

## Chapter 13

# Principles of motion economy

### 13.1 Introduction

In the previous chapters, we have seen how method study helps us to identify the unwanted movements around the workplace, thereby improving productivity. These unwanted movements we identified cover mostly the transportation of goods, tools, etc. as well as the overall body movements. However, if you closely observe the operative working in sitting position, you will realize that there are several finer movements of the individual body parts like hands, fingers, etc. which are performed unwantedly and unknowingly. These could be eliminated to achieve total reduction in the work content.

### 13.2 Basic body movements per Frank Gilbreth

Frank Gilbreth was the first to study these movements or motions during 1880 while observing a brick layer's operations. Later he refined these principles and applied them to find quicker and more efficient means of assembling and disassembling small arms in US Army.

Gilbreth named these as motion economy principles which form a set of rules and suggestions to improve the manual work in manufacturing and help to achieve productivity and reduce physical exertion of an operative at the workstation at micro or sub-micro level and eliminate wasted movements of the body parts, ease operator tasks, reduce fatigue and minimize work stress. Paragraph 13.5 explains and illustrates these therbligs further.

### 13.3 Categories of motion economy principles

During the 1930 Ralph M. Barnes codified these principles which are still valid and gave some analytical explanation to these Gilbreth's principles in his book, *Principles of Motion Economy - Some More Details*.

He broadly classified the principles of motion economy into four groups:

1. Principles related to the use of human body,
2. Principles related to the arrangement of the workplace,
3. Principles related to the design of tools and equipment,
4. Principles related to time conservation.

### 13.3.1 Principles related to the use of human body

1. The two hands should begin 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.
4. Hand motions should be confined to the lowest classification with which it is possible to perform the work satisfactorily.

These hand motions can be further categorised as

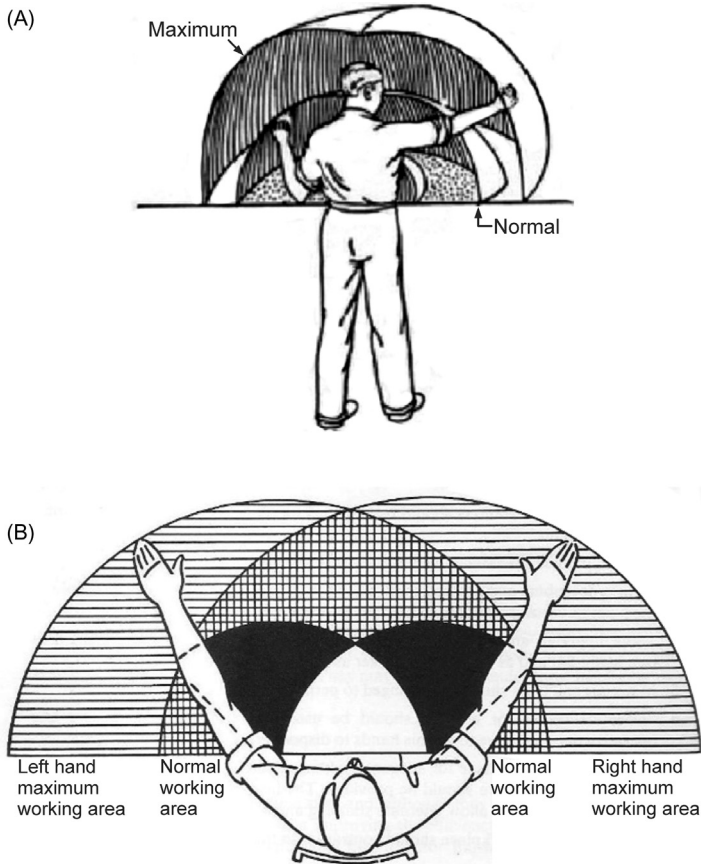
5. Momentum should be employed to assist the worker whenever possible, and it should be reduced to a minimum if it must be overcome by muscular effort.
6. Smooth continuous motions of the hands are preferable to zigzag motions or straight-line motions involving sudden and sharp changes in direction.
7. Ballistic (i.e. free swinging) movements are faster, easier, and more accurate than restricted or controlled movements.

### 13.3.2 Principles related to the arrangement of the workplace

1. There should be a definite and fixed place for all tools and materials.
2. Tools, materials, and controls should be located close in and directly in front of the operator.
3. Drop deliveries should be used whenever possible.
4. Materials and tools should be located to permit the best sequence of motions.
5. Arrange the height of the workplace and chair for alternate sitting and standing, when possible.
6. Provide a chair of the type and height to permit good posture with adequate lighting.
7. The color of the work place should contrast with that of the work and thus reduce eye fatigue.

Fig. 13.1 gives two illustrations of the minimum and maximum distance to which the operative can stretch the hands comfortably with least strain. While diagram alongside indicates the perspective view of the hand movement limitations, diagram below indicates the plan of the same. The work area should be so designed to locate all the tools and parts between the minimum and maximum distances to facilitate the easy picking up by the operator (Tables 13.1 and 13.2).

Fig. 13.2 illustrates the arrangement of the worktable for assembly of small components like screws, nuts and washers to be located in sliding chutes. While Fig. 13.2A shows, an optimal gravity based small component holder and feeder, as explained in point. No 6 of the principles related to the design of tools and equipment, Fig. 13.2C shows how a retractable screw driver can be located in the work area, within the reach of the operative.



**FIGURE 13.1** Maximum and minimum reach area at a worktable. *From Principles of work study - courtesy ILO.*

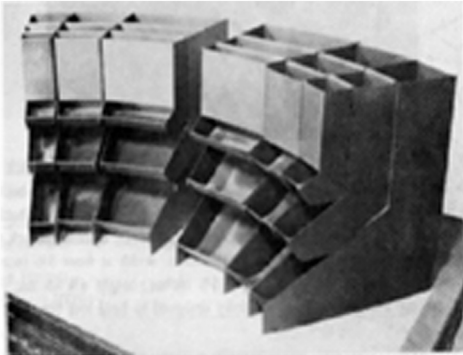
**TABLE 13.1** Categories of hand motions.

Class	Pivot	Body members moved
1	Knuckle	Finger
2	Wrist	Hand & fingers
3	Elbow	Forearm, hand & fingers
4	Shoulder	Upper arm, forearm, hand & fingers
5	Trunk	Torso, upper arm, forearm, hand & fingers resulting in disturbance of the posture

**TABLE 13.2** Effective and ineffective basic motions.

Effective	Ineffective
Reach	Hold
Move	Rest
Grasp	Position
Release load	Search
Use	Select
Assemble	Plan
Disassemble	Unavoidable delay
Pre-position	Avoidable delay
	Inspect

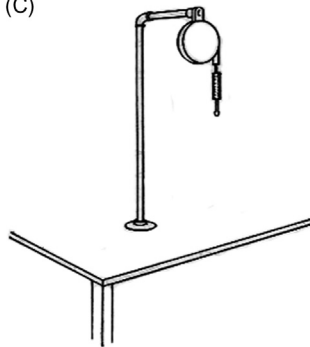
(A)



(B)



(C)



**FIGURE 13.2** Optimal work area for an assembly operation. *From Principles of work study -courtesy ILO.*

The central diagram Fig. 13.2B illustrates the optimally designed work place facilitates effective assembly operation

### 13.3.3 Principles related to the design of tools and equipment

1. Combine tools whenever possible.
2. Preposition tools and materials.
3. Where each finger performs some specific movement like while typing, the load should be distributed in accordance with the inherent capacities of the fingers.
4. For light assembly, a screwdriver handle should be small and light.
5. Momentum should be used to help the worker in doing their task not to increase their task, like using drop deliveries or ejectors where possible.
6. Levers, switches, and other machine controls should be so placed to use them with the least change in the posture and position

The following are some of the motion economy devices which should be optimally located.

- (i) Stops, which enable simultaneous working of locating and operating
- (ii) quick-acting Clamps
- (iii) Ball joint or Swivel fixtures
- (iv) Hinged fixtures
- (v) Air cylinder devices
- (vi) Rotary assembly fixtures
- (vii) Hoppers and motion economy bins
- (viii) Removable table tops
- (ix) Chutes and other drop delivery systems
- (x) Foot pedals

### 13.3.4 Principles related to time conservation

- Even a temporary delay of work by a man or machine should not be encouraged.
- Machine should not run idle, it is not desirable that a lathe machine is running and its job is rotating but no cut is being taken.
- Two or more jobs should be worked upon at the same time or two or more operations should be carried out on a job simultaneously if possible.
- Number of motion involved in completing a job should be minimized.

## 13.4 Limitations of motion economy principles of Gilbreth

Motion economy principles have the following limitations.

- They do not account for physical limitations or differences in operators.

- A movement that appears ineffective from a motion economy perspective may prevent fatigue and possible injury from static posture loading, coming in way of a rationalized design procedure to ensure a productive, safe, and optimum workstation.

### 13.5 Therbligs

As an extension of the development of the above motion economy principles, Gilbreth identified 18 finer movements of the body. He classified and named each of them, as illustrated in Fig. 13.3. He called them a therbligs spelled in the reverse of his own name. Most of the definitions on therbligs cite Gilbreth's name as the developer of this term. Basically, Therbligs are the basic building blocks of virtually all manual work performed at a single workplace and consisting primarily of hand motions.

Originally in an article published in 1915, Frank Gilbreth wrote of 16 elements which are as illustrated in Fig. 13.3. He later added two more,

- Find (sl. No. 2) and
- Plan (sl. No 17).

Each therblig represents time and energy spent by a worker to perform a task. If the task is repetitive, of relatively short duration, and will be performed many times, it may be appropriate to analyze the therbligs that make up the work cycle as part of the work design process.

With some modification, these basic motion elements are used today in a number of work measurement systems, such as Methods Time Measurement (MTM) and the Maynard Operation Sequence Technique (MOST), which are discussed in detail in the next chapter.

### 13.6 Effective and ineffective classification of basic motion elements

These basic motions can be classified into 2 groups,

- The effective elements include the motions that do the primary work
- The ineffective elements include the motions that do not perform the basic work, but provide the secondary motion with a supportive role.

### 13.7 Objectives of therbligs

1. Eliminate ineffective therbligs if possible
2. Avoid holding objects with hand, by using work holders where possible.
3. Combine therbligs by performing right-hand and left-hand motions simultaneously
4. Simplify overall method
5. Reduce time for a motion, e.g., shorten distance



















S.No	Therblig	Symbol	Abbr	Explanation	Colour
1	Search		Sh	Starts when eyes or hands or both begin to search and ends on locating.	Black
2	Find		F	Mental reaction after search	Gray
3	Select		Sl	Choosing one item among the lot	Light gray
4	Grasp		G	Taking hold of the item	Red
5	Hold		H	Prolonged grasp of the item	Gold Ochre
6	Transport unloaded		TE	Moving an empty hand for reaching an item	Olive green
7	Transport loaded		TL	Moving an item from one place to another	Green
8	Release load		RL	Releasing the item at the desired place	Carmine red
9	Assemble		A	Putting parts together into an integral part	Violet
10	Disassemble		DA	Separating one item from an assembly	Light violet
11	Use		U	Causing the device to perform its function	Purple
12	Inspect		I	Examine or test the size etc.	Burnt ochre
13	Position		P	Placing an item at a definite location	Blue
14	Pre-position		PP	Placing an item ready for use. The symbol signifies positioning in a fixture without holding	Pale blue
15	Un avoidable delay		UD	Delay beyond the control of the operator	Yellow
16	Avoidable delay		AD	Delay within the control of the operator	Lemon yellow
17	Plan		Pn	Mental action to plan how to proceed further	Brown
18	Rest		R	Take rest or pause to overcome fatigue	Orange

FIGURE 13.3 Therblig.

### 13.8 Some definitions of therbligs

Most of the definitions below refer to the therbligs being founded by Gilbreth, as explained in para 13.5.

*Therbligs are some of the manual, visual, or mental elements into which an industrial manual operation may be analyzed in time and motion study.*

Merriam Webster Dictionary.

*Therbligs are 18 Kinds of Elemental Motions used in the study of Motion economy in the workplace. A workplace task is analyzed by recording each of the therblig units for a process, with the results used for optimization of manual labor by eliminating unneeded movements.*

<https://www.scribd.com>.

*The term therblig can be used to classify the motions of fingers, arms, hands, or the activity of the body as a whole.*

<http://thediagram.com>.

*Therbligs are the smallest units of work, developed by Frank Gilbreth, to develop ways to decrease unnecessary motion in several fields,*

<https://hubpages.com/>.

*Therbligs are a set of fundamental motions required for a worker to perform a manual operation.*

Wiktionary.

*Therblig is the smallest unit of productive motion, as analyzed by early 20th century motion engineer, Frank Gilbreth.*

<http://polymathsolution.com>.

*Therbligs are the unavoidable and avoidable elements of movement found by Gilbreth, in the inversion of his name Preventable delay, planning, resting and holding. The Therbligs allow the analyst to synthesize the presenting times of manual activities synthetically as a building block system.*

Springer Gabler.

*A unit of motion, at times, utilized to depict and document industrial functions for the purpose of time and movement analyzes.*

Psychology Dictionary.

## 13.9 Conclusion

As discussed in this chapter, if the body movements are studied, analyzed and improved by the application of motion economy principles, fatigue and unnecessary movements by the worker would be reduced leading to the reduction in the work-related trauma. This would automatically improve the operative morale and increase the output in manufacturing. We have also seen how the concept of representing each motion by symbols aids the analysis and improvement.

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### Criteria questions

1. What do you understand by motion economy principles? (13.2)
  2. Explain the broad categories of principles of motion economy. (13.3)
  3. What parts of the body can be moved with trunk as the pivot? (13.3)
  4. Explain what you understand by Maximum and minimum reach area at a work table. (13.3)
  5. Sketch a rough layout of the table for the assembly of a screw with 2 washers and a nut, based on principles of motion economy. (13.3)
  6. What are therbligs? How did they get the name? (13.5)
  7. What are the objectives of therbligs? (13.5)
  8. What is the difference between. . . . . (13.5)
    - a. Grasp and hold
    - b. Avoidable delay and Unavoidable delay
    - c. Position and Pre-position
  9. Assemble and Disassemble
  10. What are effective and ineffective body motions? (13.6)
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### Further reading

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