TABLE 3 Summary of MTM-1 Motion Elements

Motion Element (Symbol) and Description
Reach (R): A basic motion element involving movement of the hand or fingers. Its purpose is to move the hand or finger to a new destination. The corresponding therblig is "transport empty." If the hand is holding something during the motion, it is still classified as a reach if its primary purpose is to reposition the hand or fingers and not to move the object—for example, reaching for an object while holding a cigarette. Reach depends on two work variables: (1) the distance moved and (2) the case under which the reach is performed. The case refers to such factors as whether the reach is toward an object in a known location or the object is jumbled amongst other objects and must be searched out. The five cases are identified in Table 4 (a), which provides time values as a function of distance and case. If the hand is in motion before and/or after the reach, then the time is reduced slightly, as indicated in the table under "hand in motion" for cases A and B. The complete symbol for a given reach element in MTM-1 includes the distance and the case (e.g., R10C).
Grasp (G): A motion element used by the fingers and hand to gain control of one or more objects. It is commonly employed as a prerequisite motion for performing the next basic motion, which is likely to be a move—for example, grasping an object prior to moving it. There are five categories of grasp: (1) pickup, (2) regrasp, (3) transfer, (4) select, and (5) contact. Within the pickup and select categories, there are several cases that must be distinguished. Table 4 (b) defines the various categories and cases and lists the times for them. The complete symbol for a grasp includes category and case (e.g., G1C3).

Move (M): A hand or finger motion whose primary purpose is to relocate an object. The corresponding therblig is "transport loaded." The move element includes pushing or sliding an object across a surface, so long as the hand controls the object. Move depends on three work variables: (1) the weight of the object being moved, (2) the distance of the move, and (3) the case under which the move is performed. There are three cases, as described in Table 4 (c). The weight variable is divided into classes, and the user selects the next higher weight given in the table for the object weight in the given application. The complete symbol for move includes the distance, case, and weight—for example, M6B10 symbolizes a move of 6 in. under case B for an object weight of 10 lb. The following formula must be used to determine the TMU value from Table 4 (c):

$$\text{TMU} = \text{Constant} + \text{Factor} \times (\text{TMU value from table})$$

where Constant is the constant value from the table for the object weight in the application, TMU; Factor is the factor value from the table for the object weight; and (TMU value from table) is the TMU value from the table for the corresponding distance of the move and the move case. For example, given the symbol M6B10, the formula would be used as follows:

$$\text{TMU} = 3.9 + 1.11(8.9) = 13.8 \text{ TMU (about } \tfrac{1}{2} \text{ sec)}$$

Position (P): A relatively short hand motion (no greater than 1 in.) employed to align, orient, or engage one object relative to another. It is usually preceded by a move. ***Align*** refers to the relative positioning of longitudinal axes of the objects; ***orient*** refers to the relative positioning of rotational axes of the objects; and ***engage*** refers to the insertion of one object into the other following either an alignment or an orientation. Accordingly, the position element may occur several times together depending on the number of separate positioning moves required. The work variables that affect the time for a position motion are the following: (1) pressure required to achieve the fit, (2) symmetry of the objects, and (3) ease of handling. Pressure to achieve fit is divided into three categories: loose (class 1), close (class 2), and exact (class 3). Symmetry is also divided into three categories: symmetrical (S)—for example, a round peg in a round hole; nonsymmetrical (NS)—for example, a key inserted into a lock; and semisymmetrical (SS), which is any case between S and NS. Ease of handling is simply divided into easy (E) and difficult (D). The categories are listed in Table 4 (d) along with the time to perform the element. The complete symbol for a position includes the three work variables (e.g., P3NSD).

Release (RL): A hand and finger motion element whose purpose is to surrender control of an object. There are only two cases of release: (1) the fingers open to effect the release and (2) contact release with no finger motion. The complete symbol for release identifies the case (e.g., RL1 or RL2). Times are given in Table 4 (e).

Disengage (D): A hand and finger motion that causes the separation of two objects from one another, where the objects were previously held together by some force. Thus, disengagement breaks the force, resulting in a recoil action by the hand. The work variables that affect the time of a disengage motion are (1) class of fit and (2) ease of handling. Classes

of fit are loose (slight effort required, class 1), close (normal effort, class 2), and tight (considerable effort, class 3). Ease of handling is either easy (E) or difficult (D). The disengage symbol indicates the two variables (e.g., D3E). Times are given in Table 4 (f).

Turn (T): A basic motion element that involves rotation of the hand and wrist about the long axis of the forearm. The hand can either be holding an object (e.g., turning a dial on a machine) or empty. Turn depends on two work variables: (1) the degrees of turn and (2) resistance to the turn. Table 4 (g) lists the time values as a function of these factors. The maximum turn in the table is 180°, which is imposed by the anatomical structure of the elbow and forearm. Resistance to turn is indicated by force of resistance, divided into three categories in the table. The complete symbol for turn includes both variables; for example, T90L symbolizes a turn of 90° and a large resisting force.

Apply pressure (AP): An MTM-1 element that involves the application of force, but the force results in little or no movement. The force is usually applied by the hand and/or fingers, but the element applies to a force applied by any body member. There are two categories of apply pressure: (1) apply pressure alone (APA) and (2) apply pressure preceded by a regrasp (APB). Time values for these two cases are given in Table 4 (h).

Eye travel (ET), **eye focus (EF)**, and **reading**: Basic eye usage motions that are important enablers for performing manual work. However, the effect of the eyes during a motion element is usually accounted for in the tabulated TMU values. For example, a reach motion that requires greater hand-eye coordination takes longer; for example, compare Case C and Case A in Table 4 (a). On the other hand, there are situations when eye travel and/or eye focus are prerequisites for subsequent motions. In these cases, they must be counted as separate basic elements. Times for the two basic eye usage motions are given in Table 4 (i). In addition, MTM-1 uses a normal time for reading text as 5.05 TMUs per word. Thus, reading a 200 word paragraph would be allowed 1010 TMUs (about 36 sec).

Body, leg, and foot motions: Additional basic motions that involve moving the body, one or both legs, and/or one or both feet. The motions include walking, bending, stooping, standing from a seated position, and sitting from a standing position. These activities are distinct from those performed at a workbench, most likely with the worker in a sitting position. These elements and others are identified in Table 4 (j), together with their symbols and normal times.

Simultaneous motions: Basic motion elements that are performed at the same time. In general, it is desirable for more than one body member to be moving simultaneously. For example, it is desirable for both the right hand and left hand to be active during the task, not only sequentially but also simultaneously. When basic motion elements can be combined simultaneously, the time required for the combination is the greater of the two parallel motions. This is called the "limiting principle," which was first proposed by the original developers of MTM (Maynard, Stegemerten, and Schwab, Historical Note 1). Certain combinations of motions are more difficult to perform simultaneously than others. The degrees of difficulty can be classified as follows: (1) easy to perform simultaneously, (2) can be performed simultaneously with practice, and (3) difficult to perform simultaneously. Table 4 (k) indicates the degree of difficulty for various combinations of basic motion elements. In degrees of difficulty (1) and (2), the limiting principle applies, assuming sufficient practice is allowed for the worker in (2). In degree of difficulty (3), both times should be added.