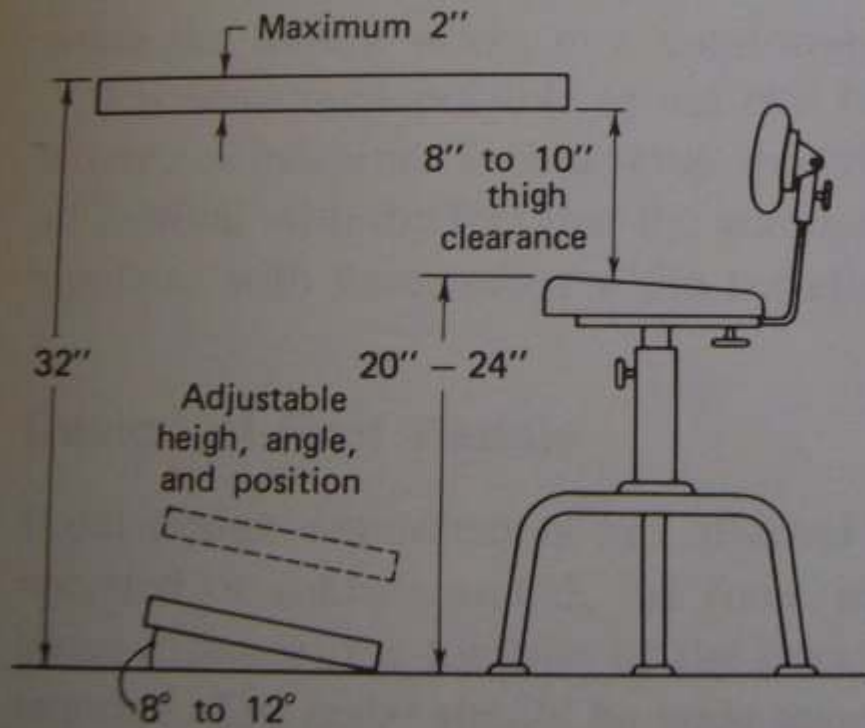


Figure 146 Sitting work place for males.

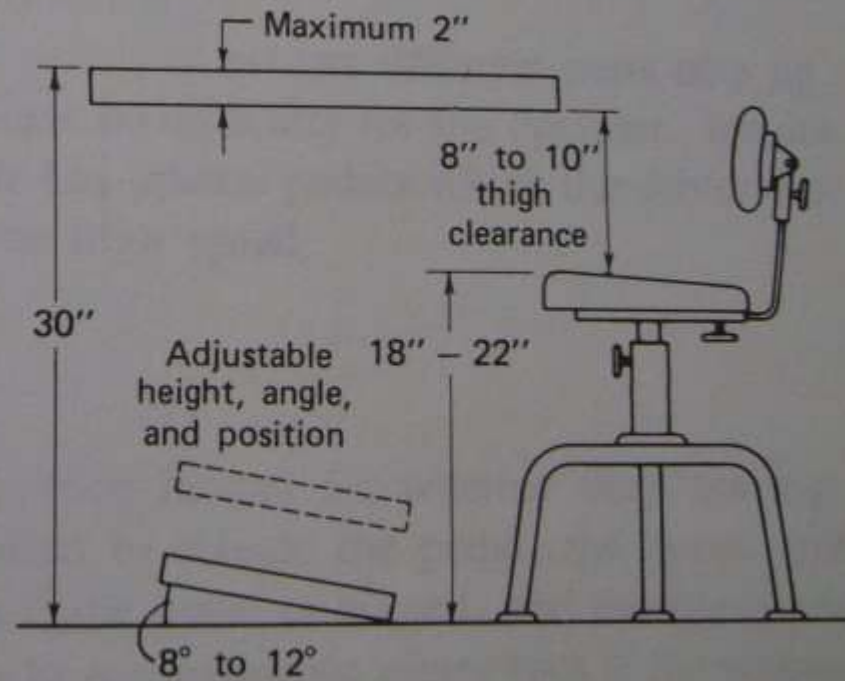


Figure 147 Sitting work place for females.

As Related To The Design Of Tools And Equipment

18. The hands should be relieved of all work that can be done more advantageously by a jig, a fixture, or a foot-operated device.
19. Two or more tools should be combined wherever possible.

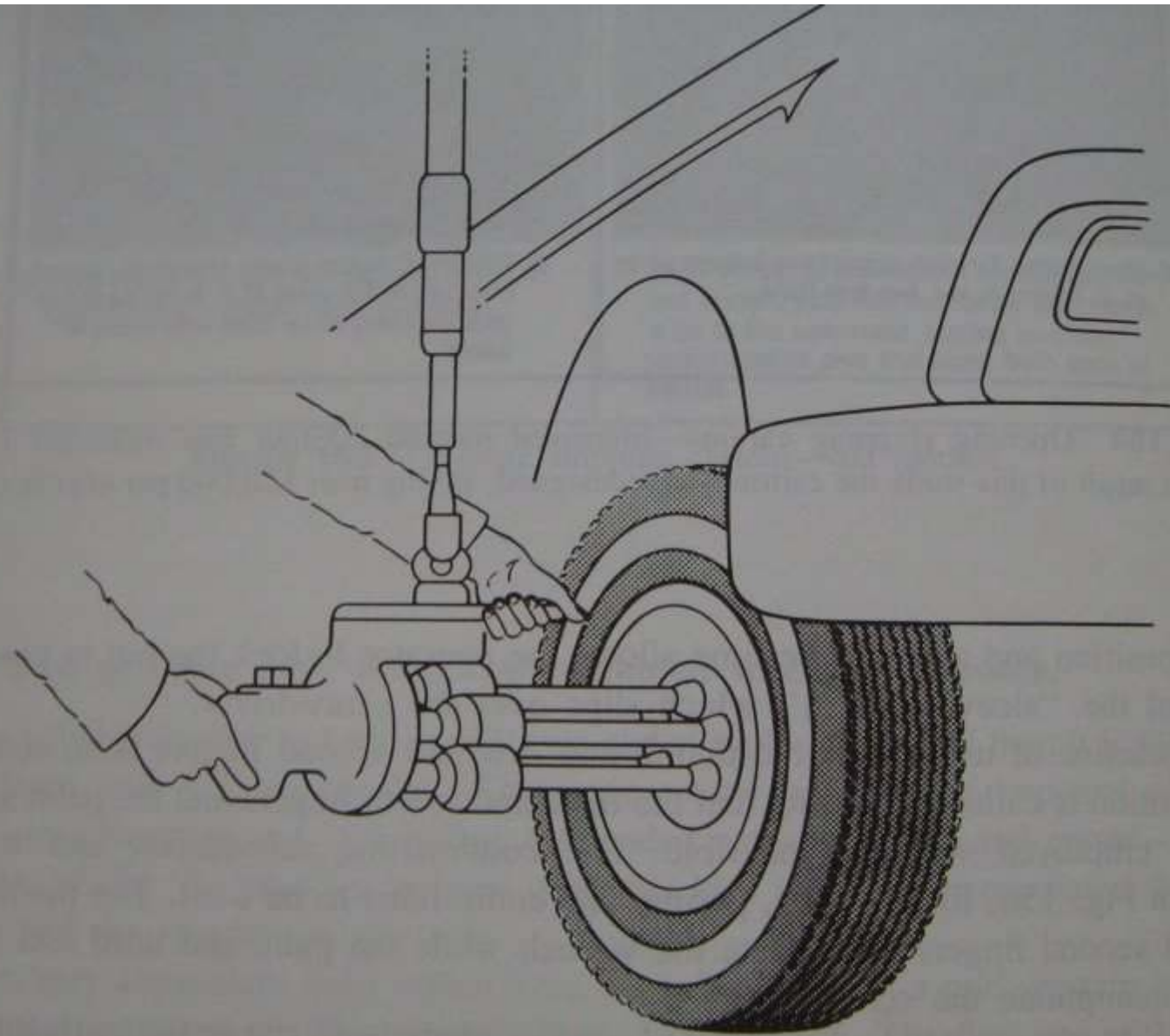


Figure 157 Multiple-spindle air-operated nut runner can tighten all five wheel nuts at once.
(Courtesy Ford Motor Company.)

As Related To The Design Of Tools And Equipment

20. Tools and materials should be positioned whenever possible.
21. Where each finger performs some specific movement, such as in typewriting, the load should be distributed in accordance with the inherent capacities of the fingers.

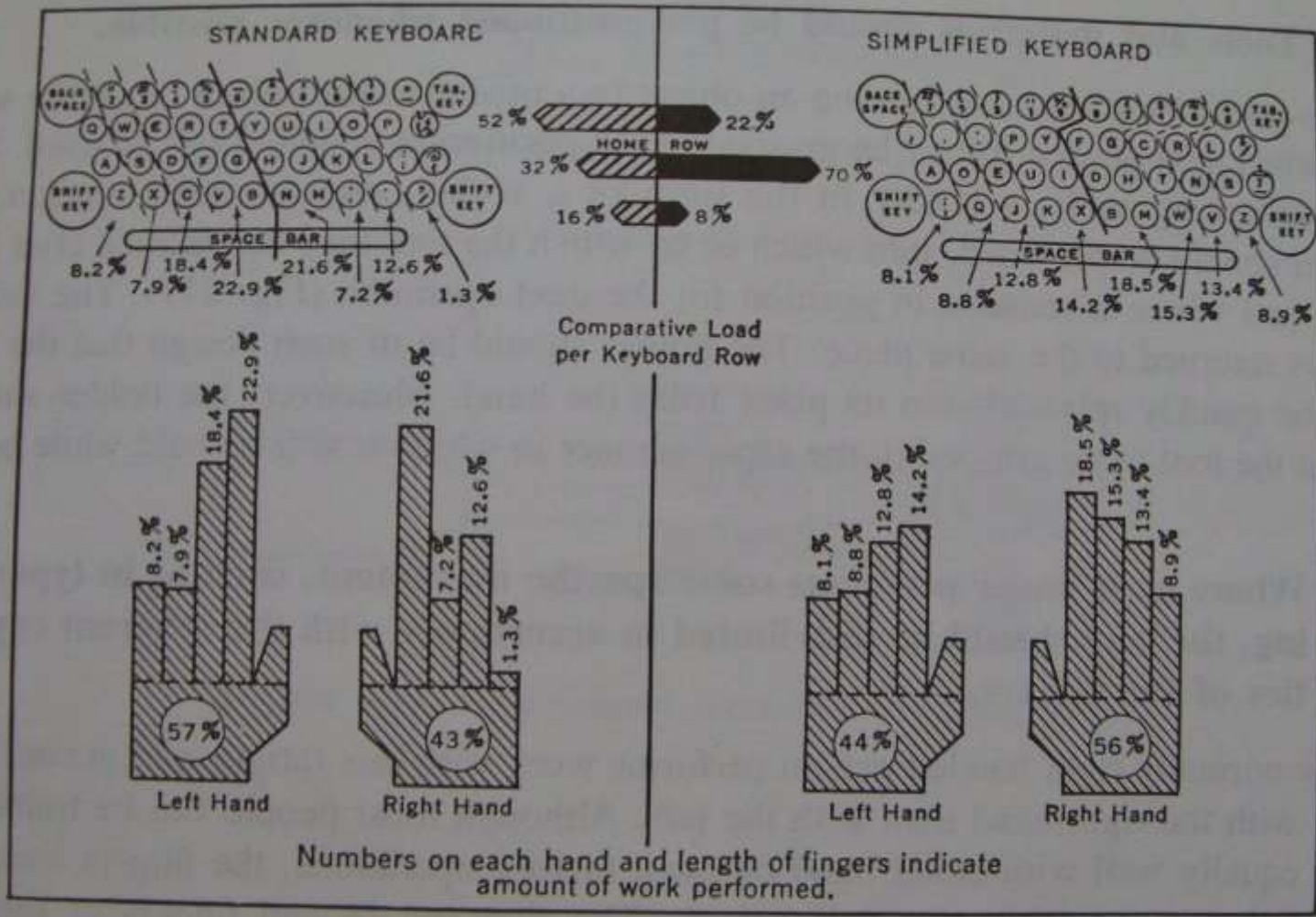


Figure 158 Comparison of standard typewriter keyboard with simplified keyboard. Figures indicate comparative loads for each row, hand, and finger. The new keyboard at the right has the letters rearranged so that the right hand carries its share of the load. Seventy percent of the commonly used words are written on the "home row" where the fingers are placed.

As Related To The Design Of Tools And Equipment

22. Levers, hand wheels and other controls should be located in such positions that the operator can manipulate them with the least change in body position and with the greatest speed and ease.