Functional Utility Of Visual Information Supporting Instructions For Actions: An Exploratory Study

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Table of Contents

List of Tables

List of Figures

List of Appendices

Appendix page:

Table:

Table:

Table:

Acknowledgments

Two roads diverged in a yellow wood,
And sorry I could not travel both
And be one traveller, long I stood
And looked down as far as I could ....
.... And I took the one less travelled by,
And that has made all the difference.

-- R Frost --

I dedicate this manuscript to Christ my Lord and dearest friend.

I would like to thank Dr. Dean H Owen for his patience through out this project, for his expertise and guidance which attuned me to the relevant information to complete this thesis. Thank You to all the people who participated as subjects. I also would like to acknowledge Dr. S Kemp for the statistical advice and the Psychology department for recognising the will of motivated individuals.

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The aim of this study was to explore the functional utility and effectiveness of arrows presented as specificational information for conveying proceduralised instructions and facilitating learning. A further objective was to investigate the effectiveness of a picture of depicting the final form of the assembled object and step-by-step pictorial instructions on performance during a novel and proceduralised task. It was hypothesised that the presence of a picture of the goal, the picture-text, and picture-text-arrow instructional formats would facilitate superior performance on the proceduralised tasks. Subjects were required to assemble and then test a prototype product termed the CPM unit, from a set of proceduralised instructions. Nine different instructions manuals were assessed. Each manual comprised a different combination of informational elements. Ninety-nine subjects were randomly assigned to one of the nine instruction manual conditions. Seven performance categories were devised to explore the scope of functional utilities and the type of specificational information a picture of the goal, step-by-step instructional pictures and arrows potentially carried. The results showed that a pictorial representation of the assembly goal was a primary source of information which facilitated superior assembly performances. This was also found for step-by-step pictures instruction. The results validated the superiority of picture-text instructional format over a text-only instruction format. Evidence was found to suggest that arrows carry functional and specificational information when presented with a picture-text instructional format. These findings and their implications were discussed in relation to the field of instructional research and education.

INTRODUCTION

The opening sections of the introduction reviews of the current literature to human error. The relationship between the precursor(s) of an error and human activity will be reviewed with reference to information in the environment. The acquisition of information and its relation to action and the consequences of these actions are also reviewed. The introduction concludes with a review of the literature concerning instructions or sets of information designed to communicate concepts, facilitate actions or problem solving; the emphasis here will be placed on the value of visual information in an instructional context. The literature review will critically examine boundaries and limitations inherent in the knowledge base for proceduralised instructions and hence, highlight the need for the current study.

Human Error

A human error can be defined as an event that is counter-productive to a person's private intentions or goals (Park, 1987; Rasmussen, 1986; Reason, 1987, 1990). From a cognitive perspective errors are viewed as a result of failure at the information-processing stage (Norman, 1981, 1988; Reason 1987, 1990). From a behavioural perspective errors are viewed as a result of failure to perform a prescribed act (error of omission) or the performance of a prohibited act (error of commission) within a given system (Hagen & Mays, 1981; Lewis, 1981; Meister, 1971). These descriptions suggest that human errors or errors in general are the end product of a long chain of events leading to an unintended result and in some cases, adverse consequences (Larson & Merritt, 1991; Rasmussen, 1986; Reason, 1990; Wagenaar, Hudson & Reason, 1990).

Norman (1981) distinguished two basic types of errors: a) slips; and b) mistakes. A slip was categorised as an incorrect execution of a correct plan. It was suggested that a slip could be discovered if it was monitored and corrected at a point when the operation begins to deviate from the intended plan (Norman, 1981, 1988; Rasmussen, 1986; Wagenaar et al., 1990). A mistake was categorised as the correct execution of a wrong plan. A mistake is more difficult to discover and correct as the execution usually matches the plan. It is the consequences of the activity which reveal that the plan has resulted in an unintended result or adverse consequence. This classification of errors suggests that human errors are defined with reference to a standard of correctness or a predetermined or desired end (Lewis, 1981). In order to understand the concept of *human error* it must, therefore, be discussed in terms of a theory which takes account of, or is in reference to human characteristics, i.e., the human environment and human goals (Reason, 1987; Rasmussen, 1986).

Psychologists concerned with the human-machine interaction agree that humans are not simple deterministic input-output mechanistic organisms. Rather, as goal-oriented organisms, humans actively both select their goals and the relevant information, and search of the means by which to achieve them (Bruce & Green, 1990; Gibson, 1966, 1979; Lombardo, 1987; Owen, in press; Rasmussen, 1986; Reason, 1990). Purposive behaviour, however, depends upon a complex sequence of activities which requires control in relation to the environment and to the goal. Rasmussen (1986) believed that a meaningful interaction between humans and their environment depended "upon the existence of a set of invariate constraints in the relationships among events in the environment and between human actions and their effects" (p. 100). That is, the laws which govern the human person in his or her environment will generally constrain their actions. The relationship between the individual and his or her environment with reference to purposive behaviour was viewed in the following manner: a) In familiar situations human activity will be oriented toward the goal and controlled by a set of rules or solutions which have been used, successfully, in the past. b) In unfamiliar situations human activity may be goal-controlled in the sense that to achieve a goal a number of solutions are attempted either physically, by way of trial and error, or as internal representations.

Human Activity

Rasmussen (1983) distinguished three levels of performance in human activity: a) skill-based; b) rule-based; and c) knowledge-based level of performance. Although the three levels were conceptualised as an interactive model of performance control, the performance levels were also arranged in a hierarchical manner. The skill-based behaviour was conceptualised as the lowest level of performance for which control is required and the knowledge-based behaviour the highest level.

At the skill-based level, behaviour is viewed as controlled automatically by the stored patterns of pre-programmed instructions or behaviours. At the various stages of the activity the automatic progress is monitored. The performance remains at the skill-based level if the activity matches the pre-programmed patterns. "It is characteristic that skilled performance rolls along without conscious attention or control. The total performance is smooth and integrated, and sense input is not selected or observed - the senses are only directed toward the aspects of the environment needed to update and orient subconsciously the internal map. The man looks rather than sees" (Rasmussen, 1983, p. 100). However, performance is passed on to the rule-based level if a discrepancy between the activity and pre-programmed pattern is discovered.

At the rule-based level, problems are identified through a process of pattern recognition. If the problem is a familiar one then the activity will be controlled by a stored solution or procedure. These patterns may have been derived from previous experiences, person-to-person communication, instructions or by conscious problem solving and planning. The solutions or programmed activity are activated by an *if-then* rule, whereby, if a certain problem arises then a pre-programmed pattern of behaviour will be activated to control performance. Activation of this behaviour pattern will lead to successful removal of the problem. The activity is, therefore, goal-oriented but controlled by a feed-forward pattern of behaviour through a stored set of rules (Rasmussen, 1986). If the rule-based level eliminates the problem then performance is passed back to the skill-based level. If the rule-based level fails to solve the problem or results in a complex, unfamiliar situation (novel problem), then performance may be passed to the knowledge-based level.

At the knowledge-based level, solutions are derived on the basis of full understanding of the factors which caused the problem. Knowledge of the current situation combined with rules established from previous encounters are used in order to solve the problem. A goal is, therefore, explicitly formulated. However, performance at the knowledge-based level functions on feedback rather than the feed-forward control as the individual has exhausted his or her repertoire of problem solving routines and is forced to resort to attentional processing within the conscious workspace.

Reason (1990) combined Rasmussen's (1983) control model with Norman's (1981) error classification to identify three types of errors. Reason (1991) claimed that the key distinction between the skill-based versus rule- and knowledge-based levels of performance was whether or not an individual was engaged in a problem solving activity. Rasmussen's (1983) description of the skill-based level of performance implied, however, that it involved non-problematic activities. Reason (1990) further claimed that the rule- and knowledge-based level of performance are only activated when a problem is recognised or encountered. It can be argued, therefore, that slips, by nature, occur at the skill-based level and precede detection of a problem, while mistakes occur either at the rule- or knowledge-based level of performance during an attempt to find a solution (Reason, 1990).

Attention As Precursors To Errors

A limited amount of performance control is required at the skill-based level. This implies that slips at the skill-based level are mainly caused by monitoring failures (Reason, 1990; Wagenaar et al., 1990). For example, an accident may result from an individual not attending to the brake lights flashing on the car in front while driving, which in turn may lead to an accident. Reason (1984, 1987) claimed that the occurrence of a slip is distinguished by the presence of attentional capture whereby, either distractions or pre-occupations cause either monitoring failure or the current activity to be overridden by a more dominant pattern of performance (Norman, 1988). This distraction or preoccupation has caused the individual to allocate the necessary attention for the problem elsewhere. Due to the performance control demands at the rule- and knowledge-based level, I suggest that some *mistakes* are not caused by inattention to the task at hand but result from over-attention or selectivity (Neisser & Becklen, 1975; Reason, 1990). In this respect, the individual focuses his or her attention on a specific aspect of the problem. This selective focusing on the part of the individual may result in aspects of the problem being ignored or considered irrelevant, when in fact they were central to the problem at hand (Wagenaar et al., 1990).

Perception As Sensitivity To Meaningful Information

Gibson (1966, 1979) proposed that when an organism searches through its environment to achieve a goal, the organism must know what the relevant information is for that particular intention or goal. Gibson claimed that this knowledge can be learned. Thus, the organism is capable of discovering variables of stimulation in the optic array which are not only specific to relevant environmental properties and to the goal, but are also invariant across other perspectives and situations. Gibson (1979) also claimed that these invariants are important meaningful to the organism in order to support life, to the extent that complementarity of the animal and the environment exists. The relationship between the organism and the environment, however, is of the kind where the organism depends on the environment for life. Gibson (1979) further postulated that the complementarity nature of the relationship between the individual and his or her environment, precludes that the behaviour of the individual also depends on the perception of his or her environment, and thus on the information acquired from the environment.

Gibson's (1979) alternative approach to visual perception was based on the invariant relationships available to an individual in the optical array. Gibson re-defined the concept of perception as an act which involved an individual being *sensitive to* (Turvey, Shaw, Reed & Mace., 1981) information in the environment with reference to an action. The information actively acquired from the environment is meaningful (Hagen, 1986), in other words has an 'act-on-able' properties for the individual (Gibson, 1979). I suggest that Gibson's approach to perception can be viewed as being consistent with information theory, which defines *information* as the reduction of uncertainty (Bharath, 1987; Sanders & McCormick, 1987, Shannon & Weaver, 1964). Thus, information contains meaning due to certainty or invariance; for example, the perception of symbols to aid actions, which is a prominent feature of human activity (Loveland, 1991). The notion of perception as the 'pick-up' of meaningful information (Gibson, 1979), however, stands in opposition to an individual being 'just aware' of the available information. An indiviudal who is just aware of infomration may not find it meaningful and thus, the available information is not perceived and utiliesed to aid action (Fodor & Plylyshyn, 1981; Lombardo, 1987). However, Gibson's (1979) account of information *pick-up* implies that perception occurs by means of meaningful information or the acquisition of meaningful information.

Affordance Theory

Gibson (1979) attempted to explain the relationship between information available in the environment, perception and action by introducing the concept of affordance. According to Gibson, affordances represent an invariant set of information which exist in the environment and is relevant to an individual's purpose. Affordances provide information which allow actions or behaviours in relation to an individuals intention because information is determinate or is specificational (Kugler & Turvey, 1987), furthermore, it has been argued that they can be perceived directly (Gibson 1966, 1979; Michaels & Carello, 1980). For example, glass affords 'seeing through' and for 'breaking', both affordances are potentially present depending on an individual's intention. Although Gibson (1979) maintained that affordances could be directly perceived, it has been suggested that this does not eliminate the possibility of mediated or aided perception of affordances (Bruce & Green, 1990; Zaff, 1989), through, for example, pointing (Hester, 1977). In addition, the acquiring of skills by which to obtain meaningful information from the environment in order to detect affordances may be advanced through practice (Cutting, 1982; Owen, in press, 1991), and learnt behaviours (Rabbitt, 1984; Rasmussen, 1986). Gibson (1979) coined these types of perception 'second-hand' perceptions. However, he believed that most of our day-to-day perception is of a direct nature.

Rasmussen (1986) believed that affordances can be perceived through a process of *direct attunement* (learnt behaviours) which is related to the conditioning of the neural system as represented by the internal dynamic world model. Rasmussen's (1983) model of human activity delineated that the neural representation of an individual's internal dynamic world model is one which underlies skill-based performance. Rasmussen's (1986) notion of affordance perception through direct attunement, therefore, implies *second-hand* that perception occurs during the learning process of detecting a particular affordance. It is my contention, however, that once an affordance is learnt via the process conditioning, a similar affordance can be perceived directly. This also implies that an affordance, regardless of how it was perceived, relates perception to action (Bruce & Green, 1990; Neuman, 1990), because affordance detection represents the means of selecting the appropriate actions in order to achieve a goal (Rasmussen & Vicente, 1989).

Gibson's (1979) contention regarding the direct perception of affordances is incompatible with the mediated process of direct attunement or the second-hand perception of affordances. The incompatibility, however, presents us with a distinction between: (a) *Information or clues that support actions* (affordances); for example, a frozen lake affords walking across if the ice is thick enough; an underpass, affords passage underneath if it is adequately elevated or the vehicle is low enough. (b) *Information or clues that convey affordances;* for example, watching an adult bear run across the frozen lake conveys the affordance that the ice is thick enough to support a person walking across it; or watching an average truck reversing from and under pass and make a detour because it cannot pass under a bridge.conveys the affordance that the bride is too low to support a double-decker bus passage.

Information Specifying Affordances

Gibson (1979) argued that information in the world was constant and specifies an observer's environment, thus, information potentially exists in the environment and is determinate regardless of its perception. The meaning of the acquired information, however, is dependent on the individual's goals or intentions. I suggest, therefore, that an individual may be aware of existing information without recognising its direct relevance to an action. For example, a person who intends to cross a frozen lake after watching an adult bear cross the lake, may not realise that an adult bear is heavier than him or herself. In turn, therefore, the individual may not recognise the significance of the bear's action in relation to his or her own own intention to cross the lake, namely, that the bear's action affords him or her to cross the lake in the same area of the lake. Likewise, the double-decker bus driver who intends to drive through an underpass after watching an average truck reverse from the same underpass and taking another route, but was distracted by a passangers question may not have been paying attention to the truck driver's action. In turn the bus driver may not realise the negative affordance of the underpass, namely it will cause damage to the top of the bus if he attempts to drive through the underpass.

Furthermore, I suggest that an individual's inability to recognise the relevance of information to an action (affordance) is more prominent when there is no well-defined goal or the individual is still in the process of selecting a solution. Gibson (1979) claimed that to perceive an affordance, the environment and the intention of the individual must be complementary, where the intention and environment will function as constraints and control for the selection of relevant information. It can be argued, therefore, that the function of relevant information or affordances is to bridge the gap between an individual's intention or goal and the action to achieve the goal. The fundamental nature of information as a facilitator for the achievement of a goal or intention has been widely recognised (Heckhausen & Gollwitzer, 1986; Mace, 1974, 1977; Michaels & Carello, 1980; Norman, 1988; Turvey et al.; 1981; Vinter, 1990; Watt, 1991).

Based on the theoretical frameworks, as outlined above, I suggest that the use of affordances to select the means or actions for obtaining an intended goal can be extended to a problem solving situation. For example, individuals are often faced with a problem solving situation where an intended goal is clearly defined but the means to achieve the goal are not. In this situation, unless the individual is able to bridge the gap between the intended goal and the means to achieve it, he or she may not be able to solve the problem. It is my contention that instructions or *'proceduralised information'* which is *designed* to communicate or convey specific behavioural objectives are information which support actions, information in the specificational sense (Gibson, 1979) or relevant information which are necessary to bridge the gap between intention and solution. In other words, "Instructions can be viewed as action descriptions', (Watt, 1991, p. 13), because the information conveyed in the instructions can determine actions if followed correctly. I suggest, therefore, that instructions or information which conveys specific messages can be contrasted with information which is indicational/injunctional and incomplete (Kugler & Turvey, 1987). Kugler & Turvey (1987) provided the example of a sign which indicated a state of affair, namely "road work ahead" as an information set which is indicational/injunctional and incomplete as it does not provide enough detail about the road work ahead. It is my contention that the sign "road work ahead', attunes or cautions drivers to the fact that there is some type of road disturbance ahead, but it does not specify how the driver should be cautious or the actions he or she should take. The sign, therefore, attunes an individual to the road works and the fact that he or she will have to take some kind of action.

According to Kugler & Turvey (1987), Gibson's (1979) conception of specificational information is close to Thom's (1975) conception of information as geometric form. He believed that, "Any geometric form whatsoever can be the carrier of information, and in the set of geometric forms carrying information of the same type, the topological complexity of the form is the quantitative scalar measure of the information (Thom, 1979, p. 145). In other words, Thom believed that geometric forms contains some specificational information. Although geometric forms may be construed as indicational/injunctional (i.e., incomplete or non-specificational) in Gibson's (1979) account of specificational information, by virtue that some forms require the individual to acquire its higher-order structures within a meaningful context to be of value to the individual (Loveland, 1991). However, I suggest that some geometric forms may also be carriers of specificational information which specify or attune individuals to affordances (Gibson, 1979; Norman, 1988), e.g., a door handle in the shape of the letter 'L' and placed on the opposite side of a hinged door, specify that it can be graspped, twisted and pulled.to facilitate opening the door (Norman, 1988, p. 89).

Errors As Misperceived Information or Affordances

Gibson (1966, 1979) acknowledged the fact that deficient perception also occurs. Affordance theory asserts that if, "information is picked up perception results; if misinformation is picked up misperception results" (Gibson, 1979, p. 142). If misperception occurs in relation to action then the 'act-on-able' properties of the environment that an individual perceives will not be relevant to the task. An individual may detect an affordance that is not there (Zaff, 1989), or one which leads to unintended actions or ill consequences, for example, an individual may not perceive the affordance of clear glass and attempt to walk through a closed glass door (Gibson, 1979).

The failure to pick up meaningful information may be due to the inadequacy of the information set that the individual is faced with, or an individual's inability to select the relevant information from the set (e.g., from a book) or the environment (Gibson, 1966). The literatures (Norman, 1988; Reason, 1984, 1987, 1990; Sanders & McCormick, 1987; and Wagenaar et al., 1990) suggests that the failure to pick up meaningful information may be a result of over-attention or lack of attention. An individual may also fail to perceive an affordance because the individual failed to detect a relationship between the available information and an intended action (Zaff, 1989). This in turn may lead to an error of omission or commission. It is my contention that failures in attention, detection of affordances or misperceptions can be reduced if individuals are attuned to the relevant information necessary for the task at hand.

Compatibility Of The Visual System, Information, and Action

Current research suggests that out of the five sensory modalities, the visual system is the most salient in the control of action (Bruce & Green, 1990; Gibson, 1966 & 1979; Mark, 1987; Rabbitt, 1984; Turvey, 1977; Watt, 1991; Zaff, 1989). Cutting (1986, 1987) suggested that when an individual is faced with a situation where more than one information source is available the visual system generally dominates in selecting relevant information. Furthermore, when information is acquired via two external attention modes, vision is usually one of them (Cutting, 1987). Gibson (1979) has given an account of the ecological approach to visual perception in which he highlighted the important relationship between available information, perception through the visual system and action. Based on the above review, I suggest that novel, purposive action and goal-oriented action largely depends on the visual system for control. This dependency is to the extent that failure to acquire task relevant visual information from the environment may lead to errors or unintended actions which sometimes leads to negative consequences. The dominant and purposive nature of the visual system (Cutting, 1987; Rabbitt, 1984; Watt, 1991) suggests, however, that human activity may be aided through visual information in the environment which directs individuals to relevant information or affordances (Gibson, 1979; Norman, 1988; Sanders & McCormick, 1987) which lead to the desired, i.e., positive consequences. Braby, Kincaid, Scott & McDaniel (1982) claimed that most proceduralised tasks were highly visual, involving the action of locating objects, manipulation of controls and tools and the act of checking for feedback. Furthermore, I suggest that the high demand on the visual modality in order to perform a proceduralised task in an unfamiliar situation presents a situation where *compatibility* between available information and human activity can be achieved.

Information theory defined the concept of *compatibility* as the relationship between stimuli and responses to human expectation (Sanders & McCormick, 1987). Information can be said to be compatible if it reduces uncertainty or conveys the message in a manner or mode which an individual expects. It is my contention that in order to achieve compatibility, a task which requires high attunement from the visual system requires information presentation that is rich in visual as opposed to auditory or tactile clues (Wickens, Sandry & Vidulich, 1983; Wickens, 1984a). I propose, therefore, that a task which requires a person to utilise his or her visual faculties would also attune a person to visual information to such an extent that information may be more readily perceived and the task efficiently executed due to the modal compatibility between the task and instructions. This suggestion is consistent with Owen's (1990) conclusion that detected, acquired information should be the same as the information utilised to control one's actions.

Information theory states, however, that the value of a message is a function of the number of message(s) presented divided by the amount of information(s) present (i.e., value of message = $^{\text{messages}}/_{\text{information}}$). Thus as the amount of information increases the probability of the message decreases (Shannon & Weaver, 1964). It is probable, therefore, that when two or more possible sets of information are conveyed and compete for the same perceptual resource, the message may be interfered with or disrupted thus reducing the clarity of the message (Wickens et al, 1983; Wickens, 1984b). Research has shown, however, that the competition for perceptual resources can be decreased (i.e, interference reduced) in a *communication* situation when compatibility is increased (Keele, 1967; Ogden, Anderson & Reick, 1979; Wickens et al., 1983; Wickens 1984b) by highlighting or attuning the individual to relevant information rather than irrelevant information. Furthermore, I suggest that when individuals are faced with an unfamiliar problem solving situation, which requires solutions communicated from one person to another or written instructions, the problem will be solved more effectively if the information and the resources necessary for the tasks successful resolution are compatible. For example, a task with high-visual resource demand aided by visual information to the extent that the visual information is used to reinforce the specific actions individuals must perform (Brody & Legenza, 1980; Gropper, 1963), or visual clues which may stimulate motor programmes contained in an individual's motor programme repertoire (Zimmer & Englekamp, 1985).

It has also been proposed that illustrations serve assimilative functions when textual information is highly related to or dependent on illustrations (Hayes & Readence, 1983). In other words, illustrations provide readers with otherwise unavailable material for which they are able to construct an assimilative context between the text and its content. Within this assimilative context, reference points for thinking and action can be established by the reader; i.e., information specifying affordances.

Severin (1967a, 1967b) discussed the notion of cue summation and stimulus generalisations (which have originated from learning theories) as a model by which to present results concerning the learning process. Cue summation theory predicts that learning increases as the number of available cues or stimuli increases, to the extent that it optimises the message conveyed. Multi-channel communications which combine words with related or relevant illustrations will, therefore, provide the greatest gain of information because of the summation of cues between the channels. Results cited by Stone & Glock (1981) support the prediction that the use of related illustrations produces superior performance (accuracy) in a proceduralised assembly task. Stone & Glock found that optimal comprehension of the instructions they had given was attained in the text and illustration condition. In addition, this condition significantly reduced errors of orientation.

Cue summation theory may account for the results reported by Stone & Glock's (1981). However, the theory does not specify how the optimal comprehension was achieved. Stone & Glock argued, that the results of their study cannot be explained by the simple argument that additional information was present in the condition, "Since the information content of text and line drawings was designed to be completely redundant" (Stone & Glock, 1981, p. 425). Two alternative explanations were offered by Stone & Glock. The first explanation was that the presence of redundant information in the manual condition (text and line drawings) provided readers with alternate sources of information when either the text or line drawings required clarification. The second explanation argued that individuals differed in their ability to acquire or use information presented verbally or pictorially, thus the presence of alternative information allowed individuals the flexibility to select the most meaningful forms for their needs. Although Cue summation does not specify the processes involved with the acquisition of information from the visual channel, I suggest that Cue summation theory is still consistent with the notion that information conveyed by a series of messages is *additive* if: (a) there is no interference (i.e., the total amount conveyed by two messages is equal to the sum of the information conveyed by each of them, Bharath, 1987; Shannon & Weaver, 1964), or the messages do not contradict (Fleming, 1988); and b) the messages complement each other whereby one message can clarify information which is lacking in the other message (Stone & Glock, 1981), or the messages are consistent (Fleming, 1988). It is my contention that the arguments presented above regarding the additive property of information, are consistent with Haber's (1970) claim that there are different paths used in the comprehension of written text (verbal channel) and pictures (image channel). Whereby, the written text and pictures can be processed in a time-sharing manner (Haber, 1970) without interference during comprehension, because the two resource channels do not overlap (Wickens et al, 1983).

Picture Perception

Shannon & Weaver's (1964) account of information highlighted a significant aspect of message selection and perception, namely the actual message a receiver perceives is the one which is selected from a set of possible messages. The concept of selective attention plays a role in the process of communication whereby the receiver must choose or combine the varying forms of information to acquire the message (Cutting, 1987). Stone & Glock (1981), in order to explain the results of their study, proposed that subjects had perceived 'higher-order structures' or distinctive features in the text and illustrations which enhanced successful completion of the task. This explanation is consistent with Gibson & Levin's (1975) account of the way people read pictures and text via distinctive features or invariant information, and by ignoring irrelevant information. I suggest that Gibson & Levin's (1975) account of reading and Stone & Glock's (1981) theory concerning the perception of higher-order structures are consistent with James Gibson's (1966, 1971, 1977, 1979) theories concerning the detection of invariants; i.e., their pick-up or perception and affordances .

Central to Gibson's (1966,1979) theoretical postulations was the notion that perception occurs due to the acquisition of invariant structures in the optical array or environment. Gibson

(1971) proposed the idea that pictures or illustrations are carriers of optical information which can be attended to in two ways. A picture can be perceived as an entity in itself, i.e., a flat arrangement of lines and forms or as a representation of real objects or scenes. It was further proposed that pictures can be perceived as representations of real objects or scenes because of the informational equivalence contained in the picture (Hagen, 1974, 1980, 1986; Gibson, 1971; Siegel, 1978). Caricatures are good examples of pictures or illustrations possess in general, namely representational properties. Gibson (1971) suggested that caricatures depict a particular person, without duplicating or conforming with the point-to-point correspondence theories concerning the nature of the structural resemblance between the picture and the depicted entity. The optical array conveyed in the caricature, however, carries the same information which specifies or identifies the person portrayed. In other words, the optical array depicted in pictures and the optical array found in the natural environment may provide equivalent information without utilising the same stimulation (Gibson, 1971).

Ryan & Schwartz's (1956) study, in my opinion is an example of illustrations as carriers of optical information which are perceived via the acquisition of invariants or the depiction of distinctive features. Ryan & Schwartz found that *cartoons* facilitated subjects perception of objects depicted in the picture in a faster time than black and white photographs and point-to-point line drawings respectively. Although the ability to generalise these findings is constrained by the type and number of objects utilised, Ryan & Schwartz (1956) and Hagen (1974) agreed that it is possible for the speed of information acquisition to be increased when the relevant information depicted in pictures is accentuated or isolated. Pick (1965) investigated the notion of distinctive features in a learning situation and a subsequent transfer task . She found that subjects who had learnt the distinctive features of the materials in the learning sessions performed in a superior manner on the transfer task in comparison to subjects who learnt the materials using prototype or memory models. I suggest, therefore, that pictorial materials which are relevant to a task can be modified and utilised to accentuate certain aspects of the information depicted in the picture in order to facilitate learning, or aid the completion of the task.

Research Directions In The Instructional Utility Of Pictures

In 1984, Brody reviewed the current state of pictorial research within the field of instructional science. Brody highlighted the point that despite the considerable amount of research concerned with the various aspects of pictures and their instructional use, there is a dearth of information with regard to a clear conception of the instructional potential of pictures. Based on Brody's (1984) observation, I suggest that an inherent limitation underlining the knowledge base regarding the instructional utility of pictures is information concerning the communicative value of pictorial materials. The review of the literature thus far highlights the fact that the communicative potential of illustrations and the type of information an illustration affords the perceiver within an instructional and communication context has not been addressed. Brody (1984) claimed that the 'missing' information within the field of pictorial and instructional science has limited practitioners and designers in utilising effectively, pictures within the instructional process.

Few persons would deny that pictures can be used to simplify complex information or to provide specific examples of new concepts. Brody (1984) proposed that a functional approach to pictorial research may cull out a role for pictures which has not customarily been thought of as an appropriate application. For example, Brody proposed that pictures may serve the following representative instructional functions: a) motivating; b) controlling learner behaviours; c) providing a common referent; d) gaining attention; e) directing attention; and f) reviewing actions. Brody (1984) also pointed out that the emphasis of future research concerned with pictures should be the identification of those conditions which allow a picture to function in the manner intended. It is important then that the role of the picture within an instructional situation is determined prior to decisions concerning pictorial content. For example, if pictures play a central role (as opposed to a supporting role) in an instructional or communicative situation, then failing to inform a learner when to look at a picture in a text may result in the learner either ignoring the picture completely or looking at the picture at an inappropriate time. In both situations the failure to utilise the pictures appropriately may diminish the likelihood of the picture fulfilling its intended function. In conclusion to his review, Brody (1984) advocated that (a) the research must pay greater attention to the instructional role or function served by pictures, and (b) the potential functions must be described in terms of their contributions to instructional processes and procedures.

The Limitation Of Instructions In Instructional Or Problem Solving Situation

Simon & Hayes (1976) suggested that following instructions was one of the most difficult comprehension tasks encountered in daily life, since instructions and the problem solving context may not specify adequately the fundamental information or actions required to develop or find a solution. Similarly, Szlichcinski (1979a) described a 'problem-solving situation' as one which required a "cognitive activity for which the goal but not the means for obtaining it are initially specified" (p. 253). Miller & Johnson-Laird (1976) claimed that instructions in written text are translated into a routine (i.e., verbal mode), and thus it is necessary that instructions are designed to communicate new concepts or proceduralised information in an effective manner. Anderson (1987) asserted that a shortcoming inherent in instructions lies in the fact that they are often developed without reference to the procedural and problem solving context. This claim supports the assertion that procedural instructions cannot take account of all the factors in a situation (Broadbent, 1977; Szlichcinski, 1979; Wright, 1981). For example, people differ widely in their knowledge, expectations and perception of a situation. Furthermore, the situation itself may vary thus, no one can design solutions which would be optimal for all situations.

In addition to the problems associated with the development of instructions, Norman (1988) suggested that difficulty in dealing with a problem solving situation may be the nature of the problem in itself. In a novel situation where the individual is unfamiliar with the means by which to derive a solution for the problem (but has experienced previously a problem with similar properties; Rasmussen, 1983) a gulf between an individual's intention and goal may occur. Difficulties also occur whenever there is more than one solution to a problem. In both these situations the individual may use a strategy of trial-and-error in an attempt to discover the operations which may successfully solve the problem, albeit effective this strategy maybe inefficient (Rasmussen, 1983, 1986). If the problem is too complicated, however, the user may believe there are no alternatives and may not even know how to begin to solve the problem.

When Are Instructions Read?

Wright et al., (1982) investigated the relationship between the claims people make about reading instructions and age, attitude to, and characteristics of the product. Literate volunteers from a subject panel of the Applied Psychology Unit, Cambridge, indicated (by way of a questionnaire/Likert scale design) how they would respond to an instruction leaflet accompanying a new product. Wright et al. (1982) found that on 53% of occasions subjects claimed they would read *all* of the instructions and conversely, on 34% of occasions that they would read *none* of the instructions. An interesting finding was that people were more likely to claim reading all the instructions accompanying an electrical product than a non-electrical product. For example: 61% of the subjects claimed they would not read all the instructions for an electric kettle; 29.6% said they would *not* read the instructions for simple electrical products; and, 76.6% said that would read *all* the instructions for complex electrical goods. Product 'familiarity' and 'frequency of use' were, therefore, identified as contributing factors to a response of reading *none* of the instructions. Wright et al. (1982) proposed that product category and a person's attitude toward a product were two primary determinants of whether instructions would be read. Although personal attitudes and product category may affect a person's willingness to read instructions, It can be argued that the type of instructions introduces a number of problems in itself. The literatures (Szlichcinski, 1979b; Wright, 1981; Wright et al., 1982; Woodworth & Schlosberg, 1955), for example suggested that the information contained in instruction manuals may be lengthy, complicated, inaccurate or difficult to comprehend.

Faulty Information In Instructional Situations

Wright (1981) claimed that product instructions may be factually incorrect in three ways. First, instructions are not always applicable to specific versions of a product. Second, the information may be difficult to comprehend or incomprehensible both in terms of its text (language) or pictorial presentation. Third, instructions are generally developed: a) after a product has been manufactured; and b) by persons or engineers who possess background knowledge concerning the system's design. Although this a reasonable process for the development of instructions, designers or engineers may fail to include information which is necessary for the customer to operate the product. The exclusion of information may result from the designer's or engineer's enhanced knowledge of the product. Instructions are often developed, therefore, on the basis of expert knowledge rather than common or novice (customer) knowledge (Szlichcinski, 1979b; Wright, 1981; Wright, Creighton & Threfall, 1982).

Researchers have also identified further shortcomings in instruction manuals. The translation of instructions from a foreign language to English or vice-versa is a common factor contributing to the existence of poorly comprehensible instructions (Broadbent, 1977; Dixon, 1982; Wright, 1981). Furthermore, incomprehensible instructions may be due to the fact that the information presented is poorly structured in relation to the task at hand. A contributing factor to the efficacy of instruction and information concerns the poor syntactic organisation of the material. The fact that written instructions are more likely to be translated into a routine by readers (Miller & Johnson-Laird, 1976) would lead to a situation where the reader is faced with a confusing situation, or faced with an incomprehensible information set if the syntactic organisation of the written material is poor (Broadbent, 1977; Chapanis, 1965; Dixon, 1982, 1987; Szlichcinski 1979a, 1979b, 1980).

Simon & Hayes (1976) claimed that a problem or a task may be categorised as 'ill-structured' when the instructions do not contain the degree of information necessary to permit usable manipulations or solutions. Based on the literature I have reviewed, I argue that it may be the instructions which are 'ill-structured' and not the problem. The following instructional factors exemplify the term 'ill-structured': a) grammatically poor; b) overly technical; c) inadequate in providing information for the reader to bridge the gap between the problem and solution; or d) inadequate in its attempt to combine the information presented to form a meaningful whole for the reader. The difficulties associated with the development of instructions have not been exhausted in this section. The following five sections will address other factors which contribute to the shortcomings inherent in instructions materials and research.

Difficulty In presenting Instructions For Consumer Products

A major problem evident in consumer product instructions and teaching aid manuals is the mode of presentation. Writers of technical manuals and teaching aids are faced continually with the problem of selecting and designing an optimal instruction format. An optimal instruction set can be described as a set of instructions which provides the user with effective information by which to utilise an object or instrument (Booher, 1975; Braby, et al., 1982; Dixon, 1982; Hodgkinson & Hughes, 1982; Sremec, 1972; Szlichcinski, 1979a).

Ergonomic designers have attempted various ways to produce an 'instruction-free' product through product design. The designs have been manufactured in such a way as to provide adequate visual information which specifies correct operational sequences and constrains against incorrect operations (Norman, 1988; Wright et al., 1982). However, in light of the complex and multi-functional products which are being produced, manufacturers are forced to develop instructions (Chapanis, 1965).

The current literature (Booher, 1975; Braby et al., 1982; Broadbent, 1977; Hartley, 1978, 1981; Hodgkinson & Hughes, 1982; Nailen,1981; Szlichcinski, 1979a, 1979b; Wright, 1981) suggests that the guidelines which writers and investigators have explicated to facilitate the development of more effective and comprehensible instructions have an inherent limitation - they do not profile specific formats and contexts in which to use these guide-lines. The ability to present usable formats and contexts for all situations may be an impossible task. However, I suggest that understanding the context and having the appropriate format for instructional information is fundamental to the optimal performance of achieving an individual's intended goal. The claim by Braby et al. (1982) that "There have been insufficient guide-lines for designing formats used in presenting information intended to communicate concepts, general information, or even simple procedures" (p. 61) leads one to believe that the information necessary to understand the appropriate application of these guide-lines, in relation to a specific format and context, will be the result of a larger knowledge base concerning instructional material than is currently available.

Instructions In Proceduralised And Complex Tasks

Booher (1975) investigated the role of picture-word formats in instructions utilising the following information contents: a) Context; b) Focus; and c) Action-Step, to assess the comprehensibility of proceduralised instructions in relation to the following tasks: (1) a **location** task where the subject located objects on the control display apparatus and made certain prescribed actions on the apparatus; (2) a **comparison** task which required the subject to compare information found in tables with information presented on the apparatus; and (3) a **symptom recognition** task which required the subject to search a chart of possible symptoms to match symptoms appearing on the apparatus.

Booher (1975) found that highly pictorial multiple-channel formats were the most effective proceduralised instruction format. A Tukey Honestly Significant Difference Test analysis of the formats showed that picture-word formats (with printed words used as supplementary information or redundant information) were consistently faster and more accurate than a printed-word or a picture-only format in facilitating task performance. The picture only group were nonsignificantly faster and more accurate than the print only group. The comparison task required a significantly greater length of time to complete than the location and symptom-recognition task. Subjects in the symptom-recognition group consistently made the fewest errors, with error scores increasing across the comparison and location tasks, respectively.

Booher (1975) reported a significant format-by-task interaction. A test of simple main effects on the basis of the interaction for each task was made, and found reliable differences among formats for all tasks were found. The comparison task showed, however, a significantly greater mean performance time across all formats than the location and symptom recognition tasks. Booher (1975) argued that this indicated the format-by-task interaction was a result of differences in degree and not direction. Overall, a general pattern for task performance on the basis of the type of instructional format emerged. The mean performance time for location, comparison and symptom recognition was slowest for the print-only group and fastest for the pictorial group (both single and multiple channels). The pictorial multiple-channel formats consistently produced the fastest time and lowest errors on all three tasks.

The results suggested that a multiple-channel format of communication, as opposed to a single-channel, was the more comprehensive format with which to convey proceduralised instructions. It was advocated that proceduralised information should be presented in a pictorial format (i.e., a visual mode) coupled with printed words (verbal mode, although the visual system in utilised to read) to clarify the specific actions individuals must perform (Booher, 1975; Braby et al., 1982; Hayes & Readence, 1983). Braby et al. (1982) claimed that most proceduralised tasks were highly visual, involving actions that require attunement to visual information. It is my contention, therefore, that the recommendation regarding the presentation of proceduralised instructions in a pictorial format, coupled with words to clarify specific actions, is consistent with the notion of *compatibility* and the idea that *information* should be presented in the same form as it is to be controlled (Owen, 1990). The pictorial presentation of information relevant to the procedural task would, therefore, be compatible with the procedural task demands of attunement to visual information relevant to the task. The visual attunement required by the procedural task also requires one to detect and select relevant information from the environment (i.e., the instruction manual, Resnick, 1976) to complete the task.

The results from Booher's (1975) study confirmed his prediction that pictorial channels were useful in conveying location and performance task information. The results further suggested that pictorial channels are not useful for tasks which required difficult or complicated logical operations. Booher suggested that as the level of difficulty for logical operations in a task increased so did the preference for a verbal channel to clarify actions, i.e., the printed word. He argued that verbal symbols were readily usable by the internal processing system characterised in logical operations, this view is consistent with Miller & Johnson-Laird's (1976) theory of the comprehension of instructions.

It is my contention that Booher's (1975) study was limited in that he only investigated the relative merits of pictures and words and picture-word combinations on location tasks and simple perceptual matching problems. He did not investigate the relative merits of pictorial and printed words for problem solving tasks and proceduralised tasks which required difficult or complicated sets of logical operation.

The Role Of Practice And Self Tests In Instructional Situations

In an experiment conducted with Navy Technical personnel, Braby et al. (1982) found a difference between two methods of training: (1) **learning aid**; and (2) **job performance aid.** Both methods of training utilised a multi-channel instructional format. The job performance aid instruction manual presented a photographic communication mode with printed words used only to clarify the specific actions which the technicians must perform. The learning aid method was a simulated version of the job performance aid manual, that is a job performance aid supplemented with practical exercises and self-tests. For example, practice of location tasks were facilitated by a mock-up photograph of an actual instrument with the aid of lines and numbered steps to designate the specific sequence of procedures.

Braby et al.'s (1982) overall findings showed that the learning aid method of training was superior to the traditional training utilising job performance aid. The results suggested that practice and the act of re-familiarising oneself with the information presented was a valuable way to facilitate optimal performance. It was suggested that learning aids were most effective when the procedures to be taught were to be: a) performed frequently from memory; b) performed on expensive or scarce equipment, the use of which is at a premium; and c) performed correctly because of safety. The authors proposed, however, that learning aids were not appropriate for all types of situations and that learning aids should not be used when: (1) individuals have access to job aids or other technical documentation when working, or (2) the task involves many *decisions* , typical of most problem solving and trouble-shooting tasks. In light of this conclusion Braby et al. (1982) suggested that problem solving tasks involved a different or more complicated set of strategical procedures other than location, manipulation of controls and/or tools, and the act of checking for feedback. They argued that in a problem solving context different degrees of practice and types of information may be required. For example, individuals may scan pictures or instruments for specific kinds of information needed to aid the diagnostic process of trouble-shooting, as opposed to just locating a particular instrument (Norman, 1988; Szlichcinski, 1979b; Watt, 1991). In other words, the individual must know what type of information to look for to help him or her solve the problem.

I argue that the study by Braby et al. (1982) was limited by the absence of a task which required a decision-making process; i.e., solving unfamiliar problems. This argument is based on the claim made by Braby et al. (1982) that tasks involving decision-making or trouble-shooting were different from tasks involving location, manipulation of controls and/or tools, and the act of checking for feedback. I suggest, therefore, that there is a need for future research to give foundation to this assumed difference, thus the research should be focused on determining the type of information relevant to specific problems and general problem solving.

Information Content Of Instructions

The assertion that a problem solving or decision-making task requires different or alternative types of information than are required for assembly tasks is indirectly supported by the work of Bieger & Glock (1984-85). Bieger & Glock investigated the information content of picture-text instructions with regard to three categories of information they believed to be fundamental to an assembly task. They are outlined as follows: 1) **operational** - information that directs an implied agent to engage in a specified action; 2) **spatial** - information that specifies the location, orientation, or composition of an object; and 3) **contextual** - information that provides the theme or organisation for other information that may precede or follow it.

Bieger & Glock (1984-85) varied the completeness of instructional sets for an assembly task, hypothesizing that the combination of all three types of information were fundamental to the successful completion of the task. Subjects who were given a *complete* combination of the three information categories produced a superior performance when compared with subjects given an *incomplete* information combination. A superior task performance was defined as one which produced the least number of errors and required the least amount of time to perform. Another experiment confirmed the effectiveness of the combined information set. In a 'felt task' experiment where subjects had to arrange geometrical shapes in a predetermined manner, the *complete* information group showed superior performance.

Bieger & Glock (1984-85) concluded that their taxonomy specified important categories of information for proceduralised assembly instructions. Furthermore, they suggested that the taxonomy provided a foundation for the development of information contained in picture-text materials in general. They argued that this taxonomy could be utilised to identify specific types of information required to perform particular tasks. I suggest that a functional difference between the proceduralised task of assembly and problem solving may be the relative frequency of one type of information, an alternative presentation or another category of information. For example, the inclusion of additional visual information which would match the type of information that is required to control actions and dominant perceptual system; i.e., vision.

Rationale For the Present Study

The results cited in Booher (1975) identified contextual, focus and action-step information as being important for a comparison task. Bieger & Glock (1984-85) found that operational, spatial, and contextual information were fundamental to an assembly task. I argue that the: a) operational; b) spatial; and c) contextual information, as identified by Bieger & Glock (1984-85), are synonymous with or an invariant informational concept of Booher's (1975): a) Action-Step; b) Focus; and c) Contextual information, respectively. In this regard, I suggest that these three information types are fundamental or facilitate the successful completion of assembly, comparison and proceduralised tasks. The applicability of these information types in a problem solving or trouble-shooting task (which involves symptom-recognition), however, has yet to be validated. The literatures suggests that trouble-shooting tasks require a more complicated, strategical procedure based on the input of different or alternative types of information. The lack of evidence in this area is due to the dearth of research which identifies a distinctive information type or mode that will facilitate trouble-shooting or proceduralised problem solving tasks.

I propose that the successful completion of an unfamiliar problem solving task (consisting of a decision-making content) are a function of an alternative or additional information input, mainly visual information which attunes individuals to salient cues or variables of the task at hand. Therefore, attuning an individual to a symptom at a specific time will provide information which aids the diagnosis of a particular problem. Furthermore, the presentation of relevant information via a non-verbal mode (i.e., pictures or illustrations) may refer individuals to the relevant information more readily, than if the information was presented in a verbal mode (i.e., written text). I assert that arrows added to pictorial components of the instructions may be this alternative information type; a) arrows depicting manipulation direction (ADMD); and b) arrows depicting manipulation location (ADML). In the context of the present study ADMD and ADML refers to the static augmentation of pictorial material which explicitly depicts the appropriate locative or directive manipulation of an object or its part(s) in relation to the object itself or the environment.

I believe that the locative and directive information conveyed by this static augmentation is comparable to or an alternative medium for conveying the spatial and operational information of Bieger and Glock (1984-85) and action-step and focus information of Booher (1975), respectively. Furthermore, the pictures which have been modified with arrows provide the *Contextual* information identified by Booher, (1975). In my opinion the arrows provide an additional dimension in that they resemble visual information which may trigger motor programmes contained in an individual's motor programmes (Zimmer & Englekamp, 1985), or a familiar and meaningful information set. In everyday situations most people encounter the visual representations of arrows as sources of information which specify direction; for example, arrows painted on the roads are utilised to direct motorists, or inform them about unlawful manoeuvres (e.g., a symbol depicting the message - *no left turn*). I propose, therefore, that there are two distinct types of information content which can be depicted by arrows in proceduralised instructions: a) direction information; and b) location information. For example, a standard nut-bolt coupling requires an individual to turn the nut counter-clockwise to loosen and clockwise to tighten the coupling. The directional movements inherent in a nut-bolt coupling (clockwise and counter-clockwise) can be pictorially represented by curved arrows. Similarly, locative and directive information can also be conveyed by straight arrows.

The decision to term this information type 'arrows depicting manipulation direction or location', was based on both the non-specific nature of verbs in the English language, and Kugler & Turvey's (1987) description of verbs as being non-determinate. Miller (1972) claimed that most action verbs in the English language were generic, describing motion but not the specific ways of moving, e.g., the English verb to *turn*, does not specify how one should turn - either right or left, or 360 degrees. In other words, verbs are incomplete because they ignore the causative component and thus require additional qualifications to specify action, for example, the various ways of moving. In written and spoken language these qualifications are termed prepositions. I propose that arrows can specify the form of motion-direction or location and are, therefore, the pictorial equivalent of the action verb and preposition found in written and spoken language.

It is also possible that the arrows may be perceived as symbols which contain specific meaning for the individual (Loveland, 1991; Rasmussen, 1983) and thus can be interpreted in relation to the person's intention. For example, if an individual was looking for a particular nut to loosen, an arrow pointing to the nut may be perceived as information which attunes the individual to the nut. Conversely, if the individual was attempting to loosen the nut (after locating it) then a curved arrow which points in a certain direction may be perceived as information which tells the individual in which direction to turn the nut. These suggestions are consistent with Szlichcinski's (1979b) claim that not all elements in pictorial instruction materials represent the definitive aspects of an object or the visual scene. Arrows which depict direction or location are examples of *non-scenic visual elements* which can be presented in pictorial material. In other words, arrows added to a picture or illustration are additional information, thus does not represent the optical array found in the environment the picture depicts. Non-scenic visual elements in pictures may, therefore, be completely *illustrative,* as in their depiction of movement (Friedman & Stevenson, 1980) depending on the manner of appropriation in the pictorial material. In this manner, Szlichcinski (1980) asserted that a non-scenic element (i.e., an arrow) will not be interpreted as scenic information because the visual form of the arrow corresponds to an experience of movement. An individual does not, therefore, interpret the arrow as an element which depicts the object itself rather, as an informational element which delineates the form of movement or action.

Research by Bieger & Glock (1984-85), Booher (1975), Braby et al. (1982), Hayes & Readence (1985) and (Brody , 1984) has not experimentally addressed the concept of non-scenic elements in instructions or their effectiveness in proceduralised tasks. Bieger & Glock (1984-85) have, however, implicitly addressed the need for explicit and specific operational information in instruction manuals. They assert that instructional information which directs an agent to engage in a specified action is often implicit rather than explicit. For example, in an imperative operational instruction directing readers to "Connect three large blocks and a small block" (Bieger & Glock, 1984-85, p. 70) identified the agent as the reader and the specific operation as one of 'connection'. They claimed that the act of connecting the four blocks (i.e., the three large blocks to the one small block) must be inferred by the reader from the instruction. Bieger & Glock (1984-85) further claimed that the implicit nature of the above operational instruction was especially true of instruction manuals with pictorial depictions in which the arrangement of objects implied an operation.

A practical example concerning the 'implicative' nature of information in instruction manuals is found in Carney & Horner (1974). These technical writers developed an instruction manual for the repair of small engines. Pictures of small engine parts were depicted or arranged in a manner that implied how the parts fitted together. A picture of the engine in its assembled form was also presented. The words in the manual provided information on how to repair the engine but not how to disassemble and reassemble the object. From the assembled picture one was expected to infer which parts were used and contained within the chasis of the engine. I suggest that information of this nature is 'implicative' in the sense that the manual does not explicitly inform the user about how the different parts relate to each other. In this respect, I propose that both errors of commission and omission may occur when an individual is faced with the task of assembling or repairing the small engine. Errors may occur as the visual similarity between the engine parts results in misperceptions in affordance, for example, parts afford acting upon.

This review has identified a number of limitations inherent in the work of Bieger & Glock (1984-85), Booher (1975) and Braby et al. (1982). Furthermore, the dearth of research investigating the functional potential of illustrations in instructional situations outlined by Brody (1984), may also contribute to the limited understanding or utilisation of information concerning the practical applications of instructions. I concur with a number of researchers who have identified these limitations as having contributed to the problem of 'insufficient guide-lines' for the development (content) and contextual use of instructions (Hartley, 1978; Hodgkinson et al., 1982; Nailen, 1981; Szlichcinski, 1979a, 1979b, 1980; Wright, 1981). I believe that these limitations will only be resolved through further investigation concerning the role of specific types of information in a specific context or identifying more effective utilisation of information for human use (Salvendy, 1988). The present study was designed to address some the limitations inherent in previous research and thus, clarify and contribute to the literature.

The Present Study

The literature review suggested that current guide-lines for designing instructional materials and manuals intended to communicate concepts, general information and simple procedures are insufficient. It was my conclusion, therefore, that further research was required to enlarge the knowledge base concerning instructional design. This research needed to identify two factors: First, the information categories which are effective conveyors of information and second, when (i.e., in what context) the information categories most appropriate. It was my intention, therefore, to explore the functional utility, and effectiveness of arrows presented as specificational information for conveying procedural instructions and facilitating learning. In other words, investigating the effectiveness of arrows and pictures in instruction manuals as a visual aid which explicitly specifies or sensitizes an individual to the action-potential of a task. A subsidiary objective was to investigate the effectiveness of a picture of depicting the final form of an object as advanced information about the goal in a novel and complex procedural task, and for learning.

I was interested in considering the following two factors: a) the effectiveness of pictorial representations augmented by arrows depicting manipulation direction and location (ADMD & ADML), and arrows depicting the location of individual parts (ADLP) in facilitating performance on a proceduralised task; and b) how different types of information, represented by arrows, enabled a person to efficiently and successfully complete a proceduralised task. In order to achieve these aims I chose an assembly task derived from a prototype product, thus ensuring that the task was unfamiliar to the participants. Subjects were required to follow a step-by-step procedure in order to successfully complete the task as accurately and as fast as possible. The experiment involved nine groups whereby participants were randomised into nine instruction manual conditions with the divisions being consistent with the distinctions amongst the instruction manuals. The nine manuals were designed to assess the effectiveness of different information-combinations on each subjects' performance.

The experimental manipulations based on the informational elements is charted in Table 1.

Rationale For The Inclusions Of Instruction Element I: Words

It is my contention that the inclusion of the step-by-step pictorial material in the instruction manuals required validation. It was necessary to substantiate whether this information facilitated superior performance compared with the performance in its absence (that is words-only) on the assembly task. This project included, therefore, an experimental condition delineated by the presentation of a word-only instruction manual to test the validity of step-by-step-pictures.

Table 1: Experimental Manipulations

This table delineates the informational elements received by each subject in the corresponding instruction manual. An asterisk indicates that the informational element was present in the manual. A blank indicates the absence of the element in the manual.

Condition	Words	Picture of the goal	Step-by-step pictures	ADMD	ADML	ADLP
1	*					
2	*	*				
3	*		*			
4	*	*	*			
5	*		*	*	*	*
6	*	*	*	*	*	*
7	*	*	*	*		*
8	*	*	*		*	*
9	*	*	*		*	

Rationale For The Inclusion Of Instruction Element II: Pictures

The instruction manuals comprised of words and pictorial information were designed to validate step-by-step pictorial material as a more effective information source for the successful completion of the task, as opposed to the word-only instructions. In addition, I was interested in assessing whether a picture of the assembled unit would enhance or inhibit a person's performance on the task. The inclusion of a picture of the goal (a picture of the assembled unit) as an experimental manipulation was based on a suggestion made by my supervisor. In the context of the present study I propose that a picture of the fully assembled object has two functions: a) It provides additional meaning to the step-by-step pictorial instructions by showing how each operational step added to the completion of the unit as a whole; and b) Pictorial information depicts the specific sub-goals and or final goal an individual must achieve (i.e., advance information about the goal).

In the section on Principles of Design for Understandability and Usability, Norman (1988) explicated the value of a good conceptual model. He claimed that a good conceptual model provided an individual with information to predict the effect of his or her actions. Smith & Goodman (1984) suggested that the presence of an explanatory schema which showed rationales for instructions can improve performances. I believe that a conceptual model or explanatory schema functions as a guide to control and reinforce actions, thus, facilitating superior performances. Based on the findings reported by Bagget & Ehrenfeucht (1988), Bieger & Glock's (1984-85), Booher's (1975), Braby et al.'s (1982), Hayes & Readence's (1983) research concerning the utility of illustrations, Norman's (1988) functional account of conceptual models and Smith & Goodman's (1984) work on the utility of an accurate expectation of a task. I propose that a picture representative of the assembled object provides a conceptual model and gives meaning to the context from which the individual can guide his or her action. In light of this proposal, the methodological design included a comparison between subject groups who did and did not receive a picture of the assembled unit (goal) on task performance.

Rationale For The Inclusion Of Instruction Element III: Arrows depicting manipulation direction (ADMD), arrows depicting location (ADML), and arrows depicting location of parts (ADLP)

Bieger & Glock (1984-85) and Booher (1975) identified three types of information as being fundamental to the completion of a proceduralised task: 1) Action-Step; 2) Focus; and 3) Contextual information. They concluded that their taxonomy specified the type(s) of information required to perform an assembly task. Furthermore, their research suggested that the information conveyed in all three taxonomies were effective when pictorial materials were coupled with printed words. Bieger & Glock (1984-85), Booher (1975) Braby et al. (1982) and Szlichcinski (1980) did not address, however, the effectiveness of arrows which represent directional or locative information in a proceduralised task.

I propose that the pictorial representation of ADMD, ADML and ADLP depict manipulation direction and location information and location of parts, respectively, which subjects require to perform a given operation. In the context of an assembly task I assert that ADMD, ADML could be perceived as symbols or a guide which attunes the individual to a particular action or goal. This motion-depiction proposition is supported by Szlichcinski's (1980) and Friedman & Stevenson's (1980) account of arrows as a non-scenic element in pictorial material depicting motion. Szlichcinski (1980) argued that arrows were interpreted as an informational element which specified the form and extent of an action, as opposed to an informational element which depicted the form of an object.

I propose that the function of ADMD and ADML information in instructional materials was twofold: a) to provide additional information which would minimise the employment of a trial-and-error strategy by individuals who lack proceduralised knowledge; and b) to confirm or reinforce the actions of individuals who possessed the specific, proceduralised knowledge for a task or operation. In this context ADMD information functioned as confirmation-information (Brody & Legenza, 1980; Gropper, 1963). For example, if a person possesses the knowledge that to loosen a nut-bolt coupling he or she has to turn the nut counter-clockwise, the ADMD representation of this information will: a) confirm or be compatible with the person's knowledge and expectation; or b) convey the information that he or she is manipulating the coupling in a correct manner. The *confirmatory* nature of ADMD, however, will be dependent on the person's intention.

The confirmation utility of ADMD, ADML and ADLP information is consistent with or indirectly supported by the findings of Bagget & Ehrenfeucht (1988). They found that performance on an assembly task was superior when the conceptualisation presented in the instructions agreed with the conceptualisation that people brought to the task.

Predictions

Based on the findings cited in the literature review and the rationales provided for the present project, the aim of this study was to examine whether: a) the presence of a picture depicting a fully assembled object facilitates superior performance on the proceduralised task;

b) the presence of step-by-step pictures in the instruction manual facilitates superior performance on the proceduralised task; and c) the static augmentation of the step-by-step pictures used in conjunction with words to convey specific procedural instructions can facilitate superior performance.

In light of Wright et al.'s (1982) findings regarding people's reading habits of instruction manuals when an unfamiliar electrical object encountered, I propose that subjects who are in instruction manual conditions which contain a picture of the goal and pictorial representations of the parts in the introductory materials will take longer to read the introductory materials. The rationale being that subjects may want to familiarise themselves with the unfamiliar object.

In light of the findings cited by Bagget & Ehrenfeucht (1988), Norman's (1988) functional account of conceptual models, and the utility of information which establishes a meaningful context (Smith & Goodman, 1984), I propose that the presence of a picture of the goal will facilitate superior performance on the proceduralised task across all conditions.

Bieger & Glock's (1984-85), Booher's (1975), Braby et al.'s (1982), and Hayes & Readence's (1983) findings regarding the effect of related illustrations or pictures on proceduralised tasks showed that visual information facilitates superior performance. I propose, therefore, that the inclusion of the step-by-step pictures in the instruction manual will facilitate superior performance on the task, compared with performance in the absence of step-by-step pictures.

Based on Gibson's (1971) account of pictures as carriers of optical information, Gibson & Levin's (1975) account of reading, Sanders & McCormick's (1987) notion of compatibility, Severin's (1967a, 1967b) account of cue summation, Pick's (1965) findings regarding the utility of distinctive features in learning, Szlichcinski's (1980) and Friedman & Stevenson's (1980) account regarding the possible interpretation of non-scenic elements in pictures, and Gibson's (1979) theory of information pickup, affordances and the fundamental nature of affordances to actions, I propose that static augmentation in the form of arrows: a) depicting manipulation direction (ADMD); b) depicting manipulation location (ADML); c) depicting the location of parts (ADLP); and d) the three arrows presented in combination will facilitate superior performances on the task.

The hypotheses in relation to each instruction manual conditions are as follows: Note that a " > " sign indicates an enhanced performance, delineated by a faster performance time, smaller numbers of exploratory procedures and smaller numbers of performance errors.

1) Subjects will take more time to read the introductory information when a picture of the goal is present in the introductory materials.

Instruction manual Condition: 2 > 1
4 > 3
6 > 5

2) A picture of the goal in an instruction manual enhances performance on the task.

Instruction manual Condition: 2 > 1
4 > 3
6 > 5

3) Step-by-step pictorial representation of the instructions enhance performance on the task.

Instruction manual Conditions (9, 8, 7, 6, 5, 4 & 3) > Instruction manual (Conditions 2 & 1)

4) Arrows depicting the location of parts and the manipulation location on the object are more effective in enhancing performance on the task than arrows depicting manipulation direction only.

Instruction manual Condition-8 > Instruction manual Condition-9

5) Arrows depicting manipulation location in an instruction manual are more effective in enhancing performance on the task than arrows depicting manipulation direction.

Instruction manual Condition-8 > Instruction manual Condition-7

6) The combination of arrows depicting manipulation direction, arrows depicting manipulation location, and arrows depicting location of parts in an instruction manual enhance performance on the task.

Instruction manual Conditions (6 & 5) > Instruction manual Conditions (9, 8, 7, 4, 3, 2 & 1)

7) The instruction manual which contains the greatest amount of picture and arrow information will facilitate a superior performance on the task. The order of superior performance as a function of information combination will be as follows:

Instruction manual Conditions 6 > 5 > 8 > 7 > 9 > 4 > 3 > 2 > 1

8) Subjects will rate instruction manuals with arrow and picture content as the most effective format for successful completion of the proceduralised task. Subject ratings will be as follows:

Instruction manual Conditions 6 > 5 > 8 > 7 > 9 > 4 > 3 > 2 > 1

9) The predictions made above will hold for both the assembly and testing procedures.

METHOD

Subjects

Eleven subjects were required for each of the nine experimental conditions, for a total of 99 (59 females and 40 males) in the main experiment. The subjects ranged in age from 17 to 50 years. Eight subjects were used for the exploratory study, 16 for the pre-pilot testing and 5 for the pilot study. A total of 134 subjects were used for the entire project. The subjects were drawn from the undergraduate student population at the University of Canterbury. The Subject Pool listing in the Department of Psychology was used to approach individuals with regard to their voluntary participation in this experiment. Informed consent was obtained from all subjects. A copy of the consent form for the pilot study and experiment can be seen in Appendix 1.

Monetary incentives were provided as the task required from 20 to 50 minutes of a subject's time. Subjects who participated in the pilot testing sessions were given the chance to win one of two grocery vouchers valued at $ 30.00. Subjects who participated in the experimental sessions were given the chance to win one of three grocery vouchers valued at $ 80.00, $ 50.00 and $ 20.00 respectively.

Materials

Assembly and Testing Object: The CPM Unit

The performance task involved assembling and testing of an orthopedic hand exercise unit (the Portable Continuous Passive Motion Hand Unit or CPM Unit); designed and manufactured by the Mechanical Engineering Department, University of Canterbury.

The CPM unit is a lightweight exercise machine designed to fit the hand. Its main objective is to therapeutically stimulate the healing and regeneration of articular tissues (flexor and extensor muscles of the patients hand) to facilitate a full range of motion after recovery of fractures and ligamentous reconstructions. A small motor operates the flexion and extension movements to ensure that continuous passive movements are maintained during recovery.

Assembly and operation of the CPM unit required the following materials and operations:

1) installation of the cursor shaft onto the motor unit
2) assembly of the hand rod unit
3) installation of the hand rod onto the cursor casing
4) installation of the cursor casing onto the cursor
5) installation of the finger linkages to the CPM base unit
6) checking the functions of the CPM unit:
    i) inserting the plug into the correct position
    ii) connecting the adapter
    iii) testing the cursor movement.

All the relevant components were presented as individual parts and arranged on a 1 m by 0.70 m white cardboard sheet. The pictures presented in the instruction manuals were synonymous with this arrangement. This particular procedure was based on observations made in the exploratory study. Arranging the parts in open containers or plastic bags (as originally proposed) was observed to be an inappropriate form of componentry organisation. For example, when Zip-Lock bags were used to organise the different parts, subjects who removed the contents of the bag one-by-one (as opposed to those who emptied the contents all at once) added to their performance time. Similarly, subjects who removed the parts one-by-one from the open boxes often missed a small component which, for example, might be lodged against the side of the box. Subjects who emptied the entire contents of the box had no such problems. In this manner, a subject's performance may have been impeded because the componentry organisation allowed for subjects to utilise individual component-selection technique, which may be less effective than others.

Based on the above observation components for the experimental sessions were presented to each subject in a pre-arranged convention on a flat surface (see page 2 of the instruction manual or the section entitled 'Names of CPM Parts' o the instruction manual in Appendix 4) . Subjects were required to select the appropriate part directly from the table. This controlled for different selection techniques across subjects and ensured that differences in performance times amongst group conditions were attributable to the experimental manipulations.

Instruction Manuals

The instruction manuals were developed with the aid of existing guidelines (AGPS, 1975; Bieger & Glock, 1984-85; Biederman, 1987; Booher, 1975; Braby et al., 1982; Broadbent, 1977; Carney & Horner, 1974; Dixon, 1982, 1987; Dyer, 1939; Hartley, 1978, 1981; Hodgkinson et al., 1982; Konishiroku, 1980; Krohn, 1983; McFarlane, 1972; Minter, 1987; Nailen, 1981; Scott, 1985; Stone & Glock, 1981; Szlichcinski, 1979a, 1979b; U.S. Navy, 1973; and Wright, 1981). Additional instructional information in the form of: a) arrows depicting manipulation direction and location along with location of parts (ADMD-ADML & ADLP); b) arrows depicting manipulation direction only along with location of parts (ADMD & ADLP); c) arrows depicting manipulation location only along with location of parts (ADML & ADLP); d) arrows depicting manipulation location only, (ADML) and; e) a picture of the assembled CPM unit were included in the manuals (picture of the goal, PG).

A task analysis of the procedures required to perform the assembly task was conducted (Resnick, 1976). I observed the assembly operations for the CPM unit performed by the workshop technician, Walter Puentener and the designer of the CPM unit, Gary Johnson.

I developed the pictorial content of the instruction manual by taking photographs of the unit and its constituent parts. The photographs were taken based on the Words-only instructions. Inclusion of photographs in the instruction manual for the Step-by-Step Pictures with Words condition was based on the validation of the corresponding written instruction in the Words-only instruction manual.

Arrows depicting manipulation direction only, location only and location of parts were presented in the instruction manuals utilising the combination of two communication mediums (pictures depicting the objects combined with arrows depicting manipulation of direction of and locations). The arrows were designed and created with the Macintosh Superpaint 2.0 programme and printed onto removable labels (Esselte 50 cm by 90 cm 'Quik Stik' self adhesive labels). The arrows were then cutout individually with an 'Exacto Knife' and positioned on the photographs in their appropriate locations.

The development of the above multiple-medium instruction format was based on the results from Bieger & Glock, (1984-85) and Booher (1975). These researchers showed that proceduralised instructions conveyed in a 'high-pictorial' format was the most effective instructional design for conveying simple proceduralised instructions. A 'high-pictorial' format referred to a convention in which pictures was used as the main medium of communication with words used to clarify the specific actions individuals must perform.

I developed nine instruction manuals which are contained in six consecutive appendices. The number of the appendix corresponding with the instruction manual is listed after each manual description. The distinctions amongst the instruction manuals were as follows: a) Words-only (W; Appendix 2; page 1 of the manual, however, did not have a picture of the assembled unit); b) Words-only and a picture of the goal (W-PG; Appendix 2); c) Step-by-step pictures with words (PW; Appendix 3; page 1 of the manual, however, did not have a picture of the assembled unit); d) Step-by-step pictures with words and a picture of the goal (PW-PG; Appendix 3); e) Step-by-step pictures with words, in combination with arrows depicting manipulation direction, location, and location of parts manual (PW-ADMD-ADML & ADLP; Appendix 4; page 1 of the manual, however, did not have a picture of the assembled unit); f) Step-by-step pictures with words, in combination with arrows depicting manipulation direction, location, location of parts and a picture of the goal manual (PW-ADMD-ADML-

ADLP & PG; Appendix 4); g) Step-by-step pictures with words, in combination with arrows depicting manipulation direction, location of parts and a picture of the goal manual (PW-ADMD-ADLP & PG; Appendix 5); h) Step-by-step pictures with words, in combination, with arrows depicting manipulation location, location of parts and a picture of the goal manual (PW-ADML-ADLP & PG; Appendix 6); i) Step-by-step pictures with words, in combination with arrows depicting manipulation location only and a picture of the goal manual (PW-ADML-PG; Appendix 7).

The word instruction component in each manual was common for all nine formats. This standardisation ensured that the performance between manual conditions on the task, was attributable to the experimental manipulations of the: a) Step-by-Step Pictures; b) Picture of the goal; c) Arrows depicting manipulation direction and location; d) Arrows depicting manipulation direction only; e) Arrows depicting manipulation location only; f) Arrows depicting location of parts; and g) The three arrows presented in combination. The standardisation of the word component ensured that this informational set was constant for all subjects.

An exploratory study and a pilot testing session were conducted to validate the 'sufficiency' of the Words-only instruction manuals. 'Sufficiency' was defined as the consistent and successful assembly of the CPM unit within a time constraint of 60 minutes.

When the Words-only instructions had been validated they were coupled with the appropriate black and white photographs (6.35 cm by 10.15 cm) which pictorially depicted the written action. The word instructions were presented in a 6.35 cm column on the left side of A4 size paper coupled with the corresponding photographs on the right side of the page this formed the Step-by-Step Pictures with Words instructions format (PW format).

Four copies of the PW instructions format were made on a Canon Laser Photocopier (CLC 200). Two of the copies were utilised as material for condition PW and condition PW and a picture of the goal (instruction manual Condition3 and 4, respectively).

One of the remaining two copies was augmented with arrows depicting manipulation directions and location, and arrows depicting location of parts (ADMD-ADML & ADLP), this constituted the master copy for all of the instruction manuals which received arrows. Two photocopies of this format were made and utilised as material for instruction manual

Condition-5 (PW-ADMD-ADML & ADLP) and instruction manual Condition-6 (PW-ADMD-ADML-ADLP & PG).

The arrows from the master copy of the arrow augmented manuals was then removed beginning with the arrows depicting manipulation direction (ADMD). Laser copies of this format were made, which created the experimental material for instruction manual Condition-8 (PW- ADML-ADLP & PG). The arrows depicting location of parts was then further removed from the Condition-8 format, leaving only the manipulation location arrows . This created the experimental material for instruction manual Condition-9 (PW-ADML & PG).

The remaining copy of the PW format was augmented arrows depicting manipulation direction creating the material for instruction manual Condition-7 (PW-ADMD-ADLP & PG). The developed material for instruction manual Condition-5 (PW-ADMD-ADML & ADLP) and instruction manual Condition-6 (PW-ADMD-ADML-ADLP & PG) were used as a guide to ensure that the arrows depicting manipulation direction added to the PW format were identical to those depicted in the material for instruction manual Condition 5 and 6. Finally, laser copies of the instruction manual Condition 7 and 9 format were made to ensure that the resolution of across the nine instruction manuals was equivalent.

Time Monitor

The lengths of time taken to 1) Read the introductory instruction material; 2) complete the assembly task; and 3) test the assembled unit, were monitored separately by a Yarok digital stop-watch. The stop watch was operated manually by the experimenter. Time recordings were noted in minutes and seconds on the performance classification sheet.

Performance Monitor

Each subject's performance was videotaped onto a Hitachi High Resolution E180 tape using a National Video Cassette Recorder (VHS) and a Hitachi Saticon Colour Video Camera (VK-1830) with a 200m lens, 8.5-68 mm; ratio of 1:16. A Hitachi 4-43 television was used to monitor the videoing procedure. The video camera was mounted on a mobile SLIK "Professional Design II" tripod for manoeuvrability. The video equipment was operated manually by the experimenter. Performance was rated on the performance classification sheet after the completion of each of the experimental sessions.

Strategy Questionnaire

The Strategy Questionnaire asked all participants to describe the strategy they used in performing the task. Subjects were required to assess the usefulness of their strategy on a 7-point Likert Scale with '1' indicating "Not Useful" and '7' indicating a strategy that was 'Very Useful'. Subjects were asked to describe how the strategy helped them perform the task.

The strategy questionnaire format was different for each experimental condition. Subjects in instruction manual Condition-1 (Words-only instructions) were asked to rate the overall effectiveness of the instruction manual. Participants in instruction manual Conditions 1, 2, 3, 4, 5, 6, 7, 8, and 9 rated the overall effectiveness of their respective instruction manual in addition to each of the information elements represented in the instruction manual conditions. A copy of the nine strategy questionnaires can be seen in Appendices 8, 9, 10, 11, 12, 13, 14, 15, and 16, respectively.

Error Feedback Sheet

Subjects who incorrectly assembled or tested the unit received correctional feedback via an Error Feedback Sheet. This sheet was designed so that only the specific step(s) subjects were required to correct and the associated instructions were given to the subject, and in a form comparable to the instruction manuals. A copy of the Error Feedback Sheet can be seen in Appendix 17.

Performance Classification Data Sheet

The classification of performance was based on the instruction manual validation studies. These validation tests identified a standard information set from which subjects were able to consistently assemble the CPM unit. A behaviour was classified as an error by virtue of its failure to conform with a chosen standard of correctness or adherance to the instruction manual (Lewis, 1981; Miller, Galanter & Pribam, 1960; Rasmussen, 1986; Reason, 1990).

The Performance Classification Data Sheet was used to record the subject's name and code number, date, and experimental condition. In addition, it was designed to record information which noted whether the subject was part of the Pre-pilot test, Pilot test or Experiment. A copy of the performance sheet can be seen in Appendix 18.

The main function of the Performance Classification Data Sheet was to classify the performance behaviour of each subject, from the videotape, into the appropriate categories. The categories were defined as follows:

1) **Incorrect procedure(s)** designated a subject's performance as not fulfilling and/or incorrectly performing what the instructions stated. An incorrect procedure was defined as an error of commission.

2) **Extra procedure(s)**[1] classified a subject's action as performing an extra procedure after having fulfilled the required action or, performing an additional action that was not stated in the instructions (regardless of whether it had positive or negative consequences or outcome).

3) **Procedure(s) Omitted** designated a subject's action as failing to perform a procedure/step stated in the instruction manual. An omitted procedure was defined as an error of omission.

4) **Reference to Names of CPM Parts** classified a subject's action as 'looking back' at the description of the CPM parts.

5) **Reference to Picture of the CPM Unit** classified a subjects' action as 'looking back' at the picture of the fully assembled unit.

6) **Successful Assembly** was defined as the completion of the assembly task to the level where the CPM unit would fulfil the mechanical/movement requirements in the testing procedure. Any deviation from this level of completion renders the assembly unsuccessful.

7) **Unsuccessful Assembly** designated a situation where a subject had incorrectly assembled the CPM unit after indicating to the experimenter he or she had completed the task.

8) **Successful Testing** was defined as the completion of the testing procedure where the movement of the cursor covered the length of the unit and back. Any deviation from this level of testing procedure renders the testing unsuccessful.

9) **Unsuccessful Testing** designated a situation where a subject had incorrectly tested the CPM unit after indicating to the experimenter he or she had completed the task.

The performance categories utilised for the Experiment, Pre-Pilot and Pilot Study were a revised version to the categories utilised in the Exploratory Study. The Exploratory Study classification sheet included a performance category called 'Procedure Out of Sequence', and defined as: 'Performing an incorrect procedure out of the sequence stated by the instructions.'

The exploratory study revealed that the 'Procedure Out of Sequence' category overlapped with the 'Incorrect Procedure(s)' category. It was decided that a procedure which was out-of-sequence was one which did not fulfil the chosen standard of correctness and/or was incorrectly performed. The 'Procedure Out of Sequence' category was subsequently determined to be overlapping with the incorrect procedure definition. These two categories were, therefore, pooled together and entitled, ' Incorrect Procedure(s)'.

Conversely, the classification sheet utilised in the Exploratory Study did not contain the category named 'Reference to Names of CPM Parts'. The 'Reference to Names of CPM Parts' was included in the Pre-Pilot and Pilot study after it was found that a description of the CPM parts was fundamental for the successful completion of the assembly task in the Words-only condition.

Incentive Scheme

The incentive scheme was organised in the form of a raffle. A slip of paper designed so that the name, contact telephone number and subject code of the participant was recorded, in addition, it was noted whether the subject participated in the Exploratory, Pre-pilot, Pilot of Experimental Study. The incentive scheme prizes differed with the stage of the project the participant had been involved in. A portion of the paper on the right side of the form was perforated. The same information was recorded on this side of the form. The subject was given this portion of the raffle form. The remaining part of the form was forwarded for raffling on completion of all experimental sessions. A copy of the pilot study and experimental incentive scheme raffle form can be seen in Appendix 19.

Procedure

Subjects were initially contacted by telephone, and those who expressed an interest in the experiment were told in general terms the aims and procedure of the study. Subjects who agreed to participate were asked to make an appointment time two weeks in advance. These corresponded with the days and times each subject had nominated on the subject pool cards. Appointment times were recorded on the experimental booking sheet. All subjects were telephoned the night before their appointment to remind them of the place and time of their experimental session.

Experimental Context

The Activity Room (Rm:114) in the Department of Psychology at the University of Canterbury was used as the experimental facility. Signs were posted at the outer doors of the psychology department directing participants to the experimental room. No arrows were present in these signs in order to control for a possible priming effect.

Four identical tables were arranged in the middle of the Activity Room, representing the work benches on which the experimental equipment was arranged. The arrangement of the tables, equipment and their locations in the Activity room can be seen in Figure 1.

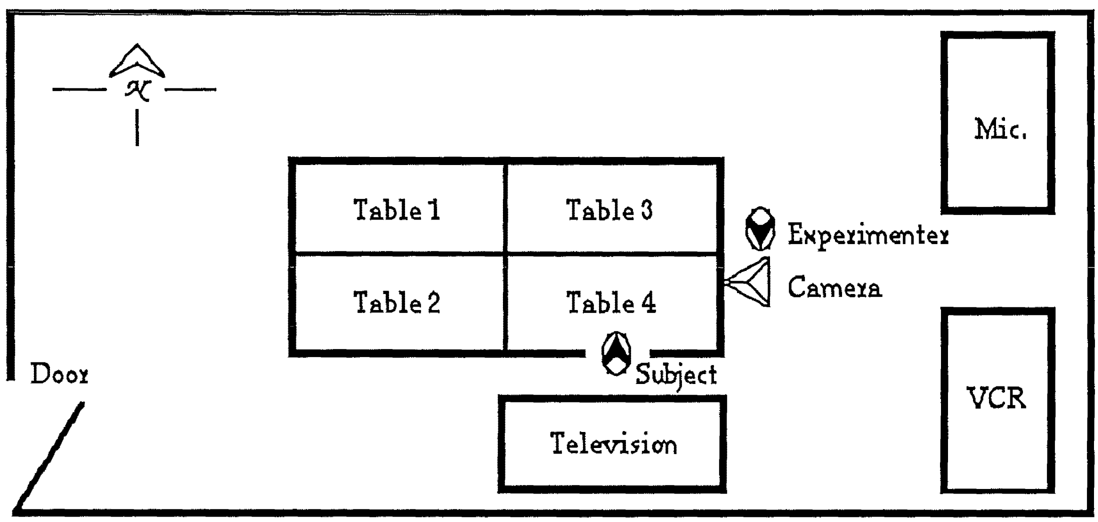

Figure 1: The context in which the experiment took place. 'Table 1' through 'Table 4' represent the work benches, 'Television' indicates the location of the television, 'VCR' indicates the location of the video recorder and 'Mic.' indicates the location of the microphone with reference to the subject, camera and experimenter.

Table -2 was used by participants to complete the consent form, raffle form and the strategy questionnaire. A box of tissues and a cylinder of antiseptic soft wipes were positioned at the edge of this table for subjects to cleanse their hands following completion of the task. Table-3 was used to position the verbal instruction script, error feedbacks sheets, performance classification sheet and the stop-watch.

The CPM parts and tools were arranged on Table-4, which was also the assembly/working area. The CPM parts and tools were covered by a 1.0 m by 0.7 m box to ensure that all subjects received no exposure to the assembly material prior to performing the task.

The video camera was positioned on the right side of Table-4, focused on the CPM parts and tools. The video recorder was placed in the bottom right corner of the room behind where the participant was seated. The microphone was located in the top right corner of the room behind where the experimenter was seated, and the television was positioned directly behind the subject's chair facing the experimenter. In this manner the experimenter (facing the television) could monitor the subject's performance on the screen, adjust the focus of the camera from the clarity of the video as represented on the screen, whilst establishing a rapport with the participants. Positioning the television behind the subject also meant that subjects could not view their own performance on the television screen, thus reducing extraneous sources of distraction during the task.

All the equipment was checked prior to each experimental session and ensured that it was placed in the designated position.

Commencement Procedures

Subjects were allocated to the experimental conditions in order of appearance. Each subject was greeted with a handshake and seated facing North at Table-2; and was asked to read and complete a consent form. They were encouraged to ask questions concerning any aspect of the form which they did not understand, prior to signing the form. Subjects were then, instructed to complete the incentive scheme 'Raffle Form'.

The verbal instructions given to the subjects were as follows:

"Good morning/Afternoon (name of the subject). Before we start with the task I would like you to complete a consent form and a raffle form. Before you complete the consent form, please make sure you understand the conditions of the experiment. If you have any questions please feel free to ask them and I will explain your query. Once you have completed both these forms you will be given instructions relating to the task itself."

After each subject had completed the consent and raffle form, they were asked to sit on a chair facing North at Table-4. Then the video tape, subject code and the video recorder counter were noted on a piece of paper to ensure that when the videos were rated, the code number on the Performance Classification Sheet matched the code number of the video tape. When the subject indicated that they were seated comfortably and ready to begin, the video recorder was started.

To ensure the anonymity of each subject only their hand movements were videotaped.

Assembly Procedure

The cover was lifted from Table-4, and the participant was given the following instructions:

"These are the parts of the CPM unit. Your task is to assemble these parts to make up a CPM unit. This instruction manual provides you with all the necessary information concerning the unit and how to perform the task."

"Your performance will be marked. At any time during the task you can choose to stop and not continue with the task but your performance will be marked as 'unsuccessful' and you will penalised one error point for each step that you did not perform, one minute will also be added to your time for each step that you did not perform."

"All the parts and tools are in front of you. There is no trick involved in this task."

"What I will ask you to do now is read the introductory material, that is, the first 5 or 6 pages (depending on the condition the subject was allocated to) of this manual. Close the instruction manual when you have finished reading. This tells me that you have finished."

"You are allowed to refer back to the instruction material contained in the previous sections and in the introduction throughout the duration of the assembly and testing procedures."

At this point the subject was handed the appropriate manual, and the timing procedure for the introductory material commenced.

The timer was started as soon as the subject turned over the cover of the instruction manual. When the subject indicated they had finished reading (by closing the manual[1]) the timer was stopped. The time period was read from the stop-watch and recorded on the Performance Classification Sheet. The subjects was then instructed that on turning the manual to the page marked 'Assembly Procedure' he or she could begin the assembly task.

The timing procedure for the assembly task commenced. If the subject had assembled the unit correctly, the time was recorded on the Performance Classification Sheet. The stop-watch was then reset, ready to commence timing for the testing procedure. If the subject had not assembled the unit correctly the timer was only stopped but not reset. Subjects were told:

"You have done well, however, there is/are..........(the number of uncorrected errors was stated) errors that you have not corrected. What I will ask you to do is to correct the error(s). I will give you a leaflet telling you the specific step(s) where you made the error(s). Your are required to disassemble the unit so that the step(s) can be corrected. Please hand me the manual."

The particular step(s) which the subject had failed to perform correctly were written on the Error Feedback Sheet. Subjects were then handed the sheet and the manual, with the sheet positioned on the top cover of the manual.

Subjects were told, "Please read all the information on this leaflet and correct the error(s)."

The stop-watch was re-started as soon as the subject turned over the cover of the manual. The subjects was expected to correct the error(s) until the unit met the criterion of successful assembly.

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1 In the exploratory and pre-pilot studies subjects were asked to indicate the completion of a task by saying "I have finished". This method of indication proved to be ineffective because few subjects fulfilled this verbal criterion. The procedure was changed, therefore, in the pilot testing stage. Subjects were asked to perform an action of closing the manual to indicate the completion of a task. This proved to be an effective method.

The timer was stopped when the subject had finished the error-correction task, indicated by closure of the instruction manual. The time was recorded on the Performance Classification Sheet.[1]

Testing Procedure

On successful completion of the assembly task, subjects were required to test the mechanical/movement properties of the CPM unit. Subjects were told: "There are two procedural sections to this experiment. You have completed the first part by assembling the CPM unit. You are now required to complete the second procedure, that is, testing the unit."

Subjects were instructed to turn the manual to the page marked 'Testing Procedure'.

Timing for the testing procedure followed the same pattern as for the assembly procedure. The stop-watch was started when the subject had turned to the appropriate page, and was stopped when the subject indicated he or she had completed the testing procedure by closing the instruction manual. If a subject had successfully completed the testing procedure the testing time was recorded on the Performance Classification Sheet and the stop-watch re-set.

If the subject had unsuccessfully completed the testing procedure, he or she was required to correct the error. Subjects were told: "You have done well, however, there is/are .... errors (the number of uncorrected error(s) were stated) you have not corrected. What I will ask you to do is to correct the error(s) by re-performing the testing procedure. I will give you a leaflet telling you the specific step(s) where you have made the error(s). You are required to re-commence the appropriate testing procedure. Please hand me the manual."

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1 Two subjects were unable to correct the error and indicated that they wished to discontinue the task. They were reminded that they would receive one error point per step missed as well as receiving a penalty of 1 minute per instruction not performed. When the subject indicated they wished to discontinue the task, the timer was stopped and the time recorded. They were penalised one error point for each step that was not performed and 1 minute was added onto their time for each step they did not perform. Data for the two subjects was deleted and replaced with data from two new subjects.

The particular step(s) which the subject had failed to perform correctly was written on the Error Feedback Sheet. Subjects were instructed to: "Read all the information on this leaflet and correct the error." Subjects were then handed the leaflet and the manual. The timing started when subjects opened the manual at the appropriate page.

The timing procedure for the correction of testing errors followed the same method used in the assembly-correction procedure. When each subject had successfully completed the testing procedure the video recorder was stopped and the number on the recorder-counter noted. In this manner, a record of where the video commenced for a given subject (counter-recording when the video was first started) and finished (counter-recording when the video was stopped) was kept.

For the duration of both the assembly and testing procedures subjects did not receive any verbal feedback. In the case where a subject asked a question concerning the task, the subject received the standard reply, "I cannot answer that question."

The performance behaviour of each subject was not scored during the assembly and test tasks. This procedure was based on the observations made during the exploratory study. It was evident that subjects found the experimenter's action of note-taking and/or marking the performance sheet to be a source of non-verbal feedback. I observed that subjects attuned themselves to the manual and often re-performed a step which they had been working on. Subjects also reported that when I made notes, they believed they had made an error.

In the Pilot testing sessions, when I only observed the subject's performance without taking notes. The subjects did not exhibit behaviours corresponding to those observed in the Pre-pilot tests, thus no information relating to the performance of an error was conveyed when I did not take notes.

Completion Procedures

On successful completion of the entire proceduralised task subjects were asked to complete a Strategy Questionnaire. Each subject was given the appropriate questionnaire which corresponded with their experimental condition. In addition, subjects were asked if they had seen the CPM unit prior to the experiment. If a subject responded "Yes", his or her data would not have been forwarded for data collection. This procedure ensured that the CPM unit was a novel object for all subjects; of the 134 subjects, none reported having previously seen the unit.

In closing the session it was strongly emphasised to each subject that their performance had been "good" and any errors committed were no reflection of their ability. Subjects were told that the aim of the experiment had been to test the effectiveness of an informational set contained in the instruction manual for a proceduralised task. In this manner, errors that had been made were considered a result of the informational/instructional material. All subjects were asked not to discuss the experiment with their friends and colleagues. Subjects were informed that the incentive scheme forms would be drawn at the end of the third term and that copies of the draw and experimental result would be posted on departmental notice boards at the end of the third term.

After the subject had left the experimental room, the CPM unit was dis-assembled and re-positioned in the standard format in readiness for the next subject.

Rating of Performance Videos

The videos were rated on completion of all experimental sessions for any given day by the experimenter and a volunteer M.A. Psychology thesis student at the University of Canterbury. The volunteer rater had no knowledge of each subject's treatment condition. This procedure ensured that this rater judged the performance solely on the basis of the performance criteria, thereby, controlling for possible experimenter bias. Crandell (1979) using the same scoring technique and reported correlations of $r = 0.960$ between experimenter and rater on judgement of mean errors for model assembly.

Each video performance was scored by the two raters simultaneously. Each rater scored the time and errors individually in accordance with the classification sheet. On completion of rating the video, the number of performance behaviours in each category were summed. A comparison of the rating totals between the two raters was made. If the ratings were the same, the performance classification sheet was forwarded for data collection. If the rating totals were different, the video was reviewed in order to identify all the performance behaviours which should have been classified. In this manner, raters were able to discuss discrepancies in classification until a consensus was agreed upon.

In addition, both raters monitored the time taken by each subject to read the introductory material, assemble and test the CPM unit were recorded per subject performance. An initial time recording was made during the actual experimental session. Two further time recordings of the performance were made during the video rating session. The volunteer rater monitored the time performances with the same digital stop-watch used by the during the experimental sessions. The experimenter timed the performances during the rating session with an alternate time device, a Casio Digital Stop-Watch.

The aim of this entire timing procedure was to validate the time recorded at the actual performance with two additional measurements, thus ensuring that the timing device is not defective. The additional time recordings were expected to fall within 1 second of the initial time. If the two additional recordings during the rating session fell within 1 second of each other, but exceeded the 1 second criterion when compared with the initial time taken during the actual performance. The average of the additional two recordings was forwarded for data collection. If all three times recorded (including the initial time) did not fall within 1 second of each other but the discrepancy was less than 2 seconds the average of all three times was taken and forwarded for data collection. In all cases, the times fell within at least 2 seconds of each other.

Finally all conversations between the experimenter and the subjects were monitored during the rating session. The volunteer rater would ascertain whether the conversation or verbal statements made Step-by-Step the experimenter biased the performance. If the rater had decided that the verbal statements were biased, for example, aiding the subject to attune him or herself to an error, then the subject's data would not have been forwarded for data analysis.

RESULTS

The present project was designed as an exploratory study to: a) investigate the utility of a picture of the goal in a procedural task; b) validate the utility of relevant pictorial information in a procedural task; and c) investigate the utility of arrows as a guide which attunes the individual to relevant information or action potentials of objects in the environment. The results were analysed in a manner consistent with the exploratory nature of the study.

Performance data were collated into nine distinct groups. Each group was representative of an instruction manual condition concurrent with the different information combinations:

Condition-1 - Words-only (W)

Condition-2 - Words-only and a picture of the goal (W-PG)

Condition-3 - Step-by-step pictures with words (PW)

Condition-4 - Step-by-step pictures with words and a picture of the goal (PW-PG)

Condition-5 - Step-by-step pictures with words, in combination with arrows depicting manipulation direction and location, and arrows locating the individual parts (PW-ADMD-ADML & ADLP)

Condition-6 - Step-by-step pictures with words, in combination with arrows depicting manipulation directions and location, and arrows locating the individual parts and a picture of the goal (PW-ADMD-ADML & ADLP-PG)

Condition-7 - Step-by-step pictures with words, in combination with arrows depicting manipulation direction, and arrows locating the individual parts and a picture of the goal (PW-ADMD & ADLP-PG)

Condition-8 - Step-by-step pictures with words, in combination with arrows depicting manipulation location, and arrows locating the individual parts and a picture of the goal (PW-ADML & ADLP-PG)

Condition-9 - Step-by-step pictures with words, in combination with arrows depicting manipulation locations only and a picture of the goal (PW-ADML-PG).

The dependent variables were:

1) The length of time taken to read the introductory materials

2) Performance categories for **(A)** assembly and **(B)** testing procedures.

a) Time to complete the procedures correctly.

b) Number of each incorrect procedures.

c) Number of each procedures omitted.

d) Number of each extra procedures.

e) Number of references made to the names of CPM parts.

f) Number of references made to a picture of the goal (CPM unit).

g) Performance classification:

(i) Unsuccessful assembly where error feedback was required to assemble the CPM unit correctly;

(ii) Unsuccessful testing where error feedback was required to complete the testing procedure correctly.

3) Ratings for the effectiveness of each manual in assisting performance during the assembly procedures.

4) Ratings for the effectiveness of the strategy(ies) employed by each subject during the assembly procedures.

The data were analysed using four statistical analyses. First, a one-way analysis of variance (ANOVA) and second, multiple range comparisons (using Newman Keul's Multiple Range Test) were used to assess the effect of each instruction manual condition on the respective dependent measures. Third, a 2 X 3 factorial ANOVA design was used to analyse data collected in instruction manual Conditions 1 through 6.

The one-way and 2 X 3 ANOVA designs use the same data and, in some cases, yielded information which overlapped. However, each ANOVA design allowed exploration of different aspects of the information manipulations and their subsequent effect on subject performance which would not have been found if only one of the ANOVAs had been employed. Both ANOVA designs yielded information on how subjects in each instruction manual condition had performed relative to the other conditions but the one-way ANOVA also determined the importance of the individual information manipulation across all nine conditions. The multiple range comparisons assessed the significance difference among the individual information manipulations based on subject's mean performance. Conversely, the 2 X 3

ANOVAs were used to assess the effect of multiple information manipulations and their interactions on performance.

The fourth analysis involved the use of Pearson's Product Moment Correlations to assess the degree of relationship between subjects' performance on the procedural task and subjects' judgements of: a) the manual's effectiveness; and b) their strategy's effectiveness.

I) Results From the One-way ANOVA and Multiple Range Comparisons for Conditions 1 Through 9: A preliminary Analysis

I-1) The length of time taken to read the introductory materials

The one-way ANOVA showed that the information manipulation had no effect on the length of time taken to read the introductory materials ($F < 1$). The multiple range comparisons also showed that no two manual conditions had average reading times which were significantly different at the 0.05 level. All subjects read the introductory material at a similar rate. Table R-1 in Appendix 20, shows the one-way ANOVA and the multiple range comparisons summary table for this analysis.

It is concluded that subjects took similar lengths of time to read the introductory material. Therefore, the length of time taken to read the introductory materials contained in each manual was not subjected to further analysis as the results from the one-way ANOVA and multiple range comparisons showed that the information manipulation had no significant effect on this variable.

I-2 A) Assembly Procedures

The results showed that subjects who received the Words-only instruction manual completed the assembly procedures successfully within the pre-determined time limit. The results also showed that this instruction manual, which formed the basis for the other eight instruction manual conditions, met the standard of correctness for this study. The standard of correctness was determined from the results of the pilot study. The pilot study established the degree of word content in the instruction manuals neccessary for consistent successful performances within sixty minutes.

Appendix 20 contains the summary tables for the ANOVA and multiple range comparisons. The applicable tables are cited with respect to the appropriate test, within each section of the results.

Time to assemble: The one-way ANOVA (Table R-2 in Appendix 20) showed that the information manipulation significantly affected the mean length of time taken to assemble the CPM unit ($F(8,90) = 12.02, p < 0.001$). The multiple range comparisons showed that the mean assembly time for Condition-1 (W) was significantly slower than the remaining eight conditions. The mean assembly time for Condition-2 (W-PG) was also significantly slower than the remaining seven conditions. No other significant differences were found among the remaining conditions.

Incorrect procedures: The ANOVA (Table R-3 in Appendix 20) showed that the information manipulation significantly affected the mean number of incorrect procedures made during the assembly task ($F(8,90) = 14.20, p < 0.001$). The multiple range comparisons showed that the mean number of incorrect procedures made by subjects in Condition-1 (W) was significantly higher than the remaining eight conditions. The mean number of incorrect procedures made by subjects in Condition-2 (W-PG) was significantly higher than the remaining seven conditions. No other significant differences were found among the remaining conditions.

Procedures omitted: The ANOVA showed (Table R-4 in Appendix 20) that the information manipulation significantly affected the mean number of procedures omitted during the assembly task ($F(8,90) = 2.24, p < 0.05$). The multiple range comparisons showed that the mean number of procedures omitted by subjects in: a) Condition-1 (W) > Conditions (2, 5, 6, 7 & 9); and b) Condition-3 (PW) > Conditions (2, 5, 6, 7, 8 & 9).[1] Condition-1 and 3 did not significantly

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1 (> denotes: 'means which were significantly higher than', thus inferior performance.)

differ on the number of procedures omitted during the assembly task, there were also no significant differences found among the remaining conditions.

Extra procedures: The ANOVA (Table R-5 in Appendix 20) showed that the information manipulation significantly affected the mean number of extra procedures made during the assembly task ($F(8,90) = 9.13$, $p < 0.001$). The multiple range comparisons showed that the mean number of extra procedures made by subjects in Condition-1 (W) was significantly higher than the remaining eight conditions. The mean number of extra procedures made by subjects in Condition-2 (W-PG) was also significantly higher than the remaining seven conditions. No other significant differences were found among the remaining conditions.

References to names of CPM parts: The ANOVA (Table R-6 in Appendix 20) showed that the information manipulation significantly affected the number of references made to the names of the CPM parts ($F(8,90) = 15.56$, $p < 0.001$). The multiple range comparisons showed that the mean number of references made to the names of the CPM parts by subjects in: a) Condition-1 (W) > Conditions (2, 3, 4, 5, 6, 7, 8, & 9); b) Condition-2 (W-PG) > Conditions (5, 6, 7, 8 & 9); c) Condition-3 (PW) > Conditions (5, 6, & 8); d) Condition-4 (PW-PG) > Conditions (5, 6, 7, 8 & 9); d) Condition-7 (PW-ADMD-ADLP & PG) > Conditions (6 & 8); and e) Condition-9 (PW-ADML-PG) > Conditions (6 & 8). No other significant differences were found among the remaining conditions.

References to a picture of the goal: The ANOVA (Table R-7 in Appendix 20) showed that the information manipulation significantly affected the number of references made to a picture of the goal ($F(5,60) = 6.33$, $p < 0.0001$). It should be noted that Conditions 1, 3, & 5 were not included in this analysis, as these instruction manual Conditions did not contain a picture of the goal. The multiple range comparisons showed that the mean number of references made to a picture of the goal by subjects in Condition-2 (W-PG) was significantly higher than the number of references made subjects in Conditions (4, 6, 7, 8, & 9). No other significant differences were found among the remaining conditions.

Performance classification: The ANOVA (Table R-8 in Appendix 20) showed that the information manipulation significantly affected the number of unsuccessful assembly performances ($F(8,90) = 5.66$, $p < 0.0001$). The multiple range comparisons showed that the average number of unsuccessful assembly performances by subjects in: a) Condition-1 (W) > Conditions (2, 3, 4, 5, 6, 7, 8, & 9); b) Condition-2 (W-PG) > Conditions (4, 6, 7, 8 & 9); and c) Condition-3 (PW) > Conditions (6 & 8). No other significant differences were found among the remaining conditions.

Summary of Results From the Assembly Procedures

The results from the preliminary analysis showed that manipulation individual of the components in the nine instruction manual conditions significantly affected all the assembly performance categories. The multiple range comparisons showed that a greater number of significant differences among instruction manual conditions resulted from the addition of a picture of the goal or Step-by-step pictures. The following is a summary of the findings.

A. The results showed that when a picture of the goal was added to the Words-only manual, the length of time taken to assemble the CPM unit was reduced. There were also significant reductions in the number of: a) incorrect procedures; b) procedures omitted; c) extra procedures; and d) references made to the names of CPM parts during the assembly performance. A picture of the goal added to a Words-only manual also facilitated a greater number of successful assembly performances than the Words-only manual.

B. The results showed that when Step-by-step pictures were added to the Words-only manual, the length of time taken to assemble the CPM unit was reduced. There were also significantly less: a) incorrect procedures; b) extra procedures; and c) references made to the names of CPM parts during the assembly performance. Step-by-step pictures added to a Words-only manual also facilitated a higher number of successful assembly performances on the first attempt than a words-only manual.

C. The results showed that when Step-by-step pictures were added to the Words and a picture of the goal manual, the length of time taken to assemble the CPM unit was reduced. There were also significant reductions in the number of: a) incorrect procedures; b) extra procedures; and c) references made to a picture of the goal during the assembly performance. The addition of Step-by-step pictures to a Words and a picture of the goal manual also facilitated a greater number of successful assembly performances on the first attempt.

D. The results showed that when the three types of arrows presented in combination were added to the Step-by-step pictures with words manual, the number of: a) procedures omitted; and b) references made to the names of CPM parts during the assembly performance was significantly reduced.

E. The results showed that when the three types of arrows presented in combination were added to the Step-by-step pictures with words and a picture of the goal manual, the number of references made to the names of CPM parts during the assembly procedures was the only performance category significantly reduced.

F. The results showed that when arrows depicting manipulation location (ADML) were added to the Step-by-step pictures with words and a picture of the goal manual, the number of references made to the names of CPM parts during the assembly procedures was the only performance category significantly reduced.

G. The results showed that when arrows locating the individual parts (ADLP) were added to the Step-by-step pictures with words and arrows depicting manipulation location only and a picture of the goal, the number of references made to the names of CPM parts during the assembly procedures was the only performance category significantly reduced.

H. The results showed that when arrows locating the individual parts (ADLP) were combined with arrows depicting manipulation location (ADML), the number of references made to the names of CPM parts was significantly reduced compared to arrows depicting manipulation direction (ADMD).

Results I-2 B) Testing procedures

The one-way ANOVA showed that the following performance categories were not affected by the information manipulation during the testing procedures, when all nine conditions were included in the analysis: a) The number of procedures omitted ($F < 1$); b) The number of references made to a picture of the goal ($F < 1$), (it should be noted that instruction manual Conditions 1, 3 & 5 were not included in this analysis because they did not contain a picture of the goal); and c) The number of unsuccessful performances in the testing procedures ($F < 1$). Although the one-way ANOVA did not show the effect of information manipulations on the number of: a) procedures omitted; b) references made to a picture of the goal; and c) unsuccessful attempts at testing the CPM unit during the testing procedures to be significant. The multiple range comparisons showed significant differences among the corresponding means (Table R-11, 14 and 15, respectively in Appendix 20).

The following four performance categories were significantly affected by the information manipulations.

Time to test: The one-way ANOVA (Table R-9 in Appendix 20) showed that the information manipulation significantly affected the mean length of time taken to test the CPM unit by each instruction manual condition ($F(8,90) = 2.6$, $p < 0.01$). The multiple range comparisons showed the mean time taken to test the unit for: a) Condition-1 (W) > Conditions (4, 5, 6, 7, 8 & 9); and b) Condition-2 (W-PG) > Conditions (4, 5, 6, 7, 8 & 9). No other significant differences were found among the remaining conditions.

Incorrect procedures: The ANOVA (Table R-10 in Appendix 20) showed that the information manipulation significantly affected the mean number of incorrect procedures made ($F(8,90) = 2.28$, $p < 0.05$). The multiple range comparisons showed that the mean number of incorrect procedures made by subjects in Condition-1 (W) was significantly higher than the mean number of incorrect procedures made by subjects in instruction manual Conditions 3 through 9. No other significant differences were found among the remaining conditions.

Extra procedures: The ANOVA (Table R-12 in Appendix 20) showed that the information manipulation significantly affected the mean number of extra procedures ($F(8,90) = 3.05$, $p < 0.005$). The multiple range comparisons showed the mean number of extra procedures made by subjects in: a) Condition-1 (W) > Conditions (3, 4, 5, 6, 7, 8 & 9); and b) Condition-2 (W-PG) > Conditions (6 & 8). No other significant differences were found among the remaining conditions.

References to names of CPM parts: The ANOVA (Table R-13 in Appendix 20) showed that the information manipulation significantly affected the number of references made to the names of the CPM parts ($F(8,90) = 5.46, p < 0.01$). The multiple range comparisons showed that the mean number of references made to the names of the CPM parts by subjects in: a) Condition-1 (W) > Conditions (2, 3, 4, 5, 6, 7, 8, & 9); and b) Condition-2 (W-PG) > Conditions (5, 6, 7, 8 & 9). No other significant differences were found among the remaining conditions.

Summary of Results From the Testing Procedures

The results from the preliminary analyses showed that manipulating individual information components in the nine instruction manual conditions significantly affected a number of the testing procedures. The multiple range comparisons showed that a greater number of significant differences among instruction manual conditions resulted from the addition of a picture of the goal or Step-by-step pictures. The results showed that when:

A. A picture of the goal was added to the Words-only manual the number of references made to the names of CPM parts during the testing procedures was reduced.

B. Step-by-step pictures were added to the Words and a picture of the goal manual, the number of: (i) incorrect procedures; (ii) extra procedures; and (iii) references made to the names of the CPM parts during the testing procedures were reduced.

C. Step-by-step pictures were added to the Words-only and a picture of the goal manual, the time taken to test the CPM unit was significantly faster and the number of each references made to a picture of the goal was reduced.

The results for the testing procedures concurred with the findings from the assembly procedures analysis. The addition of a picture of the goal or Step-by-step pictures facilitated a superior performance in relation all performance categories during the assembly procedures. Results from the testing procedures suggested that, overall, Step-by-step pictures facilitated a superior performance. It should be noted, however, that all seven performance categories were affected by the information manipulations during the assembly procedures while only four of the seven performance categories were affected during the testing procedures.

Results I-3) Manual Effectiveness Ratings

The one-way ANOVA showed that subjects' judgements of manual effectiveness during the assembly procedures were affected by the information manipulation ($F(8,90) = 2.43$, $p < 0.01$). The multiple range comparisons showed that subjects' ratings of the manual's effectiveness in instruction manual Condition-1 were lower than the ratings made by the remaining eight Conditions. Subjects in instruction manual Condition-2 rated the manual's effectiveness significantly lower that subjects in instruction manual Condition-8. No other significant differences in ratings were found among the remaining conditions. Table R-16 in Appendix 20 shows the one-way ANOVA and multiple range comparisons summary table for the mean ratings of manual effectiveness.

The results showed that the addition of a picture of the goal or Step-by-step pictures to the Words-only manual increased subjects' manual effectiveness ratings.

Results I-4) Strategy(ies) Effectiveness Ratings

The one-way ANOVA showed that subjects' judgements concerning the strategy(ies) which they employed during the assembly procedure, was not affected by the information manipulation ($F < 1$). Table R-17 in Appendix 20 shows the one-way ANOVA and multiple range comparisons summary table for the mean ratings of strategy(ies) effectiveness. The multiple range comparisons showed, however, that strategy effectiveness ratings between certain instruction manual conditions were significantly different (Table R-17 in Appendix 20). The mean comparisons showed that subject's rated their strategy as more effective when a picture of the goal was added to the Words-only manual. The discrepancy in results between the one-way ANOVA and multiple range comparisons required further investigation.

II) Factorial Analysis of Variance

To assess the effects of multiple information manipulation and the interactions among different information sets presented in the instruction manuals, a 2 (Supplementary Information) X 3 (Base Information) multivariate analysis of variance (MANOVA) design and univariate F-tests were used. The independent variable *Supplementary Information* had two levels of information manipulation namely the absence or presence of a picture of the goal. The independent variable *Base Information* was comprised of three levels of information manipulation namely Words-only manual, Step-by-step pictures with words manual and the three types of arrows presented in combination. The design utilised data from Conditions 1 through 6. The dependent variables used in this analysis were the same measures assessed in the preliminary analysis: a) assembly procedures, and b) testing procedures with their respective performance categories.

Subjective ratings of manual effectiveness and effectiveness of a strategy(ies) employed by subjects during the assembly procedures were also subjected to a 2 (Supplementary Information) X 3 (Base Information) ANOVA.

Results II-1 A) Assembly Performance for Conditions 1 Through To 6

Multivariate Analysis of Variance (MANOVA)

The MANOVA showed significant effects for Supplementary Information ($F(6,55) = 2.28$, $p < 0.05$) and Base Information ($F(16, 108) = 9.47$, $p < 0.001$). The interaction of Supplementary Information by Base Information, however, was not significant ($F(16, 108) = 1.38$, n.s.). Table R-18 in Appendix 20, shows the MANOVA summary table for the overall effects of a picture of the goal and Base Information on performance during the assembly procedures.

The MANOVA showed that both the Supplementary and Base Information manipulation affected the overall assembly performance but no significant interactions occurred between Supplementary Information and Base Information. This finding was further defined by the univariate F-tests and multiple range comparisons as presented in the following sections.

Univariate F-tests for Assembly Performance in Conditions 1 Through To 6

Table R-19 and 20 in Appendix 20 show the univariate F-tests summary tables for Supplementary Information and Base Information, respectively. Table R-21 in Appendix 20, shows the univariate F-tests summary table for the interaction of Supplementary Information by Base Information regarding the assembly procedures.

The multiple range comparisons in the preliminary analysis showed that in most performance categories during the assembly procedures instruction manual: a) Condition-1 versus Condition-5; and b) Condition-2 versus Condition-6 were significantly different to each other. These significant differences can be attributed to the addition of the Step-by-step pictures, and further attributed to the addition of the three types of arrows presented in combination. The latter conclusion, however, can only be validated if and only if: a) Condition-3 versus Condition-5; and b) Condition-4 versus Condition-6 were significantly different to each other. The differences between instruction manual: a) Condition-1 versus instruction manual Condition-5; and b) Condition-2 versus Condition-6, therefore, will not be discussed if: a) Condition-3 versus Condition-5; and b) Condition-4 versus Condition-6 were not significantly different to each other.

a) Time taken to assemble the CPM unit correctly:

The univariate F-tests showed a significant main effect for Base Information ($F(2,60) = 31.85$, $p < 0.0001$) but not Supplementary Information ($F(1,60) = 3.76$, n.s.). The interaction of Supplementary Information by Base Information was also not significant ($F(2,60) = 2.86$, n.s.). The multiple range comparisons (Table R-2 in Appendix 20) showed predicted differences between: a) Condition-1 versus Condition-2 ($q(8, 90) = 9.13$, $p < 0.05$, Newman); b) Condition-1 versus Condition-3 ($q(8, 90) = 18.17$, $p < 0.01$, Newman); and c) Condition-2 versus Condition-4, ($q(8, 90) = 7.78$, $p < 0.05$, Newman). Figure 2 shows the effect of information manipulation on the mean length of time taken to assemble the CPM unit correctly.

The results showed that the hypothesized reduction in the time taken to assemble the CPM unit correctly due to the presence of a picture of the goal was not observed. A picture of the goal, however, facilitated faster times in assembling the CPM unit when combined with the Words-only manual. Conversely, the results supported the hypothesized reduction in the length of time taken to assemble the CPM unit correctly due to the manipulation of Base Information in the instruction manuals. Step-by-step pictures only facilitated faster times in assembling the CPM unit correctly. The arrow information, therefore, had no effect on the

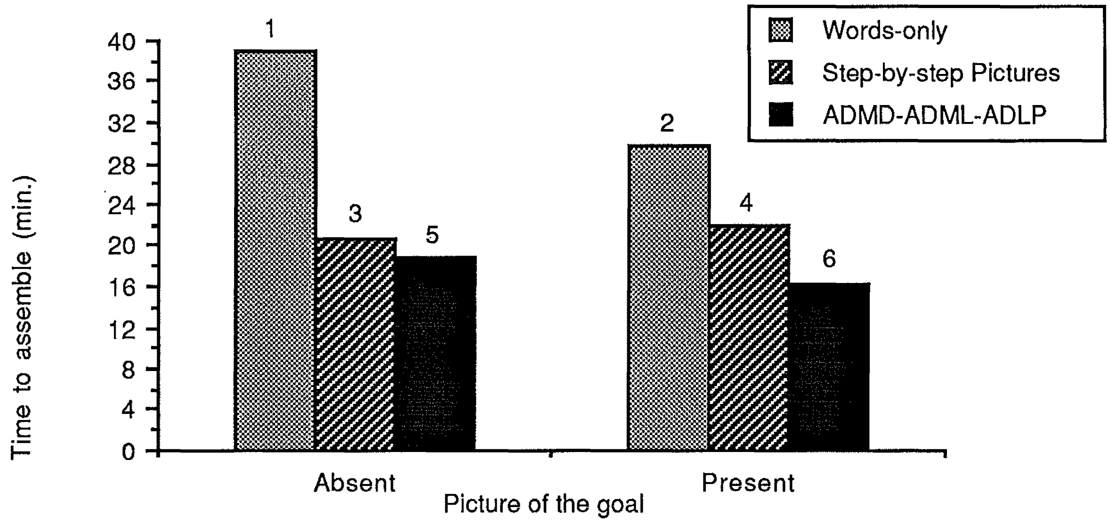

Figure 2: The mean length of time taken to assemble the CPM unit correctly in each instruction manual condition. The Condition number is shown above each bar. ADMD-ADML-ADLP denotes instruction manual with arrows depicting manipulation direction and location, arrows depicting location of the individual parts presented in combination.

length of time taken to assemble the CPM unit correctly. The results showed that having a picture of the goal did not interact with the Step-by-step pictures and/or the three types of arrows presented in combination.

b) Incorrect procedures:

The univariate F-tests showed significant main effects for Supplementary Information ($F(1,60) = 6.03$, $p < 0.05$) and Base Information ($F(2,60) = 27.80$, $p < 0.0001$). The interaction of Supplementary Information by Base Information was also significant ($F(2,60) = 6.17$, $p < 0.005$). The multiple range comparisons (Table R-3 in Appendix 20) showed the hypothesized differences between: a) Condition-1 versus Condition-2 ($q(8,90) = 10.18$, $p < 0.01$, Newman); b) Condition-1 versus Condition-3 ($q(8,90) = 15.45$, $p < 0.01$, Newman); and c) Condition-2 versus Condition-4 ($q(8,90) = 4.36,0.05.$, Newman). Figure 3 shows the effect of information manipulation on the mean number of incorrect procedures made during the assembly task.

The results showed that while the predicted reduction in the number of incorrect procedures due to the presence of a picture of the goal was observed, the reduction was caused by the addition of a picture of the goal to the Words-only manual. Furthermore the results

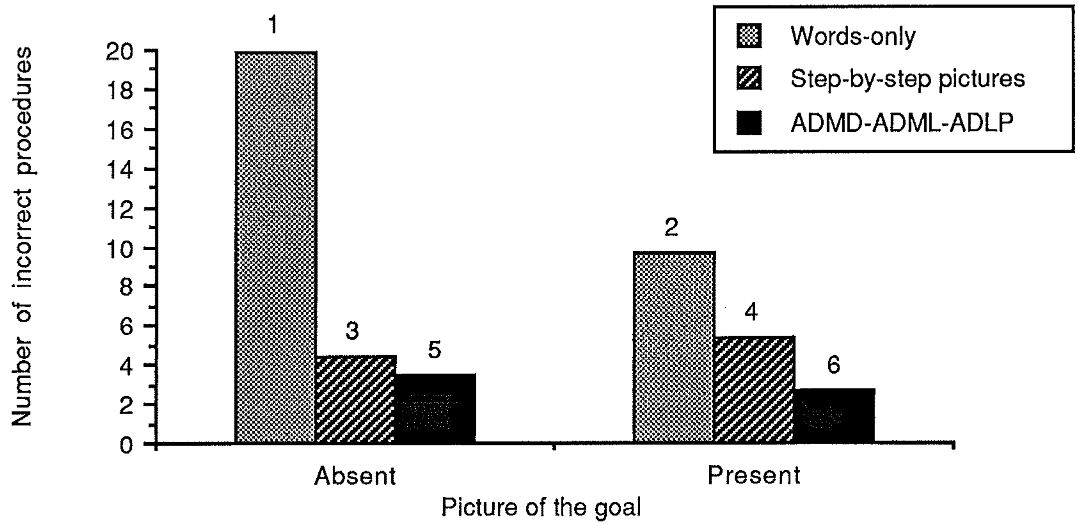

Figure 3: The mean number of incorrect procedures made in each instruction manual condition during the assembly task. The condition number is shown above each bar. ADMD-ADML-ADLP denotes instruction manual with arrows depicting manipulation direction and location, arrows depicting location of the individual parts presented in combination.

supported the hypothesised reduction in the number of incorrect procedures due to the manipulation of Base Information content in the instruction manuals. Step-by-step pictures only reduced the number of incorrect procedures made during the assembly performance. The arrow information, therefore, had no effect on the number of incorrect procedures made during the assembly task.

c) Procedures omitted during the assembly task:

The univariate F-tests showed a significant main effect for Supplementary Information ($F(1,60) = 5.04$, $p < 0.05$) but not Base Information ($F(2,60) = 2.63$, n. s.). The interaction of Supplementary Information by Base Information was also not significant ($F < 1$). The multiple range comparisons (Table R-4 in Appendix 20) showed the predicted differences between: a) Condition-1 versus Condition-2 ($q(8,90) = 0.82$, $p < 0.05$, Newman); and b) Condition-3 versus Condition-5, ($q(8,90) = 0.82$, $p < 0.05$, Newman). Figure 4 shows the effect of information manipulation on the mean number of procedures omitted during the assembly task.

The results showed that while the predicted reduction in the number of procedures omitted due to the presence of a picture of the goal was observed, the reduction was caused by

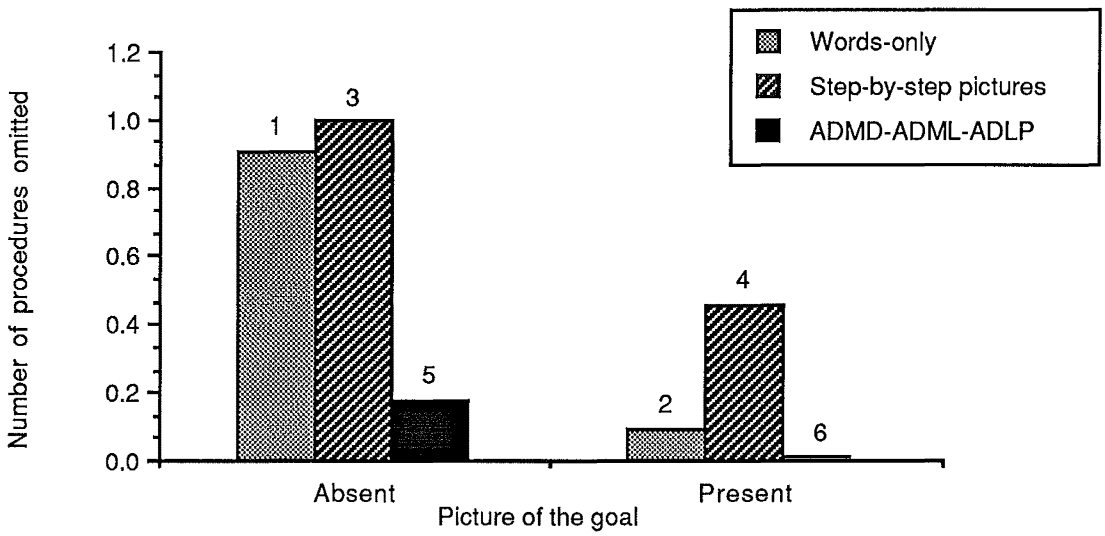

Figure 4: The mean number of procedures omitted in each instruction manual condition during the assembly task. The condition number is shown above each bar. ADMD-ADML-ADLP denotes instruction manual with arrows depicting manipulation direction and location, arrows depicting location of the individual parts presented in combination.

the addition of a picture of the goal to the Words-only manual. A picture of the goal did not reduce the number of procedures omitted when combined with the Step-by-step pictures and/or the three types of arrows presented in combination. Furthermore, the results supported hypothesised reduction in the number of procedures omitted due to the manipulation of Base Information content in the instruction manuals. The three types arrows presented in combination significantly reduced the number of procedures omitted during the assembly task, but only in the absence of a picture of the goal. Step-by-step pictures did not, however, reduce the number of procedures omitted during the assembly task.

d) Extra procedures made during the assembly task:

The univariate F-tests showed a significant main effect for Base Information ($F(2,60) = 19.27, p < 0.0001$) but not Supplementary Information, ($F(1,60) = 1.29$, n.s.). The interaction of Supplementary Information by Base Information was also not significant ($F(2,60) = 3.0$, n.s.). The multiple range comparisons (Table R-5 in Appendix 20) showed the hypothesized differences between: a) Condition-1 versus Condition-2 ($q(8,90) = 2.82, p < 0.05$, Newman); b) Condition-1 versus Condition-3 ($q(8,90) = 5.27, p < 0.05$, Newman); and c) Condition-2 versus

Condition-4 (q(8,90) = 2.09, $p < 0.05$, Newman). Figure 5 shows the effect of information manipulation on the mean number of extra procedures made during the assembly task.

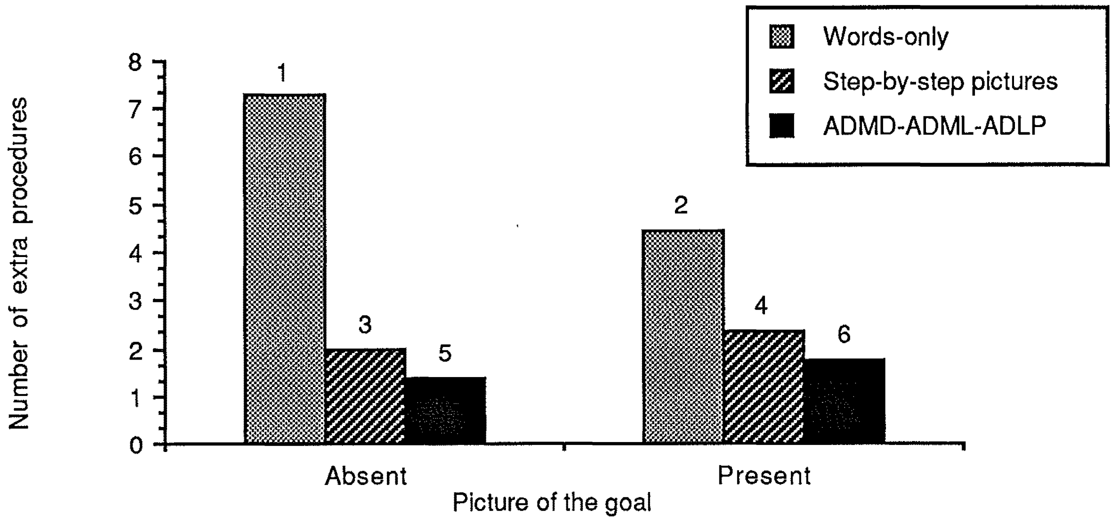

Figure 5: The mean number of extra procedures made in each instruction manual condition during the assembly task. The condition number is shown above each bar. ADMD-ADML-ADLP denotes instruction manual with arrows depicting manipulation direction and location, arrows depicting location of the individual parts presented in combination.

The results showed that the predicted reduction in the number of extra procedures due to the presence of a picture of the goal was not observed. However, a picture of the goal reduced the number of extra procedures made when it was combined with the Words-only manual. Conversely, the results supported the hypothesised reduction in the number of extra procedures made during the assembly task due to the manipulation of Base Information content in the instruction manuals. In either the absence or presence of a picture of the goal, Step-by-step pictures only reduced the number of extra procedures made during the assembly task. The arrow information did not, therfore, reduce the number of extra procedures made during the assembly task. The results also showed that having a picture of the goal did not interact with Step-by-step pictures information and/or the three types of arrows presented in combination.

e) References made to the names of CPM parts:

The univariate F-tests showed a significant main effect for Base Information ($F(2,60) = 33.66$, $p < 0.0001$) but not Supplementary Information ($F(1,60) = 2.25$, n.s.). The interaction for

Supplementary Information by Base Information was also not significant (F(2,60) = 2.39, n.s.). The multiple range comparisons (Table R-6 in Appendix 20) showed the predicted differences between: a) Condition-1 versus Condition-2 (q(8,90) = 6.0 p < 0.05, Newman); b) Condition-1 versus Condition-3 (q(8,90) = 9.36, p < 0.01, Newman); c) Condition-3 versus Condition-5 (q(8,90) = 2.09, n.s., Newman); and d) Condition-4 versus Condition-6 (q(8,90) = 2.09, n.s., Newman). Figure 6 shows the effect of information manipulation on the mean number of references made to the names of CPM parts during the assembly task.

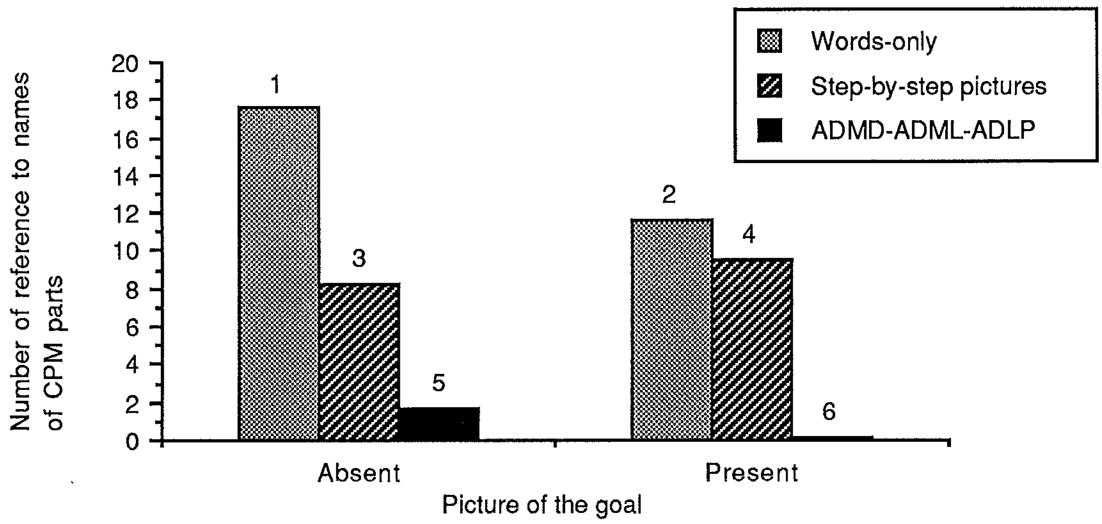

Figure 6: The mean number of references made to the names of CPM parts in each instruction manual condition during the assembly task. The condition number is shown above each bar. ADMD-ADML-ADLP denotes instruction manual with arrows depicting manipulation direction and location, arrows depicting location of the individual parts presented in combination.

The results showed that the predicted reduction in the number of references made to the names of CPM parts due to a picture of the goal was not observed. However, a picture of the goal when combined with Words-only manual reduced the number of references made to the names of CPM parts. In the absence of a picture of the goal, Step-by-step pictures reduced the number of references made to the names of CPM parts. The three types of arrows presented in combination also reduced the number of references made to the names of CPM parts during theassembly procedures. The results also showed that having a picture of the goal did not interact with the Step-by-step pictures and/or the three types of arrows presented in combination.

f) References made to a picture of the goal:

Conditions 1, 3 and 5 were not included in this analysis due to the absence of a picture of the goal in the respective instruction manuals. In this respect a MANOVA was not used to analyse the data. The results presented in this subsection are based on the findings from the one-way ANOVA and multiple range comparisons (Table R-7 in Appendix 20). The one-way ANOVA showed that the information manipulations significantly affected the number of references made to a picture of the goal ($F(5,60) = 6.33$, p , 0.0001). The multiple range comparisons showed that the Step-by-step pictures significantly reduced the number of references made to a picture of the goal (Condition-2 versus Condition-4, $q(8,90) = 3.08$, $p < 0.01$, Newman). The results also showed that there was no significant difference in the number of references made to a picture of the goal between Step-by-step pictures and the three types of arrows presented in combination with Step-by-step pictures. Figure 7 shows the effect of information manipulation on the mean number of references made to a picture of the goal during the assembly task.

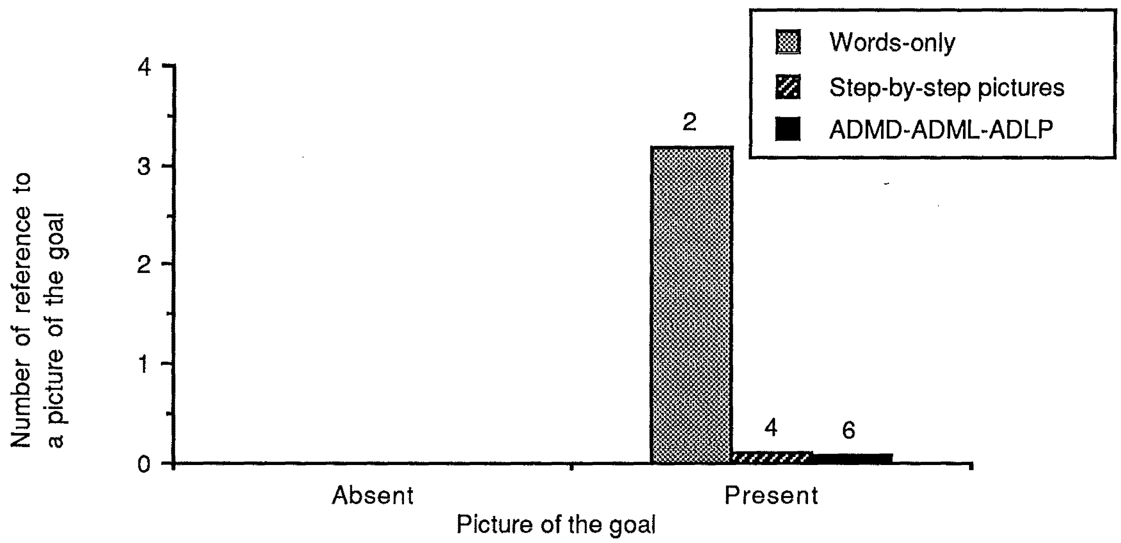

Figure 7: The mean number of references made to a picture of the goal in each instruction manual condition during the assembly task. The Condition number is shown above each bar. ADMD-ADML-ADLP denotes

instruction manual with arrows depicting manipulation direction and location, arrows depicting location of the individual parts presented in combination.

g) **Performance classification:**

The univariate F-tests showed a significant main effect for Supplementary Information ($F(1, 60) = 8.28$, $p < 0.01$) and Base Information ($F(2, 60) = 8.49$, $p < 0.001$). The interaction of Supplementary Information by Base Information, however, was not significant ($F < 1$). The multiple range comparisons (Table R-8 in Appendix 20) showed the predicted differences between: a) (Condition-1 versus Condition-2, $q(8,90) = 0.45$ $p < 0.05$, Newman; b) Condition-1 versus Condition-3 ($q(8,90) = 0.50$, $p < 0.05$, Newman); and c) Condition-2 versus Condition-4, $q(8,90) = 0.36$, $p < 0.05$., Newman). Figure 8 shows the influence of information manipulation on the mean number of assembly performances which required error feedback to assemble the CPM unit correctly.

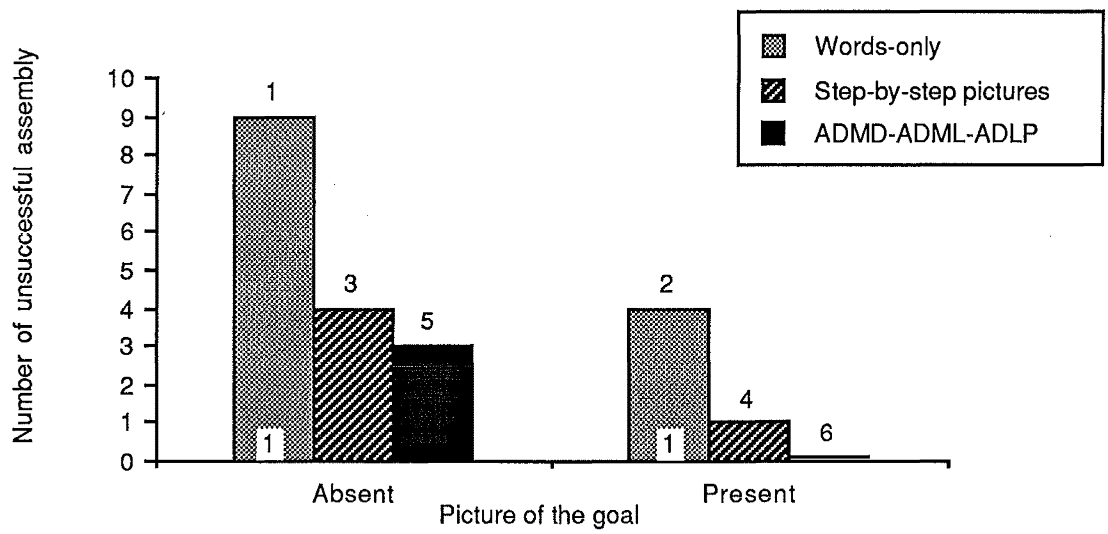

Figure 8: The mean number of unsuccessful assembly performance in each instruction manual condition (those requiring error feedback to assemble the CPM unit correctly). The condition number is shown above each bar. The numbers within the bars represent the mean number of subjects who required a second error feedback, i.e., 3 attempts to assemble the CPM unit correctly. ADMD-ADML-ADLP denotes instruction manual with arrows depicting manipulation direction and location, arrows depicting location of the individual parts presented in combination.

The results showed that a picture of the goal presented in a Words-only manual reduced the amount of error feedback required to assemble the CPM unit correctly. The addition of Step-by-step pictures also reduced the number of assembly performances requiring error feedback. However, the three types of arrows presented in combination had no effect on the number of assembly performances requiring error feedback. The results also showed that having a picture of the goal did not interact with the Step-by-step pictures and/or three types of arrows presented in combination to reduce the amount of error feedback required to assemble the CPM unit correctly.

Summary of Results for assembly procedures in Conditions 1 through to 6:

A picture of the goal was only effective in facilitating superior performances during the assembly procedure when combined with the Words-only manual. Table 2 summarises the effect of a picture of the goal during the assembly procedures.

Table 2: Effect of a picture of the goal on assembly performance. An asterisk denotes superior performance due to a picture of the goal. ADMD-ADML-ADLP denotes instruction manual with arrows depicting manipulation direction and location, arrows depicting location of the individual parts presented in combination.

	Manual		
Performance Category	Words-only	Step-by-step pictures with words	Step-by-step pictures with words & ADMD -ADML-ADLP
1) Time to assemble	*		
2) Incorrect procedures	*		
3) Procedures omitted	*		
4) Extra procedures	*		
5) References to names of CPM parts	*		
6) References to a picture of the goal	—	—	—
7) Performance classification	*		

The addition of Step-by-step pictures in the absence of a picture of the goal, facilitated superior performance during the assembly procedures in five of the six performance categories. The number of procedures omitted was not significantly aided by the addition of the Step-by-step pictures. The addition of Step-by-step pictures in the presence of a picture of the goal, facilitated superior performances during the assembly procedures in five of the seven performance categories. The number of procedures omitted and references to the names of CPM parts were not due to the addition of the Step-by-step pictures.

The addition of the three types of arrows presented in combination, in the absence of a picture of the goal reduced the number of: a) procedures omitted; and b) references made to the names of CPM parts during the assembly task. The addition of the three types of arrows presented in combination in the presence of a picture of the goal reduced the number of references made to the names of CPM parts during the task. Table 3 summarises the effect of Step-by-step pictures and the three types of arrows presented in combination on performance during the assembly procedures.

Table 3: The effect of step-by-step pictures or ADMD-ADML-ADLP presented in combination on assembly performance. An asterik denotes superior performance due to the Step-by-step pictures or ADMD-ADML-ADLP. ADMD-ADML-ADLP denotes instruction manual with arrows depicting manipulation direction and location, arrows depicting location of the individual parts presented in combination.

	Manual			
	Step-by-step pictures with words		Step-by-step pictures with words & ADMD-ADML-ADLP	
	Picture of the goal		Picture of the goal	
Performance Category	Absent	Present	Absent	Present
1) Time to assemble	*	*		
2) Incorrect procedures	*	*		
3) Procedures omitted			*	
4) Extra procedures	*	*		
5) References to names of CPM parts	*		*	*
6) References to a picture of the goal	—	*	—	
7) Performance classification	*	*		

Results II-1 B) Testing Performance for Conditions 1 Through To 6

Multivariate Analysis of Variance:

The MANOVA showed a significant effect for Base Information ($F(12,108) = 5.02$, $p < 0.0001$) but not Supplementary Information ($F(6,55) = 1.98$, n.s.). The interaction of Supplementary Information by Base Information was also not significant ($F(12,108) = 1.19$, n.s.). Table R-22 in Appendix 20, shows the MANOVA summary table for the overall effects of a picture of the goal and Base Information on performance during the testing procedures. The MANOVA showed that Base Information was the only factor which affected the overall testing performance. This finding was further defined by the univariate F-tests and multiple range comparisons as discussed in the following sections.

Univariate F-tests for Testing Performance in Conditions 1 Through 6

Main effects for Supplementary Information:

The univariate F-tests showed no significant effect for Supplementary Information; this was an expected finding. Table R-23 in Appendix 20, shows the univariate F-tests summary table for the six performance[1] categories during the testing procedures. The multiple range comparisons showed, however, that a picture of the goal reduced the number of references made to the names of the CPM parts during the testing procedure (Condition-1 versus Condition-2, $q(8,90) = 1.45$, $p < 0.05$, Newman). Table R-13 in Appendix 20 shows the multiple range comparisons summary table for the mean number of references made to the names of the CPM parts during the testing procedures. Overall, the results showed that a picture of the goal had no effect on testing performance but, when combined with the Words-only manusl, a picture of the goal reduced the number of references made to the names of CPM parts.

Main Effects for Base Information:

The univariate F-tests showed the predicted effect of Base Information on: a) the

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1 Due to the absence of a picture of the goal in Conditions 1, 3, and 5, the variable 'reference to a picture of the goal' was not included in this analysis.

length of time taken to test the CPM unit correctly ($F(2,60) = 6.76$, $p < 0.005$); b) the number of incorrect procedures made ($F(2,60) = 4.83$, $p < 0.01$); c) the number of extra procedures made ($F(2,60) = 4.37$, $p < 0.05$); and d) the number of references made to the names of the CPM parts during the testing procedures ($F(2,60) = 5.23$, $p < 0.0001$). Base Information did not affect the number of procedures omitted ($F(2,60) = 1.49$, n.s.) and the number of unsuccessful testing performances ($F(2,60) = 1.20$, n.s.). Table R-24 in Appendix 20 shows the univariate F-tests summary table for the effect of Base Information on the testing performance categories.

Interactions of Supplementary Information by Base Information during the testing procedures:

The univariate F-tests showed no significant interactions for Supplementary Information by Base Information during the testing procedures as was expected. Table R-25 in Appendix 20, shows the univariate F-tests summary table for the six performance categories during the testing procedures. The results showed that a picture of the goal did not interact with the Step-by-step pictures and/or the three types of arrows presented in combination during the testing procedures.

The following is a presentation of the main effects for Supplementary Information and Base Information during the testing procedures.

Time take to test the CPM unit: The multiple range comparisons (Table R-9 in Appendix 20) supported one of the predicted differences between instruction manuals, Condition-2 versus Condition-4 ($q(8,90) = 1.88$, $p < 0.05$, Newman). Figure 9 shows the influence of information manipulation on the mean length of time taken to test the CPM unit correctly. The results showed that in the presence of a picture of the goal, only Step-by-step pictures reduced the length of time taken to test the CPM unit. The three types of arrows presented in combination did not affect the length of time taken to test the CPM unit correctly.

Incorrect procedures: The multiple range comparisons (Table R-10 in Appendix 20) supported one of the predicted differences, Condition-1 versus Condition-3 ($q(8,90) = 1.91$, $p < 0.05$, Newman) was the only expected effect found. Figure 10 shows the influence of information manipulation on the number of incorrect procedures made during the testing performance.

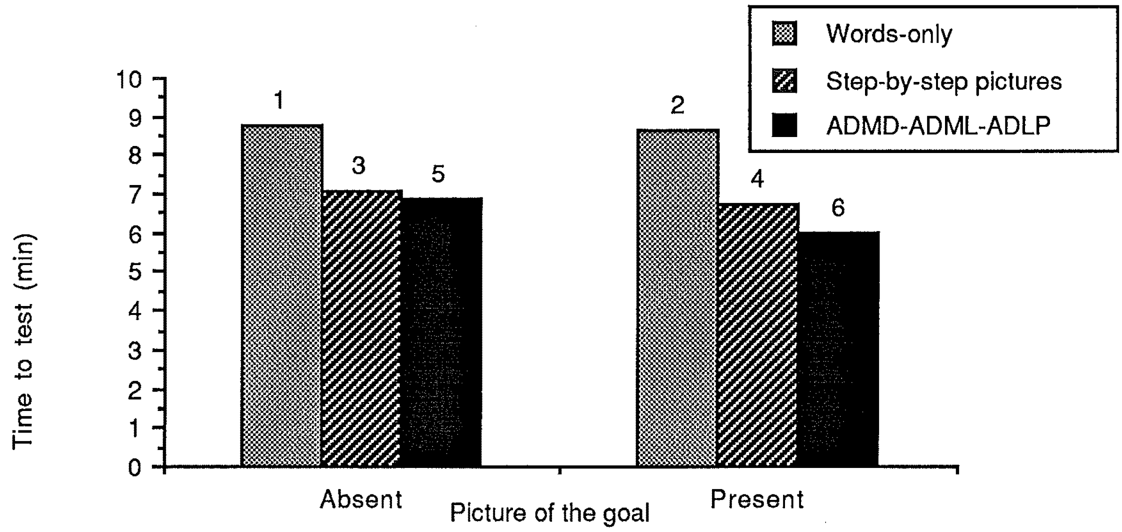

Figure 9: The mean length of time taken to test the CPM unit correctly in each instruction manual conditon. The condition number is shown above each bar. ADMD-ADML-ADLP denotes instruction manual with arrows depicting manipulation direction and location, arrows depicting location of the individual parts presented in combination.

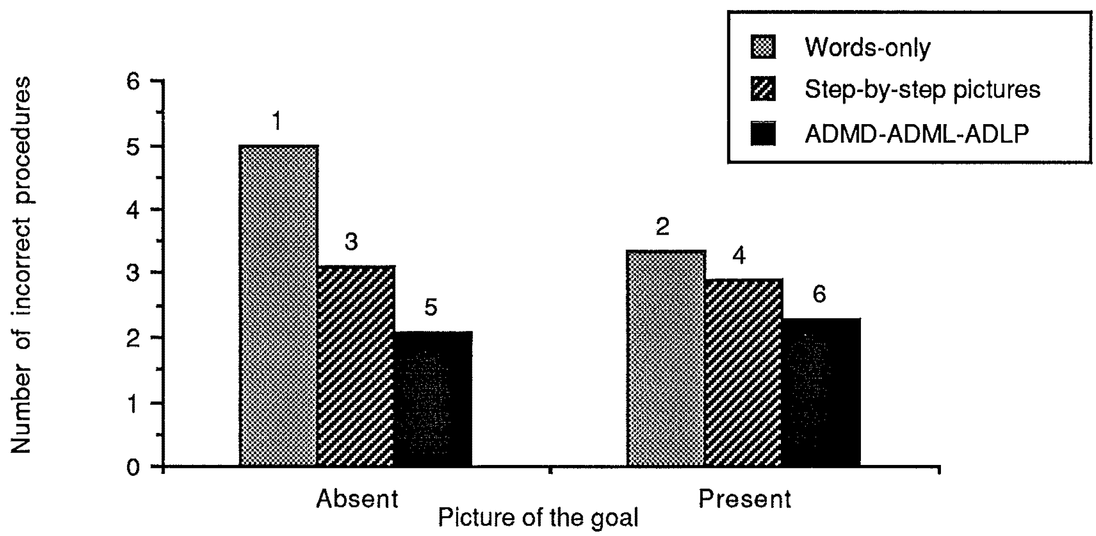

Figure 10: The mean number ofincorrect procedures made during the testing task in each instruction manual condition. The condition number is shown above each bar. ADMD-ADML-ADLP denotes instruction manual with arrows depicting manipulation direction and location, arrows depicting location of the individual parts presented in combination.

The results showed that in the absence of a picture of the goal, only Step-by-step pictures reduced the number of incorrect procedures. The three types of arrows presented in combination did not affect the number of incorrect procedures made during the testing performance.

Extra procedures: The multiple range comparisons (Table R-12 in Appendix 20) supported one of the predicted differences, Condition-1 versus Condition-3 ($q(8,90) = 1.0$, $p < 0.05$, Newman). Figure 11 shows the influence of information manipulation on the number of extra procedures made during the testing performance. The results showed that in the absence of a picture of the goal, only Step-by-step pictures reduced the number of extra procedures. The three types of arrows presented in combination did not affect the number of extra procedures made during the testing performance

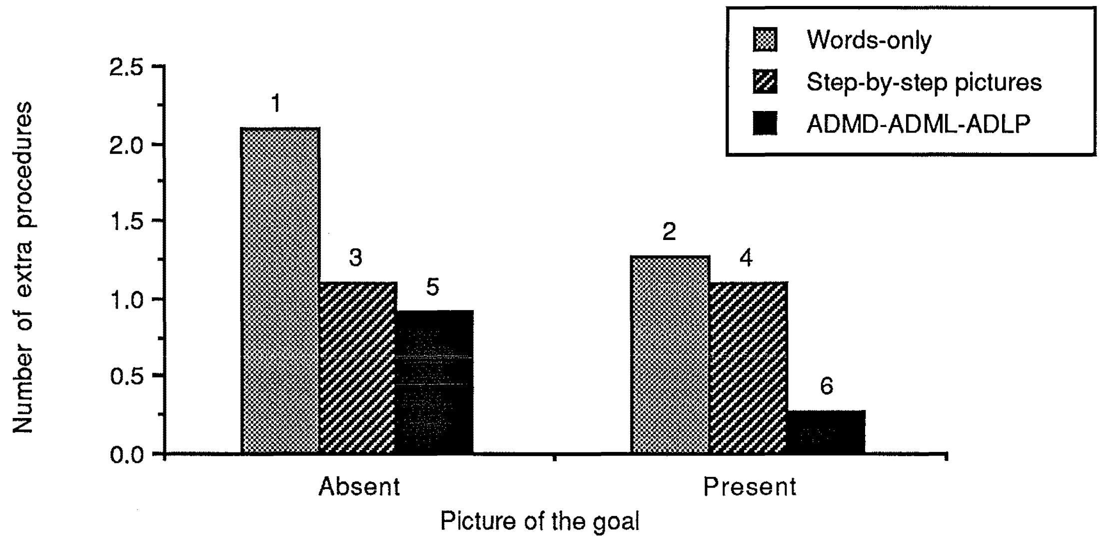

Figure 11: The mean number of extra procedures made during the testing task in each instruction manual condition. The condition number is shown above each bar. ADMD-ADML-ADLP denotes instruction manual with arrows depicting manipulation direction and location, arrows depicting location of the individual parts presented in combination.

Reference to the names of CPM parts: The multiple range comparisons (Table R-13 in Appendix 20) supported one of the predicted differences, Condition-1 versus Condition-3 ($q(8,90) = 2.0$, $p < 0.05$, Newman). Figure 12 shows the influence of information manipulation on the number of references made to the names of the CPM parts during the testing performance. The results showed that in the absence of a picture of the goal, Step-by-step pictures only reduced the number of references made to the names of CPM parts. The three types of arrows presented in combination did not affect the number of references made to the names of CPM parts during the testing performance.

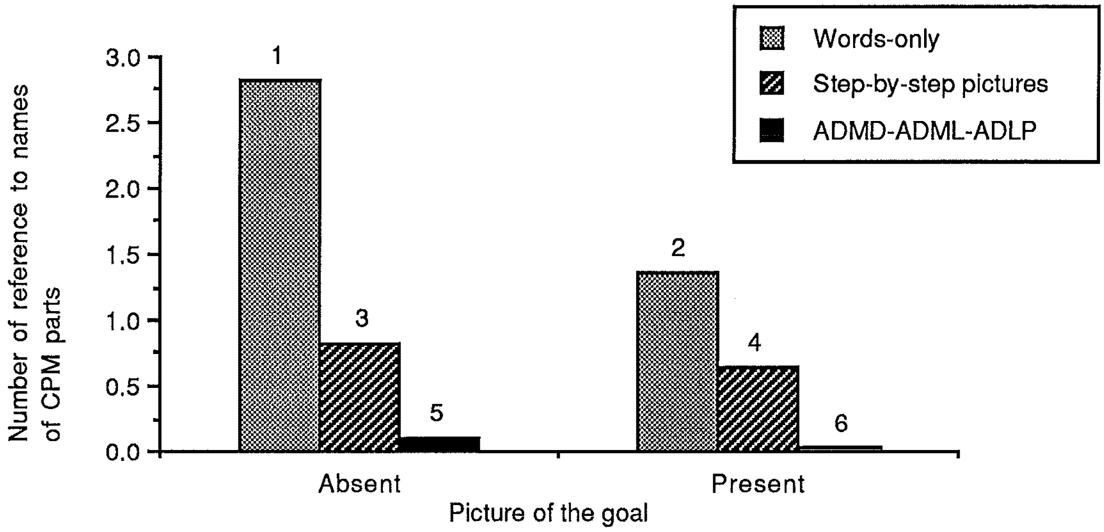

Figure 12: The mean number of references made to the names of CPM parts during the testing task in each instruction manual condition. The condition number is shown above each bar. ADMD-ADML-ADLP denotes instruction manual with arrows depicting manipulation direction and location, arrows depicting location of the individual parts presented in combination.

References to a picture of the goal: Conditions 1, 3 and 5, were not included in this analysis as these instruction manual conditions did not present a picture of the goal. for this reason a MANOVA was not used to analyse the data. The results presented in this subsection are based on the findings from the one-way ANOVA and multiple range comparisons (Table R-14 in Appendix 20). The ANOVA showed that the information manipulations did not significantly affect the number of references made to a picture of the goal ($F(5,60) = 1.0$, n.s., Newman). Although the predicted differences in the overall effect of Base Information were not significant, the multiple range comparisons showed a significant and predicted difference between Condition-2 versus Condition-4 ($q(5,60) = 0.18$, $p < 0.05$, Newman). Figure 13 shows the influence of information manipulation on the number of references made to a picture of the goal during the testing performance.

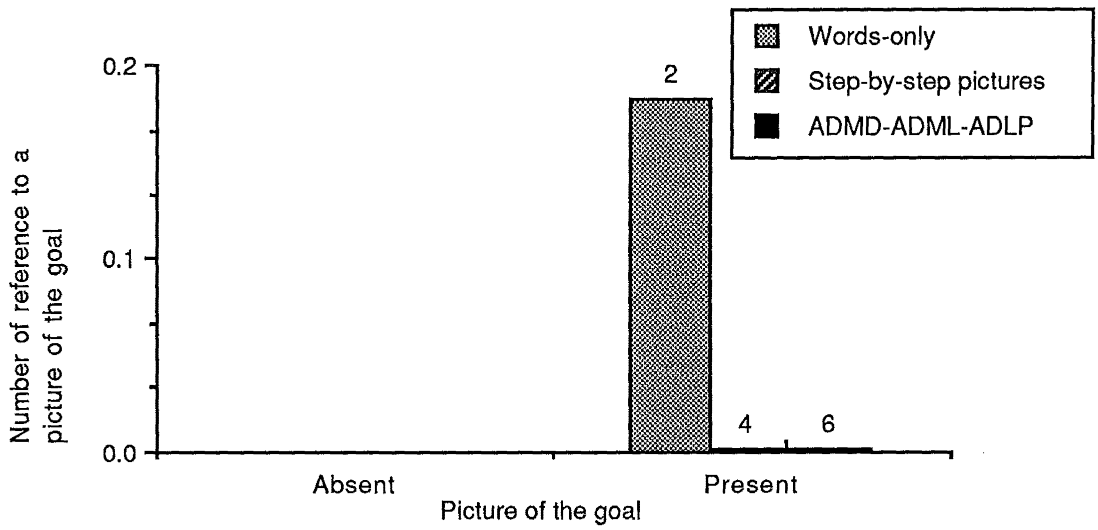

Figure 13: The mean number of references made to a picture of the goal during the testing task in each instruction manual condition. The Condition number is shown above each bar. ADMD-ADML-ADLP denotes instruction manual with arrows depicting manipulation direction and location, arrows depicting location of the individual parts presented in combination.

The results showed that Step-by-step pictures reduced the number of references made to a picture of the goal, whereas the three types of arrows presented in combination did not affect the number of references made to a picture of the goal during the testing performance.

Summary of Results for testing procedures in Conditions 1 through to 6:

A picture of the goal when combined with the Words-only manual reduced the number of references made to the names of CPM parts. Table 4 summarises the effect of a picture of the goal on performance during the testing procedures.

Table 5 summerises the effect of Step-by-step pictures information and the three types of arrows presented in combination of performance during the testing procedures. The addition of Step-by-step pictures in the absence of a picture of the goal, facilitated superior performance regarding the number of: a) incorrect procedures; b) extra procedures; and c) references made to the names of CPM parts during the testing performance. The addition of Step-by-step pictures in the presence of a picture of the goal, facilitated superior performance by reducing the length of time taken to test the CPM unit and the number of references made to a picture of the goal.

Table 4: Effect of a picture of the goal on the testing performance. An asterisk denotes superior performances due to a picture of the goal. ADMD-ADML-ADLP denotes instruction manual with arrows depicting manipulation direction and location, arrows depicting location of the individual parts presented in combination.

	Manual		
Performance Category	Words-only	Step-by-step pictures with words	Step-by-step pictures with words & ADMD -ADML-ADLP
1) Time to Test			
2) Incorrect procedures			
3) Procedures omitted			
4) Extra procedures			
5) References to names of CPM parts	*		
6) References to a picture of the goal	—	—	—
7) Performance classification			

Table 5: The effect of step-by-step pictures or ADMD-ADML-ADLP presented in combination on testing performance. An asterisk denotes superior performance due to the step-by-step picture information or ADMD-ADML-ADLP presented in combination. ADMD-ADML-ADLP denotes instruction manual with arrows depicting manipulation direction and location, arrows depicting location of the individual parts presented in combination.

	Manual			
	Step-by-step pictures with words		Step-by-step pictures with words & ADMD -ADML- ADLP	
	Picture of the goal		Picture of the goal	
Performance Category	Absent	Present	Absent	Present
1) Time to Test		*		
2) Incorrect procedures	*			
3) Procedures omitted				
4) Extra procedures	*			
5) References to names of CPM parts	*			
6) References to a picture of the goal	—	*	—	
7) Performance classification				

The addition of the three types of arrows presented in combination either in the absence or presence of a picture of the goal did not facilitate superior performance during the testing procedures. Table 5 summarises the effect of Step-by-step pictures and the three types of arrows presented in combination on performance during the testing procedures.

Results II C) 2 x 3 ANOVA for Subjective Ratings

II C-1) Manual effectiveness ratings in Conditions 1 through to 6:

The ANOVA showed a significant main effect for Base Information ($F(1,60) = 6.35$, $p < 0.005$) but not Supplementary Information ($F < 1$). The interaction of Supplementary Information by Base Information was also not significant ($F < 1$). Table R-26 in Appendix 20 shows the ANOVA summary table for the manual effectiveness ratings for the assembly procedures. The multiple range comparisons (Table R-16 in Appendix 20) supported one of the predicted differences for manual effectiveness ratings between different instruction manual conditions, Condition-1 versus Condition-3 ($q(8,90) = 1.64$, $p < 0.05$, Newman).

The results showed that a picture of the goal had no effect on the manual effectiveness ratings. However, a picture of the goal did not interact with the step-by-step picture information and/or the three types of arrows presented in combination when subjects rated the effectiveness of instruction manual condition. The results also showed that in the absence of a picture of the goal, step-by-step picture information increased subjects' effectiveness ratings of an instruction manual condition. The arrows information did not affect subjects' manual effectiveness ratings.

II C-2) Strategy(ies) effectiveness ratings in Conditions 1 through to 6:

The ANOVA showed a significant main effect for Supplementary Information ($F(1,60) = 8.47$, $p < 0.01$) but not Base Information($F(2,60) = 1.65$, n.s.). The interaction of Supplementary Information by Base Information was also not significant ($F < 1$). Table R-27 in Appendix 20 shows the ANOVA summary table for the strategy(ies) effectiveness ratings employed by subjects during the assembly procedures. The multiple range comparisons (Table R-17 in Appendix 20) supported one of the predicted differences for strategy effectiveness ratings between the different instruction manual conditions, Condition-1 versus Condition-2 ($q(9,80) = 2.10$, $p < 0.05$, Newman).

The results showed that a picture of the goal when combined with the Words-only manual, increased subjects' ratings of their strategy's effectiveness. However neither Step-by-step pictures nor the three types of arrows presented in combination did not affect subjects' judgement of their strategy(ies) effectiveness during the assembly procedures. The results also showed that a picture of the goal did not interact with the step-by-step picture information and/or the three types of arrows presented in combination when subjects rated the effectiveness of their strategy(ies).

Results III) Correlations Between the Subjective Ratings and Performance During the Assembly Procedures for Conditions 1 Through To 9

The correlations showed that in instruction manual Conditions 1 through to 9 subjects' judgments regarding the effectiveness of instruction manuals in assisting assembly performance did not relate to subjects' judgements concerning the effectiveness of the strategy (ies) employed during the assembly procedures. The correlational analyses showed, however, that subjective ratings did correlate with the scores in a number of performances categories during assembly of the CPM unit. These findings are presented in the following subsections of the results. Tables R-28 through to R-36 in Appendix 20 show the correlation matrix summary table for Conditions 1 through to 9, respectively.

Correlations in instruction manual Condition-1 (Table R-28 in Appendix 20):

A negative relationship was found between the manual effectiveness ratings and the time taken to assemble the CPM unit ($r = -0.57$, $p < 0.05$). There were no further correlations between the scores for assembly performance and the remaining five performance categories and the ratings of manual or strategy effectiveness, respectively, in instruction manual Condition-1. The results showed, therefore, that subjects rated the effectiveness of instruction manual Condition-1 lower as the length of time taken to assemble the CPM unit correctly, increased.

Correlations in instruction manual Condition-2 (Table R-29 in Appendix 20):

There were no correlations between the scores for assembly performance in all six performance categories and the ratings of manual or strategy effectiveness, respectively, in instruction manual Condition-2.

Correlations in instruction manual Condition-3 (Table R-30 in Appendix 20):

There were no correlations between the scores for assembly performance in all six performance categories and the ratings of manual or strategy effectiveness, respectively, in instruction manual Condition-3.

Correlations in instruction manual Condition-4 (Table R-31 in Appendix 20):

Negative correlations were found between the manual effectiveness ratings and the number of: a) incorrect procedures ($r = -0.72$, $p < 0.01$); b) procedures omitted ($r = -0.68$, $p < 0.01$); c) extra procedures ($r = -0.65$, $p < 0.01$); and d) references made to a picture of the goal ($r = -0.77$, $p < 0.005$) during the assembly procedures. The results showed that subjects rated the effectiveness of instruction manual Condition-4 lower as subjects performed a greater number of incorrect and extra procedures, omitted procedures and increased their references to the names of CPM parts.

Negative correlations were also found between the ratings of strategy effectiveness ratings and the number of incorrect procedures ($r = -0.63$, $p < 0.05$), and the mean number of unsuccessful assembly performances ($r = -0.61$, $p < 0.05$), respectively. The results showed, therefore, that subjects rated the effectiveness of instruction manual Condition-4 lower as the number of incorrect procedures increased and were unsuccessful in their first attempt to assemble the CPM unit correctly.

Correlations in instruction manual Condition-5 (Table R-32 in Appendix 20):

Negative correlations were found between the manual effectiveness ratings and the time taken to assemble the CPM unit ($r = -0.73$, $p < 0.005$), and the number of procedures omitted during the assembly task ($r = -0.64$, $p < 0.05$), respectively. The results showed, therefore, that subjects rated the effectiveness of instruction manual Condition-5 and the strategy(ies) employed during the assembly procedures as lower when the number of procedures omitted and length of time taken to assemble the CPM unit correctly increased. The scores from the remaining performance categories did not correlate with the subjective ratings.

Correlations in instruction manual Condition-6 (Table R-33 in Appendix 20):

There were no correlations between the scores for assembly performance in all six performance categories and the ratings of manual or strategy effectiveness, respectively, in instruction manual Condition-6.

Correlations in instruction manual Condition-7 (Table R-34 in Appendix 20):

Negative correlations were found between the manual effectiveness ratings and the time taken to assemble the CPM unit ($r = -0.53$, $p < 0.05$) and the number of incorrect procedures made during the assembly task ($r = -0.64$, $p < 0.05$). The results showed, that subjects rated the effectiveness of instruction manual Condition-7 lower as subjects performed a greater number of incorrect procedures and the length of time taken to assemble the CPM unit correctly, increased.

A negative correlation was found between the strategy effectiveness ratings and the number of references made to a picture of the goal ($r = -0.66$, $p < 0.05$). The results showed, therefore, that subjects rated the effectiveness of the strategy(ies) they employed when utilising instruction manual Condition-7 lower as the number of references made to a picture of the goal during the assembly procedures increased.

Correlations in instruction manual Condition-8 (Table R-35 in Appendix 20):

Negative correlations were found between the manual effectiveness rating and the time taken to assemble the CPM unit ($r = -0.56$, $p < 0.05$) and the number of references made to the names of the CPM parts during the assembly task ($r = -0.55$, $p < 0.05$), respectively. The results showed that subjects rated the effectiveness of instruction manual Condition-8 lower when the number of references to the names of the CPM parts and the length of time taken to assemble the CPM unit correctly increased.

A negative correlation was also found between ratings of strategy(ies) effectiveness and the number of references made to the names of CPM parts during the assembly procedures ($r = -0.56$, $p < 0.05$). The results showed, therefore, that subjects rated the effectiveness of the strategy(ies) they employed when utilising instruction manual Condition-8 lower as the number of references made to names of the CPM parts during the assembly procedures increased.

Correlations in instruction manual Condition-9 (Table R-36 in Appendix 20):

A negative correlation was found between the strategy(ies) effectiveness ratings and the number of extra procedures made during the assembly task ($r = -0.56, p < 0.05$). The results showed, therefore, that subjects rated the effectiveness of the strategy(ies) they employed when utilising instruction manual Condition-9 lower as the number extra procedures made during the assembly procedures increased.

Summary of the Correlations for the Subjective Ratings:

Overall the results showed that an increase in the length of time taken to assemble the CPM unit and the number of errors made during the assembly procedures were related to a decrease in the ratings of manual or strategy effectiveness, respectively. The scores from different performance categories correlated with the subjective ratings for each instruction manual condition. Table 6 shows a summary of the significant correlations between the manual effectiveness ratings and performance scores, and Table 7 a summary of the significant correlations between the strategy effectiveness ratings and performance scores during the assembly procedures.

Table 6: Correlations between the manual effectiveness ratings and performance scores during the assembly procedures for Conditions 1 Through to 9.

Performance Category	Instruction Manual Conditions								
	1	2	3	4	5	6	7	8	9
1) Time to assemble	-0.57	—	—	—	-0.73	—	-0.53	-0.58	—
2) Incorrect procedures	—	—	—	-0.72	—	—	-0.64	—	—
3) Procedures omitted	—	—	—	-0.68	-0.64	—	—	—	—
4) Extra procedures	—	—	—	-0.64	—	—	—	—	—
5) Reference to names of CPM parts	—	—	—	—	—	—	—	-0.55	—
6) Reference to a picture of the goal	—	—	—	-0.77	—	—	—	—	—
7) Performance classification	—	—	—	—	—	—	—	—	—

Table 7: Correlations between the strategy effectiveness ratings and performance scores during the assembly procedures for Conditions 1 Through to 9.

Performance Category	Instruction Manual Conditions								
	1	2	3	4	5	6	7	8	9
1) Time to assemble	—	—	—	—	—	—	—	—	—
2) Incorrect procedures	—	—	—	-0.63	—	—	—	—	—
3) Procedures omitted	—	—	—	—	—	—	—	—	—
4) Extra procedures	—	—	—	—	—	—	—	—	-0.56
5) Reference to names of CPM parts	—	—	—	—	—	—	—	-0.56	—
6) Reference to a picture of the goal	—	—	—	—	—	—	-0.66	—	—
7) Performance classification	—	—	—	-0.61	—	—	—	—	—

DISCUSSION

The results from this study have been organised under four main discussion topics. The topics are consistent with the information manipulations used in this experiment: (I) words-only information; (II) a picture of the goal; (III) step-by-step pictures information; and (IV) arrows information depicting manipulation direction, manipulation location, or location of the individual parts. The discussion sections concerned with the results from the arrow manipulation have been divided into sub-sections on the basis of the arrows being presented either individually, in a two-, or three-arrow combination. An overview of the results will be presented as an introduction to each section of the discussion. The results are then organised and discussed according to the main principles which have emerged from this study.

The literature review showed that previous research (Bieger & Glock, 1984-85; Booher, 1975; Brody, 1984; Smith & Goodman, 1984; Stone & Glock, 1981; Szlichcinski, 1979a, 1980) has not addressed the functional utility of augmenting pictorial information presented in instruction manuals. Previous research has placed an emphasis on studying the information content in instruction manuals or information sets designed to communicate concepts, general information, or simple procedures rather than the functional utility of pictures. These literatures will be used to critically review the results and principles that emerged from the data for the Words-only and Step-by-step pictures with words instruction manual conditions. However, due to the exploratory nature of the present study, only limited comparisons can be made between the previous work and the finding from the information addition of arrows to a picture-text instruction format. There are no studies to date which have addressed the effect of different types of arrows information on the effectiveness of instruction manuals on proceduralised tasks.

Results from the arrow manipulations will be discussed in relation to their utility as information which guides the reader to relevant information or action. The results will be presented as evidence for the theoretical principle concerning the functional potential of pictorial material in instruction manuals. Research concerned with picture perception (Friedman & Stevenson, 1980; Gibson, 1971, 1979; Gibson & Levin, 1975; Hagen ,1980, 1986; Ryan & Schwartz, 1956; Watt, 1990), the role of pictures in communication and the field of ergonomics (Bagget & Ehrenfeucht, 1988; Broadbent, 1977; Brody & Legenza, 1980; Gropper, 1963; Hodgkinson & Hughes, 1982; Norman, 1988; Pick, 1965; Sanders & McCormick, 1987; Severin, 1967a; Smith & Goodman, 1984; Szlichcinski, 1979a, 1980) will be used as a reference points from which to extend the findings of the present study toward a theoretical principle and prescriptive discipline regarding the functional potential of pictorial materials and their modification.

I. Words-Only

The results showed that the Words-only manual (W) was sufficient to aid completion of the assembly procedures within the performance criteria set for this experiment. The performance criteria required subjects to assemble the CPM unit within sixty minutes and in no more than three attempts or error feedback. As expected, however, the Words-only manual produced the poorest assembly performance in the experiment.

The Words-only manual (W) was also sufficient to aid completion of the testing procedures. Results from the testing procedures followed the same pattern of results as for the assembly task. Similarly, subjects rated Words-only as the most ineffective instruction manual element in aiding performance and enhancing the utilisation of the strategy employed during the assembly procedures. Results from the correlations further showed that the longer subjects took to assemble the CPM unit correctly, the less effective they rated the Words-only manual in aiding performance during the assembly task.

Overall, performance on the assembly and testing tasks utilising the Words-only manual in comparison to the remaining eight instruction manual conditions, produced the worst assembly and testing performances, but was sufficient to meet the performance criteria.

(A) Text-only format was validated as containing sufficient information to aid performance on the tasks within the set criteria. This result supports the hypothesis of the present study that a Words-only manual would results in the least effectual performance across all nine conditions. Similarly, this results also supported the literatures (Booher, 1975; Braby, et al., 1982; Stone & Glock, 1981), namely that text-only format (no pictures or illustrations), compared with a text-picture format, was the least effective method by which to convey information for a proceduralised task. Booher (1975) suggested that the superior performances produced by the utilisation of a picture-text manual was related to the two different paths of information processing used in the comprehension of picture-text material. Booher argued that the printed text is comprehended or translated into a step-by-step routine via the verbal channel, and the pictorial material is comprehended via the visual channel in a time-sharing manner. The two forms of comprehension, therefore, complemented each other and provided the reader with advanced information which guided their actions at all times. In my opinion, Booher's (1975) account regarding the superiority of the picture-words instruction format is consistent with Stone & Glock's (1981) account of their results. Stone & Glock concluded that the presentation of printed text with line drawings gave readers an alternative source of information, whereby, the reader could clarify an unclear message in either the text or illustrations by referring to the pictures or words, respectively.

Booher (1975) and Stone & Glock 's (1981) explanations imply that if, in the absence of pictorial material, the word instructions were unclear there would be no alternative source of information. Therefore, a persons reading the text-only manual may not receive the whole message. This may result in the person committing errors and employing a trial-error strategy in order to: a) correct the errors; or b) to comprehend the whole message. Results from the present study suggest that subjects were confronted with this situation. Subjects in the Words-only instruction manual condition committed the highest number or errors, and exploratory behaviours. In addition, subjects required a greater number of error feedback and took the longest time to complete the assembly task correctly.

These results also supports Severin's (1967a, 1967b) notion of cue summation. The text-only instruction manual provided the least amount of information gain because summation between different cues was not possible. The superior performance of the remaining eight instruction manual conditions compared to the text-only format suggests that learning increased as the number of available information increased. The results, therefore, appear to be consistent with Stone & Glock's (1981) explanation concerning the additive and complementary nature of multiple-channels of information in printed instructions. The underlying premise is that a text-only format does not provide or allow for addition or summation of information.

(B) ***Limitations of text-only format for instructing and aiding performance in novel and complicated proceduralised tasks.*** The high number of exploratory behaviours (extra procedures and references to the names of CPM parts) performed by subjects in the Words-only instruction manual condition suggests that subject were searching for more, or an alternative source of information to the printed text. The high number of errors (incorrect procedures, i.e., *errors of commission* and procedures omitted, i.e.,*errors of omission*; Park, 1987) and the longer length of time taken by subjects to complete the assembly task in the absence of a picture of the goal, suggests that a trial-error strategy was used by subjects to complete the assembly task. The high amount of error feedback required to complete the task also suggests that the Words-only manual did not contain sufficient information for subjects to monitor the errors committed or the procedures omitted during the assembly task. Therefore, subjects were unable to correct or *reverse* the errors made prior to the *completion* [1] of the task.

The results suggest that the Words-only instruction manual was an inadequate information set to perform novel and complicated proceduralised tasks efficiently, compared to the other eight instruction manual conditions. The results from the subjective ratings support this claim. The negative relationship between the manual effectiveness ratings and the length of time taken to complete the assembly task correctly, suggested that subjects found the Words-only manual to be slow and difficult to follow, therefore inefficient. An alternative source of information or additional information may be a necessary requirement in a text-only format if the number of exploratory behaviours and errors are to be reduced during a novel and proceduralised task. The additional information may be used by people to monitor errors and thus avoid *irreversible errors* (Lewis , 1981), e.g., using a product which has been assembled incorrectly and causing a personal injury or permanent damage to the product.

(C) ***The population's reading skills generated a strict criteria for the text-only format.*** It is interesting to note that the sufficiency criteria the Words-only instruction manual was established by using a literate and reading-proficient population namely, university students. The results showed that the proceduralised tasks using the CPM unit were complicated for a literate subject population. It is possible that a non-literate population or persons who are not as proficient as subjects used in this study, may have performed at a level lower than the

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1 Error feedback were provided for the subject in he or she had indicated that he or she had *completed* the task, but were unsuccessful.

subjects assigned to the Words-only instruction manual condition in this study. This suggestion is, however, speculative as no measure of reading aptitude was incorporated in the methodological design. Future research may consider including a reading measure as part of the base line performance assessment.

Consistent with the idea of literacy are the findings from Braby et al. (1982). They found that subjects with a low general aptitude performed worse, consistently, than subjects with a high general aptitude when given a text-only manual. This finding held across all their experimental sessions. However, when subjects with the low aptitude used the learning aid manual (i.e., pictorial elements modified with lines), their performance improved and was better than the performance of subjects with the high aptitude when they used the text-only manuals. Braby et al.'s (1982) findings supported the assertion that people who are illiterate or have a limited reading proficiency may benefit from pictorial information in instruction manuals (Booher, 1975), and that learning aid manuals can be used by a population with varying degrees of aptitudes (Braby et al., 1982). The literature, therefore, supports this study's claim that more information or an alternative source of information to a text-only instruction manual is necessary for people to complete novel and complicated proceduralised tasks, successfully.

II. Picture Of The Goal

The results showed that the presence of a picture of the goal in the introductory material did not significantly increase or decrease the length of time taken to read the introductory material. This result was contrary to the hypothesis that subjects would take more time to read the introductory information when a picture of the goal was present in the introductory material.

The addition of a picture of the goal to the Words-only manual (W-PG) facilitated superior assembly performance across all six performance categories when compared with the performance utilising the Words-only manual (W). A different pattern of results was found for the testing procedures. The addition of a picture of the goal to the Words-only manual reduced only the number of references made to the names of the CPM parts. The results, therefore, confirmed the hypothesis that a picture of the goal would enhance performance during the assembly procedures.

The addition of a picture of the goal to the Step-by-step pictures manual (PW) and to the Step-by-step pictures with words and the three types of arrows presented in combination (PW-ADMD-ADML & ADLP) had no effect on neither the assembly nor testing performance. This finding was contrary to the hypothesis of the present study.

Subject's did not rate manuals with a picture of the goal as a more effective instruction manual in aiding performance during the assembly procedures in compared to manuals which did not contain a picture of the goal. This pattern of results was consistent throughout the experiment. The results did not support the hypothesis that instruction manuals with pictorial content would be rated as a more effective format for successful completion of the assembly task. Subjects' judgments of their strategy's effectiveness, however, were increased when a picture of the goal was present in the Words-only manual, but not when it was present with the Step-by-step pictures manual, or with the Step-by-step pictures with words and the three types of arrows presented in combination.

Results from the correlations showed that the subjective ratings taken when a picture of the goal was added to the Words-only manual, or to the Step-by-step pictures with words and the three arrows presented in combination manual did not relate with scores for the performance behaviours. The subjective ratings taken when a picture of the goal was added to the Step-by-step pictures with words manuals, however, were negatively related to a number of performance behaviours during the assembly task.

Overall, the results showed that a picture of the goal enhanced assembly but not testing performance when combined with the Words-only manual. Results from the ratings and correlations also showed that subjects judgements regarding the effectiveness of a picture of the goal when added to the Words-only manual were inconsistent with the scores of the assembly performance behaviours.

(A) ***Subjects in each instruction manual condition read all of the introductory materials.*** The results showed that there were no differences in the length of time taken by subjects to read the introductory materials irregardless of the presence or absence of a picture of the goal. Two explanations are suggested to account for this behaviour. First, the presence (versus absence) of a picture of the goal did not limit the amount of introductory text subjects read. This result supports Booher's (1975) and Haber's (1970) suggestion that the comprehension of pictures does not interfere with the comprehension of written words. The results also supports Wright et al.'s (1982) finding that people are more likely to read *all* the instructions for complex electrical goods or unfamiliar products, as subjects took a similar length of time to read the introductory materials. A second possible explanation, however, is that subjects were following the experimenter's verbal instruction of reading, "the first 5 or 6 pages of this manual", which contained all the introductory material. As subjects were performing within an experimental context, they may have been motivated to read all of the introductory material. The length of time taken by subjects to read the introductory material may, therefore, be a reflection of the populations reading skills, i.e., psychology students at the University of Canterbury read five pages of text at a similar rate.

(B) ***A picture of the goal as a functional informational element.*** The finding that a picture of the goal facilitated superior assembly performance across all six performance categories compared to the Words-only manual (no pictorial material) is consistent with Bieger & Glock's (1984-85) finding that a more *complete* set of instructions, or those which contain pictures facilitates superior performance (less time and less errors) on an assembly task. As Bieger & Glock suggested a picture of the finished product can depict information which gives meaning to the other informational elements in the manual. The significant effect of a picture of the goal on the assembly performance also supports Bagget & Ehrenfeucht (1988) study. Bagget & Ehrenfeucht found that having an accurate expectation (i.e., conceptual model) in an assembly task facilitates superior performance on the task. The results suggest that a picture of the goal served as an informational element which provided subjects with an accurate expectation of the object's (CPM unit's) finished form.

The superior assembly performance facilitated by a picture of the goal can be generalised to support Smith & Goodman's (1984) finding that an explanatory schema facilitates superior performance on proceduralised tasks. Although their study looked at the effectiveness of rationales provided for certain behaviours, the results from the present study suggest that a picture of the goal was meaningful to the subjects, or provided clarification for actions. The fact that subjects rated manuals which contained a picture of the goal as both an effective manual and as enhancing the effectiveness of strategies employed during the assembly task, supports the claim that a picture of the goal is a source of meaningful information.

The reduction in the length of time taken to assemble the CPM unit and the increase in the number of references to a picture of the goal suggests that subjects utilised the fully assembled picture of the CPM unit as a reference point. In my opinion, the results also support Norman's (1988) claim that a good conceptual model provides individuals with the means to predict the effects of his or her actions. A picture of the goal may have been used by subjects to predict or judge whether their actions were correct or incorrect in relation to the goal, thus either confirming or allowing subjects to choose another course of action. In turn, these *predictions* reduced the number of errors and error feedback required to assemble the CPM unit correctly. Similarly, subjects may have been able to correct the errors prior to completion of the task (Cutting, 1982). These assertions are supported by the results which showed that a greater number of subjects required error feedback to successfully complete the CPM unit when a picture of the goal was absent. In my opinion, this result also suggests that subjects had difficulty monitoring the errors they had made in the absence of a picture of the goal thus, contributing to the error (Norman, 1981 & 1988; Rasmussen, 1986; Wagenaar et al., 1990) of thinking that the CPM unit was assembled correctly.

The differences in assembly performance between subjects who received versus subjects who did not receive a picture of the goal were not reflected in the ratings of manual effectiveness. Subjects who received a picture of the goal did not rate the manual as more effective that subjects who did not receive a picture of the goal. The inconsistency between the performance scores and ratings may be due to the fact that the methodological design and effectiveness questionnaires did not allow subjects to make a comparison between the two manuals.

(C) ***Learning occurred during the assembly task.*** The results showed that there were no significant differences between the performance categories during the testing procedures. There are three possible explanations to account for the overall consistent performance on the testing task. First, the results suggest that a picture of the goal was not as effective in facilitating a superior performance during the testing as opposed to the assembly procedures. Second, it is possible that the testing procedures comprised of a more concise and easier task than the assembly procedures. Third, it is also possible that that learning occurred during the assembly procedures and thus, the testing procedures were no longer a novel task for the subjects, i.e., they had reasonable knowledge and accurate expectations about the CPM unit. The results which showed that the number of references made to the names of CPM parts was reduced during the testing procedures suggests that subjects had learnt or acquired some degree of knowledge concerning the names of the CPM parts. This supports the claim that learning occurred during the proceduralised assembly of the CPM unit.

Braby et al., (1982) found that practice was an important aspect of learning which facilitated superior manipulation performances on different types of equipment. The assembly task in the present study may, therefore, have resembled a *practice* session in which subjects learnt and acquired fundamental information concerning the CPM unit. This information may have facilitated an efficient and accurate performance on the testing task.

It is of interest to note, however, that the number of references made to the names of CPM parts during the testing procedures was reduced in the instruction manual condition which contained a picture of the goal. This finding suggests that a picture of the goal provided some degree of additional meaning or useful information about the CPM unit for subjects during the testing procedures.

(D) ***Reliance on a picture of the goal diminished when step-by-step pictorial material was introduced.*** The results showed that a picture of the goal did not facilitate further performance improvements when it was added to either the Step-by-step pictures with words or the Step-by-step pictures with words with the three types of arrows presented in combination format. The overall results from the experiment suggest that the step-by-step pictures provided such a substantial amount of information that reliance on a picture of the goal during the tasks was limited. This assertion is supported by the results which showed that there was no significant difference in the ratings of manual or strategy effectiveness for a Step-by-step pictures with words instruction format in the presence or absence of a picture of the goal. This finding suggests that adequate information was presented in the step-by-step picture instruction irregardless of a picture of the goal. These results support the claim that subjects reliance on a picture of the goal as a source of information diminishes in the presence of step-by-step picture instructions.

The results also suggests that the inclusion of a picture of the goal in a text-only format, presents an optimal instructional format for this type of pictorial material. Subjects rated the effectiveness of the strategies they employed as increasing in the presence of a picture of the goal in the Words-only manual (W), but not when it was present with the Step-by-step pictures manual (PW) or with the Step-by-step pictures with words and the three types of arrows presented in combination (PW-ADMD-ADML & ADLP). This finding implies that when people are given text-only instructions with which to perform a novel and proceduralised task, the presence of a picture depicting the end product can facilitate the utilisation of more effective performance strategies to perform the task. These results also support Bagget Ehrenfeucht (1988) and Norman's (1988) claim that a good conceptual model can also facilitate more accurate behaviours (i.e., reducing the use of a trial-error strategy). I suggest that the results from this study have validated the claim that a picture of the finished product provides both meaning and functional information about the task at hand (Bieger & Glock, 1984-85).

III. Step-By-Step Pictures

Step-by-step pictures with words (PW): The addition of step-by-step pictures to the Words-only manual (PW) facilitated superior assembly performance when compared with the Words only manual format (W). This finding confirmed the hypothesis that step-by-step pictures would enhance performance during the assembly procedures. It should be noted, however, that step-by-step pictures did not significantly affect the number of procedures omitted when compared to its absence in the Words-only instruction manual condition.

The results from the testing procedures did not support the hypothesis that step-by-step pictures would enhance performance on all performance categories. The results showed that only three of the six performance categories were affected by step-by-step pictures. The number of procedures omitted was not significantly reduced by the presence of step-by-step pictures. In addition, step-by-step pictures did not significantly reduce the length of time taken to test the CPM unit or the amount of error feedback required to test the CPM unit correctly.

Subjects rated manuals with step-by-step pictures as a more effective instruction manual in aiding performance during the assembly procedures compared to manuals which did not contain step-by-step pictures. This finding confirmed the hypothesis that instruction manuals with pictorial content would be rated as a more effective format for successful completion of the assembly task than manuals without pictures. Subjects' ratings of their strategy's effectiveness, however, were not significantly increased in the presence of step-by-step pictures. The results from the subjective ratings showed, therefore, that step-by-step pictures were judged to effectively aid performance on the assembly task but do not increase the effectiveness of the strategy employed to perform the assembly procedures.

Step-by-step pictures with words and a picture of the goal (PW-PG): The results showed that the addition of step-by-step pictures to the Words-only and a picture of the goal manual (PW-PG) had a similar effect on assembly performance as the addition of step-by-step pictures to the Words-only manual (PW). Step-by-step pictures reduced the length of time taken to assemble the CPM unit correctly and the number of incorrect and extra procedures made during the assembly performance. In addition, there were more successful assembly performances in the presence of step-by-step pictures than in its absence. Step-by-step pictures also reduced the number of references made to a picture of the goal during both the assembly and testing tasks. The length of time taken to test the CPM unit correctly, however, was reduced in the presence as opposed to the absence of a picture of the goal. These results confirmed the hypothesis that step-by-step pictures would enhance performance during the assembly task. The results from the testing procedures, however, did not support the hypothesis that step-by-step pictures would enhance performance in all performance categories.

Subjects did not rate manuals with step-by-step pictures as a more effective instruction manual in aiding performance and enhancing the utilisation of the strategy employed during the assembly procedures, compared to manuals which did not contain step-by-step pictures. This finding did not support the hypothesis that instruction manuals with pictorial content would be rated as a more effective format for successful completion of the proceduralised task than instruction manuals without pictures.

Overall, the results showed that step-by-step pictures enhanced consistently the assembly performance in both the absence and presence of a picture of the goal. The results showed, however, that only certain performance behaviours were affected by step-by-step pictures during the testing procedures. Furthermore, the superior performances facilitated by step-by-step pictures during the testing procedures were found to be more pronounced in the absence of a picture of the goal. The results also showed that step-by-step pictures increased the number of successful assembly but not testing performances. Finally, it is interesting to note that the Step-by-step pictures with words manuals were only rated as a more effective instruction manual in the absence, as opposed to presence of a picture of the goal.

(A) ***Picture-text format validated as a superior format for conveying proceduralised instructions compared to the text-only format.*** The consistent improvements in performance behaviour facilitated by the step-by-step pictures in both the absence and presence of a picture of the goal during the assembly task supports the finding from previous research that the use of illustrations or pictures with text produces significantly more accurate and faster performances (Bieger & Glock, 1984-85; Booher, 1975; Braby et al., 1982; Hayes & Readence, 1983; Stone & Glock, 1981; Severin, 1967b). The results, therefore, validate the superiority of a picture-text instruction manual format as a more effective format for conveying proceduralised instructions than text-only instruction manual format.

The fact that step-by-step pictures improved performance on the assembly tasks also validates Cue Summation theory (Severin, 1967a) and the notion that speed of comprehension can be increased when relevant pictorial material or illustrations are presented (Gropper, 1963; Hagen, 1974; Ryan & Schwartz, 1956). Multi-channel communications which combine words with related or relevant illustrations will provide the greatest gain of information because of their complementary nature (Booher, 1975; Haber, 1970). The reduction in the length of time taken to assemble the unit following presentation of a step-by-step pictures with words manual suggests that the speed of information acquired may have been increased because relevant information depicted in the pictures accentuated the accompanying text. Furthermore, if step-by-step pictures reasonably depicted the visual scene that subjects were confronted with at each point of the assembly task, the results imply that subjects used the pictures to review their own actions (Brody & Legenza, 1980; Brody, 1984). The pictures, therefore, may have been used to confirm actions and monitor the occurrence of errors, thus aiding performance overall.

The literature suggests that pictures can represent accurately the visual scenes in which subjects are engaged (Haber, 1970; Hagen, 1980, 1986; Watt, 1990). Furthermore, the visual information contained in the pictures can be directly acquired and does not, therefore, require translation into a different information form (Gibson, 1979; Haber, 1970; Hagen, 1986). Similarly, perception and comprehension of the pictures does not interfere with the resources required to comprehend the written text (Haber, 1970). In light of the of the evidence regarding the ease of comprehension for multiple-channel communication, and the informational capacity contained within pictures, the results from the step-by-step pictorial material used in this study suggests that this informational format is necessary and sufficient information to complete a proceduralised task successfully.

(B) ***Constancy of information and meaning represented by a picture of the goal.*** It is interesting to note that: a) Step-by-step pictures reduced the number of references made to the names of CPM parts in the absence but not the presence of a picture of the goal; and b) Step-by-step pictures also reduced the number of references made to a picture of the goal. This pattern of results was found for both the assembly and testing procedures. These findings suggest that when a picture of the goal was absent subjects increased the number of references made to the names of the CPM parts. Conversely, when a picture of the goal was present, subjects reduced the number of references made to the names of the CPM parts this pattern of behaviour suggests that subjects referred to a picture of the goal as a primary source of alternative information. Stone & Glock (1981) argued that the presentation of printed text with line drawings gave readers an alternative source of information. The results from the present study suggests that a picture of the goal was used as an alternative source of information to clarify information contained in the step-by-step pictures or text.

Results from the testing procedures showed that step-by-step pictures facilitated significant improvements in only a number of the performance categories. As previously discussed, these results suggest that: a) the testing procedures comprised a more concise and easier task than the assembly procedures, as step-by-step pictures did not enhance testing to the same degree as assembly behaviours; and b) subjects learnt information about the CPM unit which enhanced the testing performance.

The results also showed an interesting finding namely, that step-by-step pictures appeared to enhance the improvement already found in testing performances in the absence rather than the presence of a picture of the goal. This finding implies that a picture of the goal was a useful source of information which subjects utilised in addition to step-by-step pictures to aid performance during the testing task. The results further suggest that the addition of step-by-step pictures to an instruction manual with no picture of the goal increases subjects' reliance on the step-by-step pictorial information.

(C) *A picture of the goal may interfere with performance.* The raw data showed an interesting but non-significant trend between the assembly performance of subjects in the Step-by-step pictures with words instruction manual condition when a picture of the goal was absent (PW) versus present (PW-PG). The trend appeared to suggest that subjects who received a picture of the goal performed less accurately and efficiently in five of the six performance categories (see Figure 2 through to Figure 7 in the results section) than subjects who did not receive a picture of the goal. This trend in the raw data suggests that there were some degree of interference during the assembly performance, whereby, a picture of the goal inhibited rather than facilitated performance on the assembly task. Booher (1975) claimed that when pictures are organised inappropriately they may not be helpful sources of information. Brody (1984) and Fleming (1988) made similar claims to Booher (1975). In my opinion, it is possible that the information contained in the picture of the goal may have appeared to the subjects as contradicting some of the information presented in the text or pictures during assembly process thus, causing the subjects to initiate exploratory behaviours. These result do appear to substantiate Booher's (1975), Brody's (1984), and Fleming's (1988) claims, however, the fact that the trend was not significant may imply its occurrence was due to statistical chance.

One explanation which may account for this trend in the raw data was offered by Wright (1981) and Wright et al., (1982). They suggested that people often ignore instructions, and engaged previous knowledge and assumptions about the product or task at hand. It is unlikely that subjects ignored the instructions in light of the experimental context and the fact that the CPM unit was both a novel and electrical product. However, a picture of the goal may have provided subjects with advance knowledge concerning the CPM unit's final form. In this manner subjects may used the advance knowledge to assume certain procedures and hence may not have relied completely on the instructions to guide their actions. Actions such as these may have resulted in the subject committing errors or omitting procedures. The results support this assertion as there was an increase in the number of exploratory behaviours (i.e., references to the names of CPM parts and a picture of the goal), prolonging the length of time taken to assemble the CPM unit correctly. In addition, subjective ratings of the effectiveness of a picture of the goal in the Step-by-step pictures with words instructional manual decreased compared to its absence in the same instruction manual format.

The raw data showed, however, that the inhibitory trend disappeared when the arrows were added to the Step-by step pictures with words manuals (see Figure 2 through to Figure 8 in the results section), i.e., performance in all categories improved when the additional information was added. This trend tentatively suggests that interference did not persist in the presence of additional information, thus refuting the possibility that the inhibitory trend was caused by too much instructional information.

A result which may have validated the appearance that a picture of the goal interfered with performance on the assembly task was the interaction effect found for Supplementary Information by Base Information in the Incorrect Procedures category. A review of the ANOVA and the multiple range comparisons (see Figure 3 in the results section) suggests that the interaction effect was due to differences in the degree of significance between the information manipulation and not in direction, i.e., the effect of Base Information was more significant than the effect of Supplementary Information. This result and the trend in the raw data suggest that further research is needed to specifically assess whether or not a picture of the goal interferes with performance on a proceduralised task.

(D) ***Inconsistent judgements regarding the effectiveness of informational elements presented in the instruction manual.*** Results from the subjective ratings showed that in the absence of a picture of the goal subjects judged manuals with step-by-step pictures to be more effective than manuals without Step-by-step pictures. No significant increase was found for manual effectiveness ratings in the presence of a picture of the goal. These findings suggest that step-by-step pictures were more heavily relied on in the absence of a picture of the goal. A picture of the goal may also have depicted a particular type of information which was not conveyed in the step-by-step pictures thus minimising the perceived effect of step-by-step pictorial information. Bieger & Glock (1984-85) claimed that picture of a finished product provided contextual information , i.e., "information that provides the theme or organisation for other information that may precede or follow it" (Bieger & Glock, 1984-85, p. 69). Subjects may , therefore, have had an accurate expectation of the CPM unit's assembled form (Bagget & Ehrenfeucht, 1988) whereby, the effect of step-by-step pictorial information was judged to be secondary to the pictorial representation of the units assembled form.

A point previously raised in the discussion may account for the result which showed that effectiveness ratings for a picture of the goal did not increase in the presence of the step-by-step pictures. The questionnaires only asked subjects if step-by-step pictures were effective in aiding performance during the assembly task. The rating questionnaires did not ask subjects to make a direct comparison between the effectiveness of step-by-step pictures as an informational element versus the picture of the goal.

IV a. Presentation of Arrows Depicting Manipulation Direction, Arrows Depicting Manipulation Location, or Arrows Locating The Individual Parts Of The CPM Unit

Arrows depicting manipulation location (ADML): The results showed that the addition of arrows depicting manipulation location to the Step-by-step pictures with words and a picture of the goal manual (PW-ADML & PG) had no effect on neither assembly nor testing performance. However, the arrows did reduce the number of references made to the names of CPM parts during the assembly procedures. These results did not support the hypothesis that instruction manuals with arrows depicting manipulation location (ADML) would be a more effective manual for successful completion of the assembly and testing tasks, compared to manuals which did not contain the arrows.

Subjects did not rate the manuals with arrows depicting manipulation locations as a more effective manual in aiding performance and enhancing the utilisation of the strategy employed during the assembly procedures, than manuals which did not contain the arrows depicting manipulation direction (i.e., PW-PG). This finding did not support the hypothesis that instruction manuals with arrows depicting manipulation location would be rated as a more effective manual in aiding the successful completion of the assembly task, compared to manuals which did not contain the arrows. Results from the correlations further showed that the ratings for effectiveness decreased as the number of extra procedures increased.

Arrows depicting manipulation location, and arrows locating the individual parts (ADML & ADLP): The results showed that the addition of arrows depicting manipulation location and arrows locating the individual parts to the Step-by-step picture with words and a picture of the goal manual (PW-ADML-ADLP & PG) had the same effect on assembly and testing performance as the addition of arrows depicting manipulation location (ADML). Ratings of the manual's and strategy's effectiveness were also not affected by arrows depicting manipulation location and arrows locating the individual parts (ADML & ADLP). The results did not, therefore, support the hypothesis of this study. Results from the correlations showed that the ratings for effectiveness decreased as the subjects increased the number of references made to the names of the CPM parts and took longer to complete the assembly task. The effectiveness ratings for the strategy employed during the assembly task also decreased as the number of references subjects made to the names of CPM parts increased.

Arrows depicting manipulation direction, and arrows locating the individual parts (ADMD & ADLP): The results showed that the addition of arrows depicting manipulation direction and arrows locating the individual parts to the Step-by-step picture with words and a picture of the goal manual (PW-ADMD-ADLP & PG) had the same effect on assembly and testing performance as the addition of arrows depicting manipulation location (ADML). Ratings of the manual's and strategy's effectiveness were not affected by arrows depicting manipulation direction and arrows locating the individual parts (ADMD & ADLP). The results did not, therefore, support the hypothesis of this study. Results from the correlations showed the ratings for effectiveness decreased as subjects made more errors and took longer to complete the assembly task. The ratings for the strategy subjects employed during the assembly task also decreased as the number of references made to a picture of the goal increased.

Overall, the results showed that arrows presented individually, or two types of arrows presented in combination did not significantly enhance assembly and testing performance in either the absence or presence of a picture of the goal. However, the arrows presented either individually, or the two types presented in combination did significantly reduce the number of references made to the names of CPM parts. Furthermore, the results showed that arrows depicting manipulation location combined with arrows depicting location of the individual parts (ADML & ADLP) facilitated an even greater reduction in the number of references made to the names of CPM parts than the arrow combination depicting manipulation direction and location of the individual parts (ADMD & ADLP), or arrows depicting manipulation location only (ADML).

IVb. Arrows Depicting Manipulation Direction And Location, And Arrows Locating The Individual Parts Presented In Combination (The three types of arrows presented in combination)

Step-by-step pictures with arrows depicting manipulation direction and location, and arrows locating the individual parts (PW-ADMD-ADML & ADLP): The addition of the three types of arrows presented in combination (PW-ADMD-ADML & ADLP) had a limited effect on the assembly performance when compared with performance utilising the Step-by-step pictures with words manual (PW). The results showed that the arrows presented in combination reduced only the number of procedures omitted and the number of references made to the names of the CPM parts during the assembly performance. These results did not confirm the hypothesis that arrows would enhance performance during the assembly procedures.

The arrows presented in combination (ADMD-ADML & ADLP) did not significantly affect the testing performance. This finding did not support the hypothesis of this study.

Subjects did not rate manuals with the three arrows presented in combination (ADMD-ADML & ADLP) as a more effective instruction manual in aiding performance and enhancing the utilisation of the strategy employed during the assembly procedures, than manuals which did not contain the three types of arrows presented in combination, (i.e., PW). This finding did not support the hypothesis that instruction manuals with arrows would be rated as a more effective format for successful completion of the assembly task than manuals without arrows. Results from the correlations showed that the ratings for effectiveness decreased as the subjects omitted procedures and took longer to complete the assembly task.

Step-by-step pictures with words in combination with arrows depicting manipulation directions and location, and arrows locating the individual parts and a picture of the goal (PW-ADMD-ADML & ADLP-PG): The results showed that the addition of the three types of arrows presented in combination (ADMD-ADML & ADLP) to the Step-by-step pictures with words and a picture of the goal manual (PW-PG) had no effect on neither assembly nor testing performance. However, the arrows did reduce the number of references made to the names of CPM parts during the assembly procedures. These results did not support the hypothesis that instruction manuals with an arrow content would be an effective format for successful completion of the assembly and testing tasks.

Subjects did not rate the manual with the three types of arrows presented in combination (ADMD-ADML & ADLP) as a more effective instruction manual in aiding performance and enhancing the utilisation of the strategy employed during the assembly procedures, than manuals which did not contain the three types of arrows presented in combination, (i.e., PW-PG). This finding did not support the hypothesis that instruction manuals with arrows would be rated as a more effective format for successful completion of the assembly task than manuals without arrows.

Overall, the results showed that the three types arrows (ADMD-ADML & ADLP) presented in combination did not significantly enhance assembly and testing performance in either the absence or presence of a picture of the goal. It is interesting to note, however, that the reduction in the number of references made to the names of the CPM parts during the assembly procedures was consistent in both the absence and presence of a picture of the goal. The results from the subjective ratings also showed that subjects' judgements regarding the effectiveness of the three types of arrows presented in combination were consistent with the assembly performance behaviours.

(A) ***Arrows as functional source of visual information.*** Results from the arrow manipulations presented individually or two types of arrows presented in combination, overall, did not enhance performance during the assembly and testing task. Although this finding did not support the hypothesis of the present study overall trend in the raw data showed that the arrows did not inhibit performance on either the assembly or testing tasks (see Figure 2 through to Figure 13 in the results section). The data in fact suggests that the arrow(s) presented individually or two types of arrows presented in combination enhanced performance on both the assembly and testing task, but the effect was not enough for us to conclude superior performances.

The results do suggests, however, that the three types of arrows presented in (ADMD-ADML & ADLP) combination were functional and useful source of information which reduced the number of references made to the names of the CPM parts during the assembly task. The results further showed that when arrows depicting the location of the individual parts were combined with arrows depicting manipulation location (ADLP & ADML), these manuals were more effective in reducing the amount of references made to the names of the CPM parts than manuals which contained arrows depicting the locations of the individual parts and arrows depicting manipulation direction (ADLP & ADMD) , or manuals which contained only arrows depicting manipulation location (ADML).

These findings suggest that arrows depicting the location of the individual parts (ADLP) convey meaningful information about the different CPM parts which were relevant to the sub-assembled unit. These findings also suggest that arrows depicting manipulation location (ADML) are more effective than arrows depicting manipulation direction (ADMD) in conveying information about the different parts of the CPM unit during its proceduralised assembly. The results from the correlations support these suggestions. Subjects' ratings of manual and strategy effectiveness associated with the presentation of arrows depicting manipulation location decreased as the number of references to the names of the CPM parts increased. Subjects appeared, therefore, to be dissatisfied with having to refer back to the names of the CPM parts during the assembly task.

This study, however, is unable to determine if there was any significant difference between arrows depicting manipulation location or arrows locating the individual parts of the CPM unit in reducing the number of references made to the names of the CPM parts. This experiment did not include an instruction manual condition which presented arrows depicting the location of individual parts with the Step-by step pictures with words and a picture of the goal format. This limitation should be addressed by future research.

Results from the addition of the three types of arrows presented in combination (ADMD-ADML & ADLP) showed that, this arrow combination did not significantly enhance performance during the assembly and testing tasks. This finding was consistent in both the absence and presence of a picture of the goal. Although the results, overall, showed that arrows had no significant effect on performance, a trend in the raw data (see Figure 2 through to Figure 13 in the results section) suggests that the three types of arrows presented in combination facilitated enhanced performances. All the performance behaviours during the assembly task and six of the seven performance behaviour categories during the testing task were more accurately and efficiently performed. Three types of arrows presented in combination either in the absence or presence of a picture of the goal, facilitates an enhanced performance on proceduralised and testing tasks compared to a Step-by-step pictures with words format.

One particular finding which is salient, despite its statistical *non-significance* is the fact that subjects who received the instruction manual which contained the step-by-step pictures with words and a picture of the goal and the three types of arrows presented in combination (PW-ADMD-ADML & ADLP-PG), did not require error feedback in order to complete successfully the assembly task. This trend in the data suggests that subjects did not commit *irreversible* errors. Overall the data suggests that arrows are functional and useful sources of information which aid the performance of a novel and procedural tasks. The fact that the trends in the data were only approaching statistical significance suggests that some information was redundant.

A further explanation which may account for the trend in the data which only approached significance concerns the subject population itself. The population sample was comprised of university students who were assumed to be literate and reasonably fluent in comprehending the English language. Subject may not, therefore, have relied on the arrows as salient sources of information to aid performance during the tasks. I suggest that people who are not proficient in reading or writing the English language, or for whom English is a second language, may use non-textual materials as salient or primary sources of information. In this respect, the arrows may afford a greater functional potential or a more meaningful source of visual information (i.e., as symbols, Rasmussen, 1983) if presented to a different subject population. This suggestion is consistent with Braby et al.'s (1982) claim that people with a lower aptitude, or people who do not read proficiently may benefit from the augmentation of pictorial information, i.e., addition of lines or arrows to guide actions. These assertions, however, requires further research.

(B) *An excessive amount of pictorial material restricted the scope of measuring, effectively, the functional potential of arrows in an instructional context.* Based on the results from the nine instruction manual conditions, I believe that the step-by-step pictures contained a large amount of information which subjects utilised and relied on to aid them in performing the tasks. The step-by-step pictorial information was presented in such a manner that subjects did not require additional information to clarify possible ambiguities. In this respect, the reliance on arrows as an additional source of information may have been diminished. The instruction manuals may have contained an excessive amount of pictorial material which hindered assessing the true functional potential of arrows.

This explanation accounts for the fact that the three types of arrows presented in combination facilitated superior performances in only a small number of performance categories. The results showed that in the absence of a picture of the goal, the arrows significantly reduced the number of procedures omitted and references to the names of the CPM parts during the assembly procedures. In the presence of a picture of the goal, the arrows also significantly reduced the number of references made to the names of the CPM parts. In the absence of a picture of the goal, the results imply that subjects had to rely on other sources of information namely, the arrows. The results also indicated that three types of arrows presented in combination were more effective in the absence of a picture of the goal. This suggests that as subjects relied on the arrows they also became more attuned to the instructions, which in turn reduced the number of error or reference procedures made during the task. These results, validate my contention that arrows can be utilised to convey functional information. These results, also confirm the suggestion that certain instruction manuals may have contained an excessive amount of pictorial material, by virtue that information added onto these manuals produced positive but limited effects.

(C) ***Arrows convey a unique type of information.*** The reduction in the number of references made to the names of CPM parts suggests that the arrows: a) conveyed information about the CPM parts; or b) substituted for information previously conveyed by the names of the CPM parts. The overall results from the different arrows manipulations suggest that the arrows were an alternative method of conveying or substituting the descriptions of each individual CPM parts. It is possible that the arrows which substituted for the names of the CPM parts in instruction manual conditions six to nine, represented an informational element which aided memory during the proceduralised assembly task.

Results from the three types of arrows presented in combination with the Step-by-step pictures with words (PW-ADMD-ADML & ADLP) suggests, however, that the arrows presented in combination conveyed more information than descriptions of each individual CPM part. In this instructional manual condition the arrows also significantly reduced the number of procedures omitted during the assembly task in addition to reducing the number of references made to the names of the CPM parts. This finding coupled with the overall superior performance by subjects in this arrow condition implies that the arrows attuned subjects to relevant information during the task. Thus the three types of arrows presented in combination are functional and useful sources of information which aid performance on a novel and proceduralised tasks. The fact that the improved performances were not significant, however, substantiates the suggestion that the instruction manuals may have contained too much pictorial material to effectively assess the functional potential of arrows.

The above results are in line with the literature which suggests that arrows can be used to convey a unique type of information (Friedman & Stevenson, 1980; Szlichcinski, 1980), and that proper augmentation of pictorial materials serves a useful function (Braby et al., 1982). Thom's (1975) assertion that geometric forms can carry specificational information about the internal and external dynamics of the form (Kugler & Turvey, 1987) further suggests that arrows can be utilised to convey a unique type of information. The question of whether the unique type of information is different to that described by Booher (1975) and Bieger & Glock (1984-85) (i.e., fundamental information required for the successful completion of an assembly task - Action-Step, Focus and Contextual information), however, is a contention which requires further investigation.

Limitations Of The Present Study

Inherent in any research is the expectation that there will be certain limitations associated with the methodological design and control over extraneous variables. This section addressed the limitations associated with the present study. As the experimenter, I was aware of a number of limitations in the study prior to the data collection. However, these were limitations which could not be resolved due to the time constraints and a number of factors outside my control. The first six limitations addressed these factors, where applicable, suggestions on how future research may resolve the limitations have been presented.

First this study did not include a second task which required a higher level of decision-making content, i.e., a trouble-shooting or repair task. I believe this project should have included, ideally, a second task which required participants to repair the assembled CPM unit. The performance behaviours obtained from this task may have elucidated the claim made by Braby et al. (1982) that problem solving, trouble-shooting or repair tasks require different types of information than assembly tasks. In other other words the trouble-shooting, or repair task would assess the functional utility of arrows in a task which may require additional information other than the information which has been identified as fundamental to a proceduralised assembly task (i.e., Action-Step, Focus and Context information, Booher, 1975; Bieger & Glock, 1984-85). Future research should consider investigating the informational elements fundamental to a trouble-shooting, repair task and/or transfer repair task.

Second the pictorial materials utilised in the study may have affected performance. The pictorial materials presented in the instruction manuals were not the original photographs or original laser copies. These two factors reduced the resolution of the pictorial materials which may have inhibited subjects acquisition, or the comprehension of information depicted in the pictures. Future research should attempt to resolve this limitation by using original photographs of the pictorial material in each instruction manual if funding permits.

Third the results appeared to substantiate the limitations associated with a university student sample population. In the discussion, it was suggested that the critical reading skills which are taught and developed within the university environment, may have attuned subjects to the to textual forms of communication rather than an alternative sources of information. The reading proficiency of a the sample population may have diminished the effect of the additional information, such as a picture of the goal or arrows, on the performance. Future research could resolve this limitation by including as part of the methodological design a performance assessment between as: a) university versus non-university subject sample and b) English speakers versus subjects who speak English as a second language.

Fourth, the experimental context in itself may have resembled a limitation. Subjects performed the tasks in an unfamiliar room whilst being videotaped and monitored by the experimenter. It is unlikely that an individual in a real-life setting would perform a task in such unfamiliar surroundings. I believe that the experimental context, i.e., unfamiliar surrounding and the test-like situation, may have biased the results of the experiment in one of two ways. First, the participant may have been flustered by the presence of the camera or the experimenter, thus inhibiting the person's capacity to perform the task at an optimal level. Second, the participant may have been motivated to perform the task at a higher level than when he or she was not in the experimental context. As the experimenter I cannot control for subjects response to the experimental context, therefore, the conditions were made consistent across all subjects. In an attempt to minimise the effect of the experimental conditions on subjects' performance, the sufficiency criteria set for the experiment allowed subjects two error feedbacks and, therefore, three attempts at completing, successfully both the assembly and testing tasks. This methodological strategy was incorporated in an attempt to minimise subjects feeling as if they were not allowed to perform exploratory behaviours or errors.

Fifth, the time periods within which subjects performed the task may have affected their performance behaviour. Subjects the tasks between a 9 am. to 6 pm. time period during both the weekdays and weekend. The point of contention is that some subjects may have been more alert (due to, for example, changes in circadian rhythms, food consumption, activity or mood) during certain times of the day or week which may have affected performance on the experimental tasks. Future research may resolve this limitation by asking subjects to perform, the task at a similar time period throughout the experiment, or at the subject's most alert period.

The sixth limitation concerns the type of equipment chosen for this study.. The CPM unit is a specialised equipment which subjects would not have or encountered in an everyday situation. Subjects' unfamiliarity with the CPM unit may have facilitated cautious performance behaviour. However, I believe that using an unfamiliar and novel piece of equipment in research such as the present study, is justified by the following three rationales. First, there are tasks encountered in everyday situations which are more difficult than the one this project had devised. Second, the experimental context was designed to resemble a learning situation where the instruction manuals represent the instructional aid to teach subjects how to assemble a novel and electrical object. In fact the novel nature of the task may provide an interesting and motivating stimulus for the subjects to perform the task to their best potential. Third, the CPM unit was selected on the basis of its novelty. The aim of this research was to assess the optimal instruction format or informational element necessary for superior performance on proceduralised tasks. In choosing the CPM unit for the present study, I attempted to minimise the degree of personal knowledge and information each subject brought to the task (i.e., assumptions about the CPM unit), as well as attempting to increase the motivation level of subjects to perform the task well (Owen, in press; Woodworth & Schlosberg, 1955).

Based on the principles which emerged from the results, a further two limitations have been identified in this study. These limitations were identified following the completion of the experiment. First, the experiment did not include an instruction manual condition which presented arrows depicting location of the individual parts separately. This limited the extent of conclusions that could have been made regarding the superiority of the different arrow types in reducing he numbers of references made to the names of the CPM parts. Second and finally, one the most significant limitations in this study appeared to be the excessive amount of pictorial material contained in the Step-by-step pictures with words and arrows-augmented manuals. Although the step-by-step pictures were significantly useful for facilitating superior performances on the experimental tasks, they appeared to limit exploratory analysis of the functional potential of arrows in an instructional context.

Suggestions For Future Research

Based on the methodological design of this study, the results and associated discussion, and the limitations of this research , there are a number of suggestions for future research which can be made.

The results from the present study suggested that an excessive amount of pictorial information limited the effective assessment of the functional potential of arrows in instruction manuals. The first suggestion for future research is, therefore, to determine the amount of step-by-step pictorial information which should be present in a picture-text instruction manual format to facilitate correct and optimal performance on a proceduralised task.. This suggestion should, however, be taken with a degree of caution, as it implies that instruction manual formats should contain a limited amount of pictorial information (i.e., not the highest possible amount). Instruction manuals with pictures of sub-assemblies, for example may be a more appropriate format by which to measure the scope of informational potential which arrows carry. Furthermore, future research at a commercial and economic level should consider this suggestion of primary importance. The results of such research would be to establish the boundaries at which pictorial material becomes inappropriate. This may prove to be research which has a cost-effective result for the designer of instructions manuals. Future research also needs to establish the amount of information that should be depicted in a picture when arrows are being used. Based on the results of this study, future research should expect that arrows will significantly improve performance on proceduralised tasks when coupled with the sufficient or correct amount of pictorial information. A phenomenon may also occur where the addition of arrows or other types of augmentation can replace the information lost by a reduction in the amount of step-by-step pictorial content.

The functional utility of arrows as a source of visual information in an instructional context have not been validated prior to the present study. For this reason, one suggestion for future research is to first, validate the functional utility of arrows and second, to identify the unique type of information required and depicted by arrows during a repair task. A second suggestion is to utilise a task which was designed to investigate the type of unique information that arrows may have conveyed in a trouble-shooting or repair task. This future research may answer the question of whether the unique type of information required for a trouble-shooting task is different to the information-types described by Booher (1975) and Bieger & Glock (1984-

85) as fundamental information required for the successful completion of an assembly task, i.e., Action-Step, Focus and Contextual information.

The results suggests that arrows depicting location of the individual parts (ADLP) substituted for the references made to the names of CPM parts, but only when they were in combination with another set of arrows. The methodological design of this study did not include an instruction manual condition which assessed, separately the effect of arrows depicting location of the individual parts. Future research should, therefore, assess the degree of application these arrows have for instruction manual format designs. In addition, as arrows depicting location of individual parts requires a high picture contents, future research should also attempt to determine a more economical form of conveying this type of information.

Future research also needs to investigate the effectiveness of arrows between subjects who are proficient versus non-proficient readers in one form of language (e.g., English). Similarly, it would be interesting to compare subject's performances on the basis of age. Future research such as this would assess the level of reliance placed on alternative information by subjects who are not proficient readers. In turn, these results may validate the utility of arrows as an alternative source of visual information, which are salient for the performance of novel and proceduralised tasks.

Implications Of The Present Study

Implication of pictures as advance relevant information which facilitates motivation and learning

The significant results from the addition of a picture of the goal to the text-only instruction manual format and the verification of the picture-text format as a superior instructional format for conveying proceduralised instructions offers a number of theoretical and practical implications for the fields of instructional research and education.

The fact that a picture of a fully assembled object was significantly useful for subjects in a text-only format, implies that subjects were reliant on the information which was depicted in the pictures to perform the task. Gibson & Levin (1975) and Stone & Glock (1981) claimed that people utilise or comprehends pictures by perceiving the higher-order structures (invariant information) that are depicted in the picture. On the other hand, Haber (1970), Dixon (1982, 1987) and Wright (1981) suggested that people encoded proceduralised instructions or written statements in terms of an action-plan. The results which assessed the effectiveness of a picture of the goal in the text-only instruction format imply, therefore, that a picture of the goal provided subjects with the information (i.e., invariant structures) to aid their action-plan, which in turn helped to guide their actions (Bagget & Ehrenfeucht, 1988; Norman, 1988) and facilitated a more accurate and efficient performance on the task. The effectiveness ratings which subjects gave to the strategy they used in the presence of a picture of the goal, further implies that the presence of higher-order structures which resembles a goal (i.e., a picture of fully assembled objects) can facilitate a better action plan or more effective strategy with which to perform the task.

It is my contention that these results can be generalised further, to support Thom's (1975) claim concerning geometric forms as carriers of dynamic information about the form, but only to the point that pictures depict static geometric forms or higher-order structures of geometric forms (Gibson, 1966, 1971, 1979). In my opinion, the dynamic information Thom (1975) mentioned is, therefore, depicted in the pictures but must be abstracted from them. The relevance of these structures is, therefore, only evident in relation to an individual's need or intention. It is not possible, from the results, to conclusively comment on the specific type of information a picture of the fully assembled object conveys. The results do, however, imply that a picture of the goal contains functional and useful information for a novel proceduralised assembly task.

It is possible that the information depicted in the picture of the goal, provided subjects with an information set which allowed them to form assumptions or expectations about the task. Thus the information can be said to be compatible with the task ahead (Sanders & McCormick, 1987). Pictorial representation of fully assembled objects (i.e., a picture of the goal) may also have been conceptualised as source of information which conveys advance information about the task at hand or relevant information about the goal (Bieger & Glock, 1984-85; Bagget & Ehrenfeucht, 1988; Brody, 1984; Norman, 1988; Smith & Goodman, 1984; Szlichcinski, 1979a). It is my contention that if the expectations match the information or actions descriptions presented (i.e., step-by-step instructions, Watt, 1991) then the information will benefit subsequent actions. The literatures, and results from this study do strongly imply that a picture of the fully assembled object, or pictures in general serve as information which facilitates superior performances (i.e., accurate & efficient actions) in a novel situation.

It can be argued, therefore, that a picture of the goal or information about the goal can be perceived as a useful or functional set of information by the individual to aid them in bridging the gap between intention and action, and consequently, achieving the goal. This implication is consistent with the claim that pictures may function as a source of information which facilitates learning (Braby, et la., 1982: Brody, 1984; Gropper, 1963; Pick, 1965).

Woodworth & Schlosberg (1955) and Owen (in press) acknowledged that motivation was an important factor in a learning context. Motivation, as a psychological factor, can be viewed as a *component* which drives an individual to perform a task until he or she achieves an acceptable level of performance standard or competence (Owen, in press). The degree of motivation, is, however, dependent on the type of reward available for the individual weighted against the amount of work or effort underlying the task (Woodworth & Schlosberg, 1955). Woodworth & Schlosberg's account of motivation suggests an evaluation process on the part of the learner, where the potential learner must decide whether he or she wishes to engage in the task of learning. The decision to undertake the task of learning, therefore, is dependent on the rewards the individual will acquire upon completion of the task or the amount of effort he or she must exert in the process. In other words, a prerequisite for an individual to learn or engage in a novel task may be an awareness of the requirements and operations posed by the task. Moreover, *motivation* itself requires an accurate view of reality which demands accurate or relevant information by which to evaluate the incentives and probabilities of success or failure (Heckhausen & Gollwitzer, 1986). The fact that motivation is a salient factor for learning and requires an accurate view of reality, implies that the presence of information which can be utilised to form this view is fundamental for both the motivation to learn and the subsequent learning process itself.

Pictorial materials have been established as sets of information which depict or can function to provide accurate and relevant information in advance. It can be argued, therefore, that this information set can be utilised by the individual to evaluate the incentives and probabilities of success or failure on the task. This implies that a picture of a fully assembled object or information about the goal may serve a motivational function in a learning situation if utilised properly. In my opinion , the results from the present study and Braby et al.'s (1982) findings that performance levels of lower aptitude subjects were significantly improved when pictures were presented in the learning material, substantiates the implications for pictures serving as a motivational element in a learning situation. They are also consistent with Gibson's (1966, 1979) account that learning involves advance knowledge or "an individual's assumption that something will stay the same" (Gibson, 1966, p. 276). Pictures, therefore, potentially depicts or fundamental information which individuals can use to evaluate the incentives and probabilities of success or failure in the situation, thus, information which is fundamental for motivation.

The fact that a picture of the goal significantly enhanced performance when it was added to the text-only format has further implications for the instruction manual designer or manufacturers of products. The results also showed that the text-only format is an inadequate format for conveying proceduralised instructions. Therefore, any type of information set which conveys complicated proceduralised instructions should include a picture or illustration of the products final form or advance information about the goal.

Implications of picture-text instruction format as a fundamental format for conveying complicated proceduralised instructions

The results in this study showed that superiority of a picture-text format compared to a text-only format. This result also verified the findings of Booher (1975), Bieger & Glock (1984-85), Braby et al. (1982), and Stone & Glock (1981). This implies that pictures in general are an important element in conveying complicated instructions. Furthermore, the finding that additional information added to pictorial material did not significantly improve overall performance on the tasks, implies that picture-text instructional format is currently the most effective format for conveying printed, proceduralised instructions.

Instructions have been conceptualised as "any set of environmental conditions that are deliberately arranged to foster increases in competence," (Resnick, 1976, p. 51). In addition, instructions have also been conceptualised as an information set which guide actions (Bagget & Ehrenfeucht, 1988; Watt, 1991). These two descriptions of instructions can be argued to be compatible, they both imply that instructions are sets of information which provides specificational information that facilitate action. The consistent finding in this study that, relevant pictures improves performance on a proceduralised task (i.e., accurate and efficient actions; Booher, 1975; Bieger & Glock, 1984-85; Braby et al., 1982; Stone & Glock, 1981) implies that pictures presented as instructions are the most effective set of information which can be arranged to improve performance. In my opinion, a number of specific results from this study highlight further implications on the functional utility of pictures for printed instructions.

Improvements in performance on the tasks caused by pictorial material (i.e., a picture of the goal or step-by-step pictures), particularly in the length of time taken to complete the procedures and error reduction implies that the speed of comprehension can be increased without a decrease in accuracy when relevant pictorial material or illustrations are presented (Gropper, 1963; Hagen, 1974; Ryan & Schwartz, 1956). Furthermore, the fact that extra procedures were also significantly reduced, implies that the picture-text format minimises uncertainty in a novel and complicated situation. Finally, the results also imply that the picture-text instructional format may minimise the utilisation of trial-error strategies in a novel and complicated task.

In the discussion section I discussed the significance of the error feedback component included in the present study. I suggest that the performance improvements found in this particular category following the presentation of pictorial material offers a number of implications for the field of instructional research. Results from the present study imply that the pictures may have been used by the subjects to review their own actions (Brody & Legenza, 1980; Brody, 1984) to aid and enhance their performance overall. Implications exists, therefore, for the application of picture-text format in situations where speed and accuracy is critical to the success of a task or action (Larson & Merritt, 1991; Rasmussen, 1986; Reason, 1990; Wagenaar et al., 1990).

In my opinion, the feedback element simulated a situation where an individual have performed a proceduralised task but had not detected or monitored the errors they had committed. It is possible that these uncorrected errors are precursors to irreversible errors (Lewis, 1980; Park, 1987) if they remained undetected, and may cause undesired consequences if the task involved a fatal element. The significant reduction in the number of error feedbacks required to complete the task implies, therefore, that picture-text instructional formats may reduce irreversible errors.

The step-by-step pictorial material in the instruction manuals represented every step of the tasks subjects had to perform. The results showed that the addition of this pictorial material did not interfere with assembly of testing performance. These factors imply that a large amount of relevant pictorial material in instruction manuals will not harm performance and suggests, therefore, that pictures or illustrations should, whenever possible, be: a) presented with instructions involving complex actions; and b) be a fundamental component of printed assembly instructions.

Implications of pictorial materials for ecological psychology

There is an interesting implication which emerges from the results with regard to the principles of Ecological Psychology. Results from the present study appear to imply that pictures can be used to improve performance on a proceduralised task thus, modifying the learner's behaviours. The results also showed that the pictorial material presented in this study conveyed information relevant to the subjects' task. The superior performances facilitated by pictorial material in the instruction manuals suggests that subjects were attuned to this type of information. Owen (in press) argued that advance information can potentially guide an individual's attention to the relevant variables. In other words advance information can be utilised to attune learners to the relevant information in the learning process. The results from this study imply that pictures attuned subjects to the higher-order or invariant information required for them to perform the task successfully. The higher-order structures depicted in the pictures were, therefore, acquired and utilised to guide actions in relation the final form of the object (Gibson, 1971, 1979; Gibson & Levin, 1975; Pick, 1956; Stone & Glock, 1981).

The above implication is consistent with the ecological approach account of reciprocity between the individual and the environment, i.e., where the environment supports the actions of the individual (Bruce & Green, 1990; Gibson, 1966, 1979; Lombardo, 1987; Loveland, 1991; Mace, 1977). The research design suggests that the pictures presented in the instruction manuals (picture-text format) resemble the environmental *conditions* (Resnick, 1976) which were organised to foster an improvement in performance on the tasks. In light of the ecological view that environments supports actions for organisms, it can be argued that the step-by-step pictures combined with a picture of the assembled goal gave subjects a substantial amount of information on which to base their actions. The results imply, therefore, that the pictures have supported individual's actions in light of their intention to complete assembling and testing the CPM unit successfully in the fastest time and as accurately as possible.

The results showed that pictorial material which resembled the environmental condition in which subjects were engaged, enhanced performance. This results offers an implication for the question, "does information have affordance properties" (Owen, 1991, pp. 1). Cutting, (1986) claimed that one of the functional utility of affordances within the scope of affordance theory is that they potentially carry meaningful information for the individual (Gibson, 1979; Lombardo, 1987; Mace, 1977; Michaels & Carello, 1980; Turvey et al., 1981). In my opinion, the fact and that information reduces uncertainty (Shannon & Weaver, 1964; Bharath, 1987; Sanders & McCormick, 1987), and by definition pictures are carriers of invariant information, which prove to facilitate improvements in performance on a proceduralised task, implies that relevant illustrations or pictures (i.e., a picture of the goal, step-by-step pictures or arrows) has the properties of meaning which guide an individual's action, or guide individual's to the relevant information which carry meaning for subsequent actions.

Implications of arrows or augmentation

The results showed that the three types of arrows presented in combination did not significantly enhance performance. A trend in the raw data showed , however, this effect (although not statistically significant) was in a positive direction, thus arrows presented in combination did not interfere with performance. This trend offers a number of implications which are acknowledged as inconclusive based of the non-significance of the results. The exploratory nature of this study does, however, call for one to draw attention to these trends.

The results imply that augmentation of pictorial materials with relevant symbols (i.e., arrows) in a picture-text instructional format can be useful for performance (Friedman & Stevenson, 1980; Haber, 1970; Braby et al., 1982; Szlichcinski, 1980). The results also imply a functional utility for pictures namely, that they can be used to provide the higher-order structure or meaning for additional or alternative specificational information, i.e., arrows or. The results further imply that visually modifying pictorial materials to accentuate the relevant information attunes people: a) to that relevant information; and b) minimises the effort to search for this information. This in turn allows the individual to direct their attention to other sources of information or events (Bagget & Ehrenfeucht, 1988; Bruce & Green, 1990; Hagen, 1974; Hester, 1977; Neisser & Becklen, 1975; Norman, 1988; Ryan & Schwartz, 1956; Severin, 1967a; Szlichcinski, 1979a; Watt, 1991) which facilitate efficient and effective actions.

The significant reduction in the number of procedures omitted during the assembly task, even though it was only in the absence of a picture of the goal, implies that arrows heightened subjects awareness of, or attention to relevant information in the instruction manuals. This result coupled with the trend in the data which showed that arrows facilitated successful completion of the task with least number or no error feedbacks, implies that arrows may be a salient informational element in printed instruction formats. This implication is based on the fact that most errors of omission or mistakes occur during the search for a solution, (Neisser & Becklen, 1975; Norman, 1988; Reason,1990) and stem from the failure to acquire meaningful information (Gibson, 1979; Loveland, 1991). The arrows may, therefore, attune people to either the relevant information, thus reducing the search for a solution, or allow them to detect errors, thus avoiding irreversible errors and undesired consequences (Lewis, 1981; Park, 1987; Rasmussen, 1984, 1987; Rasmussen & Vicente, 1989; Reason, 1990).

The results from the arrow manipulation also offers practical implications for the field of education. Pictures and arrows are similar informational elements in that they contain both higher-order structures depicted on a flat surface. The two elements differ, however, in terms of the information-content they represent. Pictures depict the visual scene that individuals are confronted with, while the arrows depict specificational information (i.e., direction and location) or accentuate other relevant information (i.e., attuning readers to the direction of motion, relevant locations associated with the task at hand). Subjects, therefore, will not perceive the arrows as being a representational element of the visual scene that they are confronted with, but will perceive them as an informational element which attunes them to relevant information (Szlichcinski, 1980; Friedman & Stevenson, 1980).

It has been suggested that people actively search for specific information to guide their actions when they are confronted with a novel situation (Neisser & Becklen, 1975; Norman, 1988; Szlichcinski, 1979; Watt, 1991). This suggestion, along with the knowledge concerning the dominance of the visual system in relation to actions (Cutting, 1987; Rabbitt, 1984; Watt, 1991) implies that arrows can be arranged in a learning context to facilitate teaching a person how to attune themselves to the relevant information. This claim is consistent with Gibson's (1979) concept of learning. Gibson suggested that learning involves the education of attention whereby, the task of the educator is one of attuning the learner to the relevant variables pertinent to a certain field of knowledge (Gibson, 1979; Owen, in press).

The results from the arrow manipulations also offer a number of implications for the field of ergonomics. Ergonomics has advocated a future trend toward both an informational rather than an industrial society, and a long term-rather than a short-term emphasis in product design, i.e., repairable products as opposed to disposable products (Salvendy, 1988). I propose that the inclusion of relevant information to facilitate efficient repairs, and re-assembly in non-disposable products is, central to the long term emphasis in product design. Although the functional utility of arrows in an assembly or repair task has not conclusively been verified, the results of this study suggest a positive potential for arrows as: a) carriers of specificational information; and b) an element which attunes the individual to relevant information in complicated proceduralised tasks and trouble-shooting or repairs tasks. Arrows may, therefore, contribute to the advancement of the knowledge base concerning the development of instructional designs for repairable products.

Conclusions

The present study has shown that the picture-text format is the most effective instructional format for conveying complex proceduralised instructions for assembly and testing tasks, via the printed channel. The presence of a picture of the goal in a text-only format also facilitates superior performance on a novel and complex assembly task. Pictorial material is, therefore, an important source of meaningful information which produces accurate and efficient actions during a novel and complicated set of procedures.

This study also found that a picture of the goal represented advance information about the final form of an object. This pictorial material is a fundamental informational element for the successful completion of complex assembly procedures. The optimal instruction manual format for a picture of the goal is its addition to a text-only format. Advance knowledge about the goal or object's final form is a critical and useful source of information, as the results showed that in its absence individuals will perform a greater number of exploratory behaviours, inaccurate actions, and are unable to effectively monitor and correct the errors they have made.

Based on the results of the study, it can be concluded that instruction manuals which convey text-only information (i.e., no picture of goal or other visual representations) for a proceduralised task, are inadequate. The results suggest that whenever possible ,pictures, illustrations or other visual representations should be presented with the written text via a printed and static channel. If financial costs in designing the instruction manual is a major limitation, then a text-only instruction manual should at least include a picture of the goal. The results in this study showed that the addition of a picture of the goal to a text-only format will facilitate a faster and more accurate performance on a proceduralised task.

The trend in the data suggested that presenting arrows depicting manipulation location, or direction, or locating the individual parts of an object, in combination, produces an overall superior performance. The data suggests that the three types of arrows presented in combination serve a functional role.

It is acknowledged that this study has not achieved one of its intentions namely, to validate the functional utility and effectiveness of arrows presented as specificational information to support actions in an instructional context, and facilitating learning. The significant reduction in the number of references to the names of CPM parts and procedures omitted, do, however, lead to the conclusion that arrows are a functional source of alternative information which can reduce the search for information and attune readers, in a more diligent manner, to the information set.

The significant reduction in the number of procedures omitted following the presentation of arrow information leads to the conclusion that arrows can carry specificational information which minimises errors of omission during a novel and complicated proceduralised assembly task. Arrows should, therefore, be presented in a picture-text format when conveying a complicated set of proceduralised instructions. Arrows may attune individuals, more precisely and selectively, to the information set, minimise errors of omission, or provide information which assist to monitor and correct errors. Future research is,therefore, warranted to validate their overall effectiveness and scope of their utility during a proceduralised performance of a novel task.

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Appendix 1.

Subject's consent forms for the pilot study and experiment.

UNIVERSITY OF
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PILOT CONSENT FORM

Brief Description of The Project: This project aims to see if pictures in instructions helps people to perform assembly and repair task.

As a subject, you will be asked to assemble an object. Instructions will be provided to help you perform the task.

Risks Associated With Participation: The assembly tasks do not directly expose you to psychological or physical risk. However, the tools used to perform the assembly and testing tasks may cause you physical injury if you do not handle them properly. For this reason each instruction manual will contain information concerning the correct utilisation of the tools relevant to the experiment.

Time Required: The time required for the experiment will vary depending on the group that you are allocated to, the approximate time required for the condition is:

Pilot condition: you are asked to attend one experimental session, 30 minutes duration per session.

Name of Researcher: Andre' Pekerti
Name of Supervisor: Dr. D. H. Owen

I agree to participate in the project described above, on the understanding that if at any time I wish to withdraw from the experiment I may, without prejudice, do so. All information collected will be confidential as will the identity of participants.

I understand that I will receive a docket each time I participate in an experiment which will entitle me to be part of a subject pool giving me a chance to win one of two prizes: 1) $ 30, 2) $ 30 in the form of a grocery voucher.

I understand that for scoring purposes, my performance on the task will be videoed.

I understand that I cannot reveal the nature of this experiment to other people.

Name: ______________________________

Subject code: _______________________

Phone number: ____________________

Signature: ____________________________ Date: _____________

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EXPERIMENTAL CONSENT FORM

Brief Description of The Project: This project aims to study the effectiveness of proceduralised instructions.

As a subject, you would be randomly allocated to one of nine groups.

You will be asked to assemble an object. Instructions will be provided telling you how to perform the task.

Risks Associated With Participation: The assembly tasks do not expose you to psychological or physical risk. However, the tools used to perform the assembly and testing tasks may cause you physical injury if you do not handle them properly. For this reason each instruction manual will contain information concerning the correct utilisation of the tools relevant to the experiment.

Time Required: The time required for the experiment will vary depending on the group that you are allocated to, the approximate and/or average time required is 40 minutes.

Name of Researcher: Andre' Pekerti
Name of Supervisor: Dr. D. H. Owen

I agree to participate in the project described above, on the understanding that if at any time I wish to withdraw from the experiment I may, without prejudice, do so. All information collected will be confidential as will the identity of participants.

I understand that I will receive a docket each time I participate in an experiment which will entitle me to be part of a subject pool giving me a chance to win one of three prizes: 1) $ 80, 2) $ 50, 3) $ 20 in the form of a grocery voucher.

I understand that for scoring purposes, my performance on the task will be videoed.

I understand that I cannot reveal the nature of this experiment to other people.

Subject code: ____________________

Name: ________________________

Phone number: ________________

Signature: ______________________ **Date:** ___________

Appendix 2.

Instruction manual Conditions 1 and 2.

Note: A picture of the CPM unit on page 1 of the manual was absent in instruction manual Condition-1.

THE CPM UNIT:

ASSEMBLY AND TESTING INSTRUCTIONS

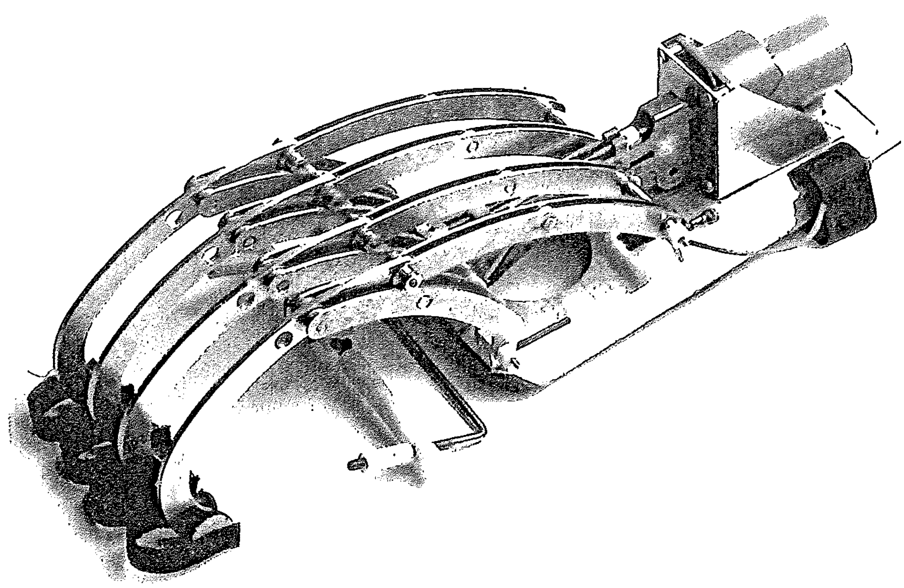
CONTENTS

The CPM Unit

The portable continuous passive motion hand unit (CPM) is an orthopaedic hand exercise unit, designed to help the healing of the hand and/or finger muscles after injury. The lightweight design of the unit means the patient can take the unit home and supervise their own personal therapy for up to 24 hours.

The unit fits comfortably on top of the hand and wrist. It is secured with velcro binding for easy attachment to and release from the fingers and wrist.

A small motor operates the finger linkages of the CPM unit which helps the patient to exercise his/her hand without effort.



1.0) Names of CPM Parts

The following names refer to the names of the CPM parts and their location on the CPM unit. The order of presentation corresponds with the order of the procedural steps.

A) **The CPM Base Unit:** The CPM base unit is the largest sub-assembled component made up of an aluminium base-plate, a motor unit, a red plug, and 4 linkage attachment blocks.

B) **The Cursor Shaft:** The cursor shaft is the longest metal rod with a brass block threaded onto it. The cursor shaft is attached to the motor shaft.

C) **The Switch Rod:** The switch rod is the brass rod with 2 short plastic nuts threaded onto it. The switch rod is attached to the motor unit.

D) **The Cursor:** The cursor is the brass block with 2 holes and a groove. The cursor is threaded onto the cursor shaft.

E) **The Allen Screw:** The Allen screw is the screw threaded into the white portion of the cursor shaft.

F) **The Motor Shaft:** The motor shaft is the small metal rod protruding from the motor unit.

G) **The Cursor-Shaft-Block:** The cursor-shaft-block is the long rectangular block with holes on it. The cursor-shaft-block is fastened onto the CPM unit base-plate.

H) **The Bolt Rod:** The bolt rod is the long brass rod with a short plastic nut threaded onto it. The bolt rod secures the finger linkages onto the CPM unit.

I) **The screw:** The screw is the smallest un-assembled CPM component. The screw secures the cursor-shaft-block onto the CPM unit base-plate.

Proceed to the next page.

J) **The T-Bar:** The T-bar is the metal component which represents the alphabetical letter 'T', a short plastic nut is threaded onto it. The T-bar is a sub-part of the hand rod unit fastened onto the cursor casing.

K) **The Plastic Sleeves:** The plastic sleeves are the longest plastic component of the CPM parts. Each plastic sleeve is partially hollow with a hole on one end. The plastic sleeves are a sub-part of the hand rod unit slotted onto the T-bar.

L) **The U-Bar:** The U-bar is the metal component which represents a very wide alphabetical letter 'U'. The U-bar is a sub-part of the hand rod unit and is fastened to the T-bar.

M) **The Long Plastic Nut:** The long plastic nut is the longest nut of the CPM parts. It is a sub-part of the hand rod unit which secures the U-bar to the T-bar.

N) **The Cursor Casing:** The cursor casing is the largest metal component of the CPM parts. The cursor casing is an aluminium block with 6 holes fixed between the metal at the front-end, with gaps in the mid-section and one hole at the back-end of the metal part. The cursor casing encases the cursor and the cursor-shaft-block.

O) **The Finger Linkages:** The finger linkages are the 3-pronged aluminium objects with a black velcro strip fastened at the front-end. The finger linkages are attached to the CPM base unit in 2 places: 1) the 4 linkage attachment blocks, 2) the cursor.

P) **The Attachment Blocks:** The attachment blocks are the 4 short metal blocks secured onto the front-end of the CPM unit base-plate.

Q) **The Plastic Nut:** The plastic nut is the shortest plastic component of the CPM parts. The nut secures the bolt rods attaching the finger linkages to the attachment blocks and the cursor.

R) **The Aluminium Spacer:** The aluminium spacer is the hollow, pipe-like aluminium component of the CPM parts. The aluminium spacer is slotted onto the bolt rod between the back finger linkage attachments.

Proceed to the next page.

S) The Motor Unit: The motor unit is the sub-assembled component secured to the back-end of the CPM unit base-plate.

T) The Plug: The (red) plug is attached to the black velcro strap located at the back-end of the CPM base unit.

U) The Adapter: The adapter is the black 'cubical' object with a silver socket attached to the black cord.

V) The Direction Switch: The direction switch is the brown PC board located on the top of the motor unit.

W) The Adapter Plug: The adapter plug is the silver metal rod that protrudes from the back end of the motor unit.

Proceed to the next page.

Assembly and Testing Procedure Instructions

All the parts and tools you will need to assemble and operate the CPM unit are in front of you.

1) Perform the task as accurately and as fast as you can.

2) Please follow the procedures and notes in a step-by-step manner

3) Please close the instruction manual.

Assembly Procedures

2.0) Cursor Shaft Assembly

The cursor shaft is the metal shaft which is threaded through the cursor. When the motor is operating, the cursor allows for forward and backward motion of the finger linkages.

2.1) Positioning the cursor shaft into the motor shaft:

1) Position the CPM base unit so that the 4 linkage attachment blocks are facing you.

2) Select the cursor shaft.

3) With one hand, lift the switch rod.

4) With your other hand, position the cursor shaft below the switch rod.

5) Place the switch rod in the groove of the cursor.

(**Note:** The cursor should be positioned between the 2 plastic nuts.)

6) Turn the cursor shaft so that the Allen screw is aligned with the flat side of the motor shaft.

7) Insert the cursor shaft into the motor shaft as far as you can.

Proceed to the next page.

2.2) Mounting the cursor-shaft-block onto the CPM base unit:

1) Select the cursor-shaft-block.

2) Hold the cursor-shaft-block so that the black side is facing the motor unit.

3) At the same time, slot the hole located in the middle of the cursor-shaft-block into the cursor shaft and the top hole into the switch rod.

(**Note:** The bottom of the cursor-shaft-block should be touching the CPM unit base-plate.)

4) Select one of the bolt rods.

5) Starting from the right-most attachment block, insert the bolt rod through the side holes of the linkage attachment block.

(**Note:** The bolt rod should slide through the 4 attachment blocks and the cursor-shaft-block.)

6) Turn the CPM unit over and rest the unit on the table.

(**Note:** The cursor-shaft-block should be positioned upright, touching the table.)

7) Select a standard screwdriver.

8) Select the screw.

Proceed to the next page.

9) Hold the CPM unit firmly and ensure that the cursor-shaft-block is touching the table.

10) With the screw, secure the cursor-shaft-block to the CPM unit base-plate.

11) Using the screwdriver, tighten the screw.

12) Turn the unit back over and position the CPM base unit so that the 4 attachment blocks are facing you.

13) Remove the bolt rod from the attachment blocks.

Proceed to the next page.

2.3) Removing the Allen key from its holder:

1) Select the Allen keys and locate the 1mm. Allen key.

2) With one hand, hold the spring-like holder.

3) With your other hand, pull the 1mm. Allen key from the spring-like holder.

Proceed to the next page.

2.4) Tightening Allen Screw:

1) Slot the long-end of the Allen key into the Allen screw.

2) Tighten the Allen screw.

You have finished the cursor shaft assembly.

Proceed to the next step.

3.0) Hand Rod Assembly

The hand rod functions as a hand rest which supports the patient's hand while the hand and/or finger muscles are being exercised.

3.1) Hand rod assembly:

1) Select the T-bar.

2) Select the 2 plastic sleeves.

3) Slide the length of the 2 plastic sleeves onto the T-bar.

4) Hold the T-bar so that it represents the alphabetical letter 'T'.

5) Position the U-bar above the T-bar.

6) Slot both ends of the U-bar into the holes on the plastic sleeves.

7) Secure the U-bar onto the T-bar with a long plastic nut at each end.

8) Tighten both nuts until they stop.

Proceed to the next page.

3.2) Fastening hand rod onto cursor casing:

1) Select the cursor casing.

2) With one hand, hold the cursor casing so that the straightest edge of the cursor casing is on top.

3) With your other hand, position the T-bar underneath the cursor casing.

4) Insert the T-bar of the hand rod into the 3rd hole from the front of the cursor casing.

(**Note:** The T-bar should be positioned at a 'cross-angle' with the cursor casing.)

5) Fasten the T-bar in place with the remaining long plastic nut.

6) Tighten the nut until it stops.

You have finished the hand rod assembly.

Proceed to the next step.

4.0) Cursor Casing Assembly

The cursor casing functions as a guide rail for the cursor which ensures the correct movement of the finger linkages.

1) Locate the black square of the metal block (connected to the switch rod).

2) Hold the cursor casing so that the straightest edge of the cursor casing is on top.

3) Slot the cursor casing onto the cursor-shaft-block and the cursor.

4) Align the back of the cursor casing so that it covers the black square of the metal block, leaving a gap between the cursor casing and the motor casing.

(**Note:** This will allow for easier assembly of the finger linkages.)

You have finished the cursor casing assembly.

Proceed to the next step.

5.0) Finger Linkage Assembly

The finger linkages are attached to the CPM base unit in 2 places:

1) The linkage attachment blocks located at the front of the CPM unit base-plate.

2) The cursor.

5.1) Fastening the (front) finger linkage attachment to the blocks:

1) Position the CPM base unit so that the back of the motor faces towards you.

2) Select one of the finger linkages.

4) Slot the front finger linkage attachment onto the 1st attachment block, located at the right front of the CPM unit.

(Note: a) The velcro strip should be positioned in front of the hand rod.

b) The back linkage attachment should be positioned behind the attachment block.)

5) Select one of the bolt rods.

6) Insert the bolt-rod through the hole on the side of the front linkage until it protrudes slightly on the other side of the 1st linkage.

Proceed to the next page.

7) Slot a 2nd linkage onto the next block.

8) Push the cursor casing slowly towards the motor at the same time you are inserting the bolt-rod through the 2nd linkage.

9) Continue to fasten the remaining 3rd and 4th linkages.

10) Fasten the bolt-rod with one of the plastic nuts.

11) Tighten the nut until it stops.

Proceed to the next page.

5.2) Fastening the (back) finger linkage attachment to the cursor:

(**Note:** Begin with the right-most finger linkage.)

1) Insert the bolt-rod through the hole at the back-end of the linkage.

2) Select one of the aluminium spacers.

3) Insert the bolt-rod through the aluminium spacer.

4) Insert the bolt-rod through the hole of the next linkage.

5) Lift the cursor casing slightly and hold it in a position where you can see a 2nd hole on the cursor.

6) Insert the bolt-rod through (both) the gap on the cursor casing and the 2nd hole on the cursor.

7) Insert the bolt-rod through the next linkage.

8) Insert the bolt-rod through the remaining aluminium spacer.

9) Insert the bolt-rod through the last linkage.

10) Fasten the bolt rod with the remaining plastic nut.

11) Tighten the nut until it stops.

Proceed to the next page.

You have completed the assembly procedure.

Please close the instruction manual.

Testing Procedures

6.0) Testing Procedures

The following procedures allow you to operate and test the finger linkage movements of the CPM unit.

6.1) Inserting the plug into the cursor:

(Note: Ensure that the back of the motor unit is facing you.)

1) Remove the plug for the velcro strap.

2) Insert the plug through the hole on the cursor, up to the black line of the plug .

Proceed to the next page.

6.2) Testing cursor movement:

1) Select the adapter.

2) Position in front of you the box marked 'TESTING BLOCK'.

(**Note:** The label should be facing you.)

3) Place the CPM unit on top of the testing block and align the front edge of the CPM unit base-plate with the edge of the block.

(**Note:** The hand rod should be hanging over the edge of the block.)

4) Pull back the direction switch located at the top of the motor unit until it 'clicks'.

5) With one hand, hold the CPM unit by its motor casing.

6) With your other hand, push the adapter socket into the adapter plug as far as you can (until it 'clicks').

Proceed to the next page.

7) Plug the adapter into the extension cord (located on the top right-hand corner of the table.)

(Note: The CPM unit will make a 'roaring' sound as soon as the adapter is plugged into the extension cord.)

> **The cursor will move forward until it reaches the front (white) plastic nut on the switch rod. The cursor will automatically reverse the motor and move the cursor back towards its original position.**

8) Disconnect the adapter socket when the cursor touches the plastic nut on the back end of the switch rod.

Proceed to the next step.

7.0) Test With Plug in Cursor Casing Position

7.1) Inserting plug into the cursor casing:

1) Place the CPM unit back on the table so that the back of the motor is facing you.

2) Remove the plug from the cursor.

3) Insert the plug through the hole on the back of the cursor casing up to the black line of the plug.

Proceed to the next page.

7.2) Testing cursor movement:

1) Position in front of you the box marked 'TESTING BLOCK'

2) Place the CPM unit on top of the testing block and align the front edge of the CPM unit base-plate with the edge of the block.

(**Note:** The hand rod should be hanging over the edge of the block.)

3) Pull back the direction switch located at the top of the motor unit until it 'clicks'.

4) With one hand, hold the CPM unit by its motor casing.

5) With your other hand, push the adapter socket into the adapter plug as far as you can (until it 'clicks').

(**Note:** The CPM unit will make a 'roaring' sound as soon as the adapter socket is pushed into the adapter plug.)

The cursor will move forward until it reaches the front (white) plastic nut on the switch rod. The cursor will automatically reverse the motor and move the cursor back towards its original position.

6) Disconnect the adapter socket when the cursor touches the plastic nut on the back end of the switch rod.

Proceed to the next page.

You have completed the testing procedures.

Please close the instruction manual.

Thank you for your participation.

Appendix 3.

Instruction manual Conditions 3 and 4.

Note: A picture of the CPM unit on page 1 of the manual was absent in instruction manual Condition-3.

THE CPM UNIT:

ASSEMBLY AND TESTING INSTRUCTIONS

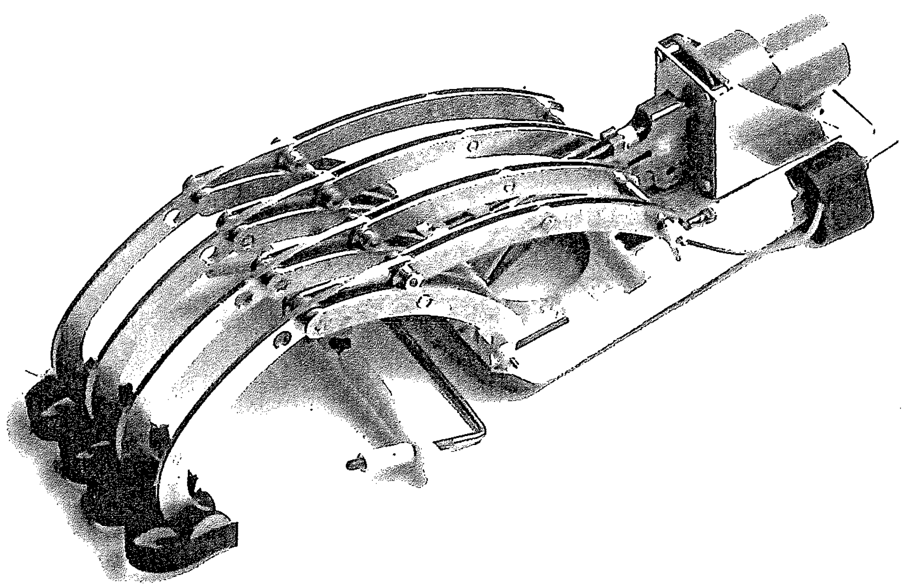
CONTENTS

The CPM Unit

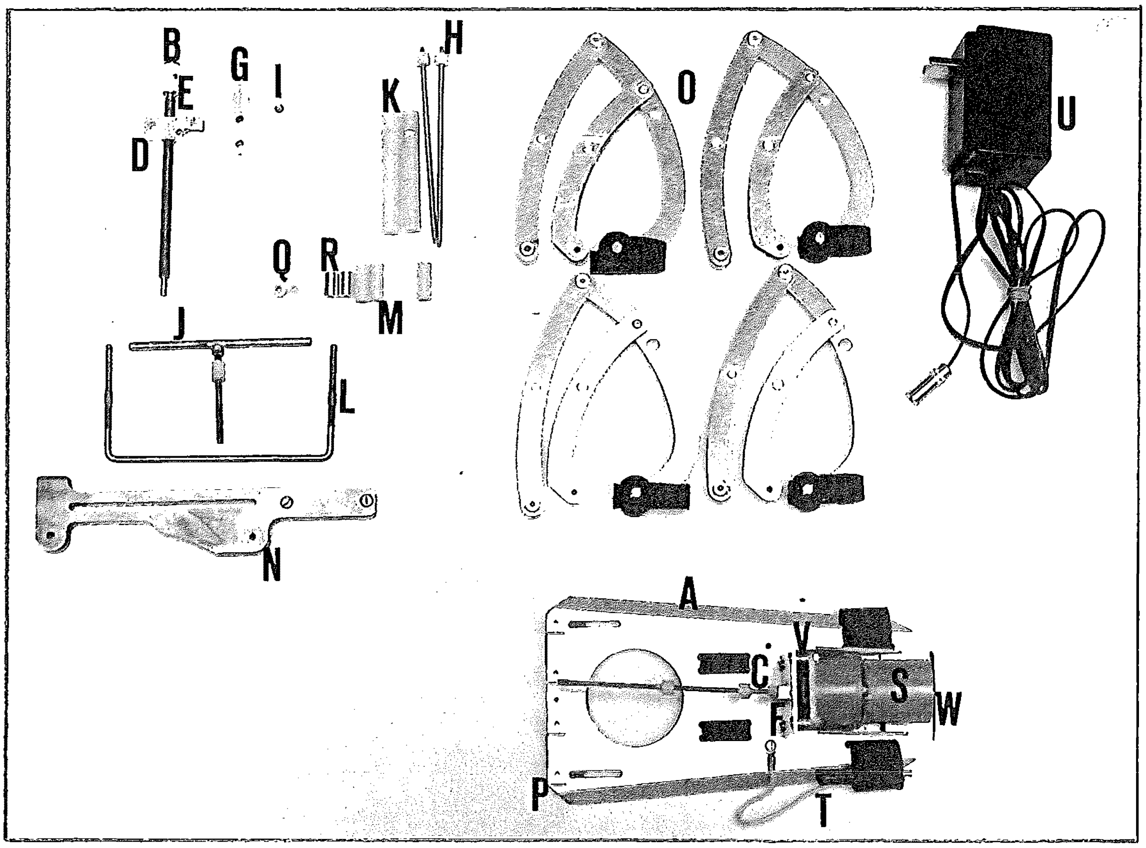
The portable continuous passive motion hand unit (CPM) is an orthopaedic hand exercise unit, designed to help the healing of the hand and/or finger muscles after injury. The lightweight design of the unit means the patient can take the unit home and supervise their own personal therapy for up to 24 hours.

The unit fits comfortably on top of the hand and wrist. It is secured with velcro binding for easy attachment to and release from the fingers and wrist.

A small motor operates the finger linkages of the CPM unit which helps the patient to exercise his/her hand without effort.



Names of CPM Parts



1.0) Names of CPM Parts

The following names refer to the names of the CPM parts and their location on the CPM unit. The order of presentation corresponds with the order of the procedural steps.

A) **The CPM Base Unit:** The CPM base unit is the largest sub-assembled component made up of an aluminium base-plate, a motor unit, a red plug, and 4 linkage attachment blocks.

B) **The Cursor Shaft:** The cursor shaft is the longest metal rod with a brass block threaded onto it. The cursor shaft is attached to the motor shaft.

C) **The Switch Rod:** The switch rod is the brass rod with 2 short plastic nuts threaded onto it. The switch rod is attached to the motor unit.

D) **The Cursor:** The cursor is the brass block with 2 holes and a groove. The cursor is threaded onto the cursor shaft.

E) **The Allen Screw:** The Allen screw is the screw threaded into the white portion of the cursor shaft.

F) **The Motor Shaft:** The motor shaft is the small metal rod protruding from the motor unit.

G) **The Cursor-Shaft-Block:** The cursor-shaft-block is the long rectangular, aluminium block with holes on it. The cursor-shaft-block is fastened onto the CPM unit base-plate.

H) **The Bolt Rod:** The bolt rod is the long brass rod with a short plastic nut threaded onto it. The bolt rod secures the finger linkages onto the CPM unit.

I) **The screw:** The screw is the smallest un-assembled CPM component. The screw secures the cursor-shaft-block onto the CPM unit base-plate.

Proceed to the next page.

J) **The T-Bar:** The T-bar is the metal component which represents the alphabetical letter 'T', a short plastic nut is threaded onto it. The T-bar is a sub-part of the hand rod unit fastened onto the cursor casing.

K) **The Plastic Sleeves:** The plastic sleeves are the longest plastic component of the CPM parts. Each plastic sleeve is partially hollow with a hole on one end. The plastic sleeves are a sub-part of the hand rod unit slotted onto the T-bar.

L) **The U-Bar:** The U-bar is the metal component which represents a very wide alphabetical letter 'U'. The U-bar is a sub-part of the hand rod unit and is fastened to the T-bar.

M) **The Long Plastic Nut:** The long plastic nut is the longest nut of the CPM parts. It is a sub-part of the hand rod unit which secures the U-bar to the T-bar.

N) **The Cursor Casing:** The cursor casing is the largest metal component of the CPM parts. The cursor casing is an aluminium block with 6 holes fixed between the metal at the front-end, with gaps in the mid-section and one hole at the back-end of the metal part. The cursor casing encases the cursor and the cursor-shaft-block.

O) **The Finger Linkages:** The finger linkages are the 3-pronged aluminium objects with a black velcro strip fastened at the front-end. The finger linkages are attached to the CPM base unit in 2 places: 1) the 4 linkage attachment blocks, 2) the cursor.

P) **The Attachment Blocks:** The attachment blocks are the 4 short aluminium blocks secured onto the front-end of the CPM unit base-plate.

Q) **The Plastic Nut:** The plastic nut is the shortest plastic component of the CPM parts. The nut secures the bolt rods attaching the finger linkages to the attachment blocks and the cursor.

R) **The Aluminium Spacer:** The aluminium spacer is the hollow, pipe-like aluminium component of the CPM parts. The aluminium spacer is slotted onto the bolt rod between the back finger linkage attachments.

Proceed to the next page.

S) The Motor Unit: The motor unit is the sub-assembled component secured to the back-end of the CPM unit base-plate.

T) The Plug: The (red) plug is attached to the black velcro strap located at the back-end of the CPM base unit.

U) The Adapter: The adapter is the black 'cubical' object with a silver socket attached to the black cord.

V) The Direction Switch: The direction switch is the brown PC board located on the top of the motor unit.

W) The Adapter Plug: The adapter plug is the silver metal rod that protrudes from the back end of the motor unit.

Proceed to the next page.

Assembly and Testing Procedure Instructions

All the parts and tools you will need to assemble and operate the CPM unit are in front of you.

1) Perform the task as accurately and as fast as you can.

2) Please follow the procedures and notes in a step-by-step manner

3) **Please close the instruction manual.**

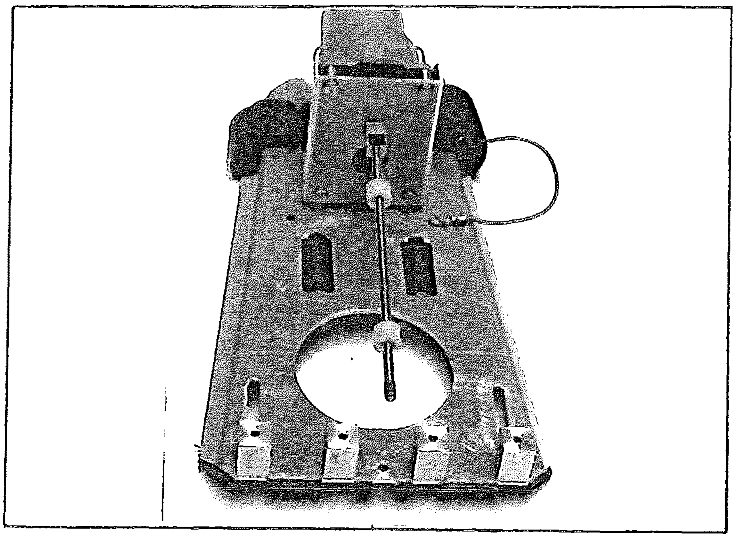
Assembly Procedures

2.0) Cursor Shaft Assembly

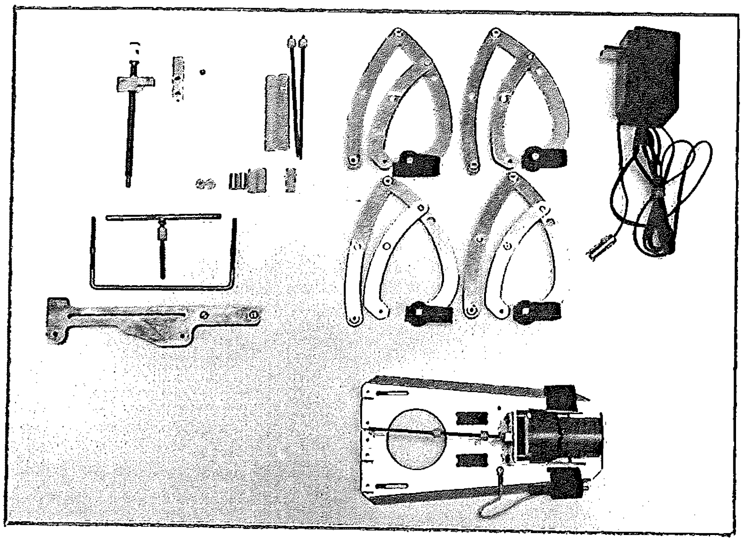
The cursor shaft is the metal shaft which is threaded through the cursor. When the motor is operating, the cursor allows for forward and backward motion of the finger linkages.

2.1) Positioning the cursor shaft into the motor shaft:

1) Position the CPM base unit so that the 4 linkage attachment blocks are facing you.



2) Select the cursor shaft.



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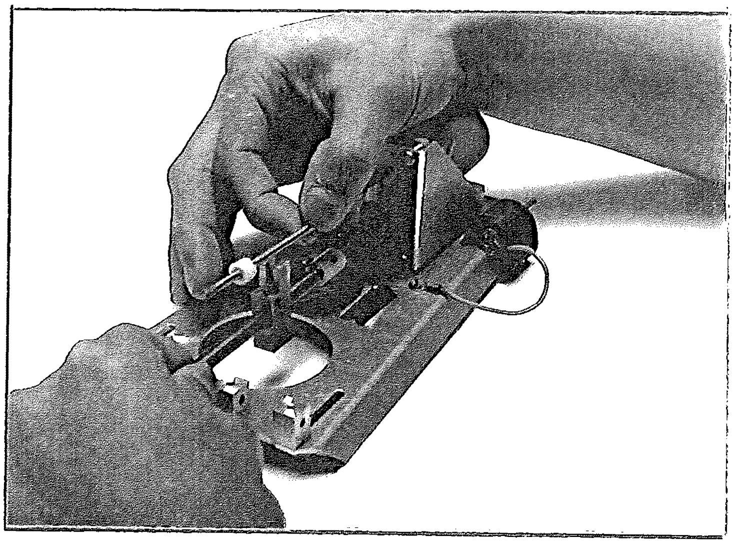
3) With one hand, lift the switch rod.

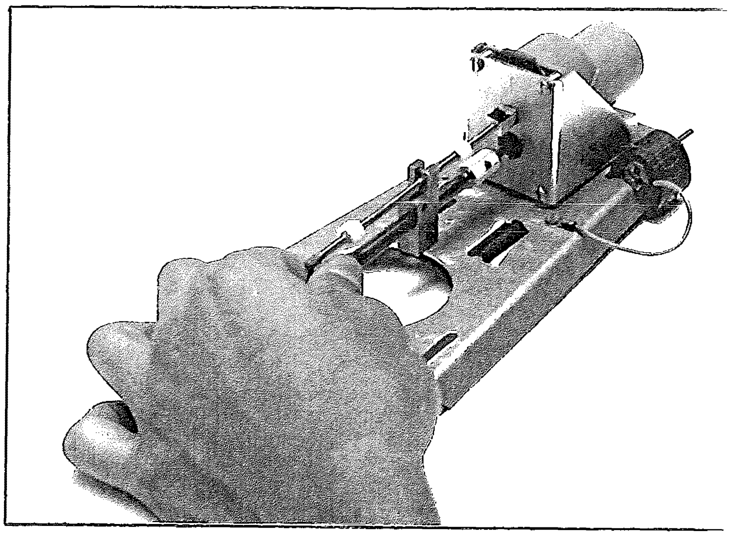


4) With your other hand, position the cursor shaft below the switch rod.

5) Place the switch rod in the groove of the cursor.

(**Note:** The cursor should be positioned between the 2 plastic nuts.)

6) Turn the cursor shaft so that the Allen screw is aligned with the flat side of the motor shaft.



7) Insert the cursor shaft into the motor shaft as far as you can.

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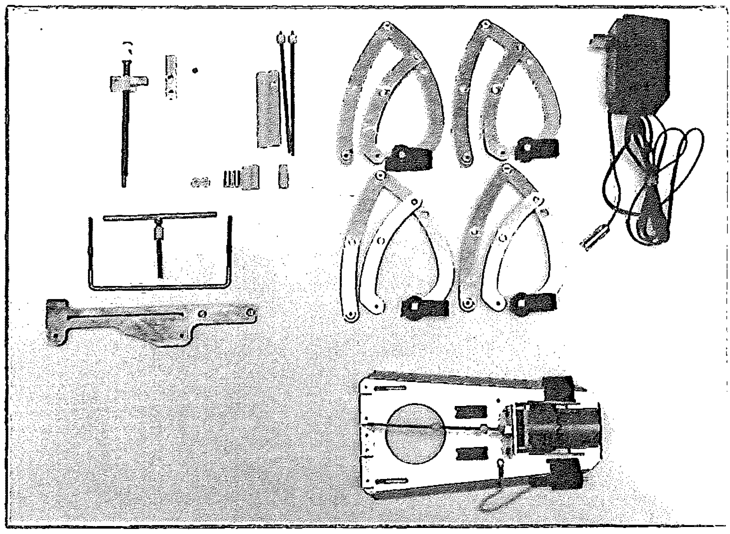
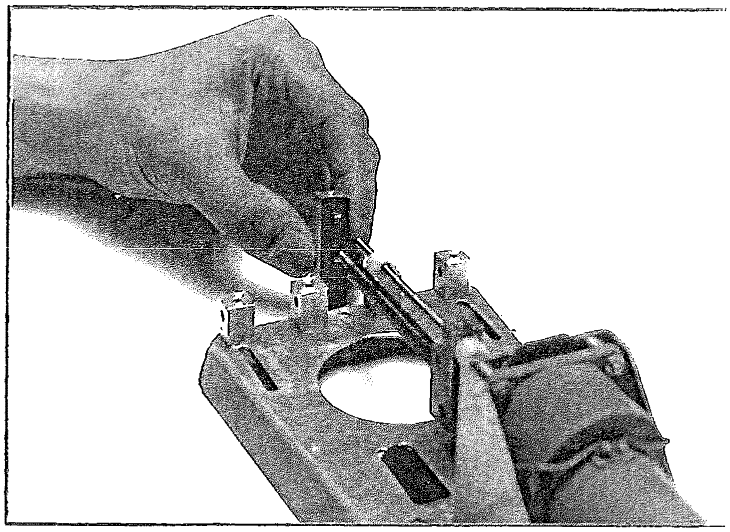
2.2) Mounting the cursor-shaft-block onto the CPM base unit:

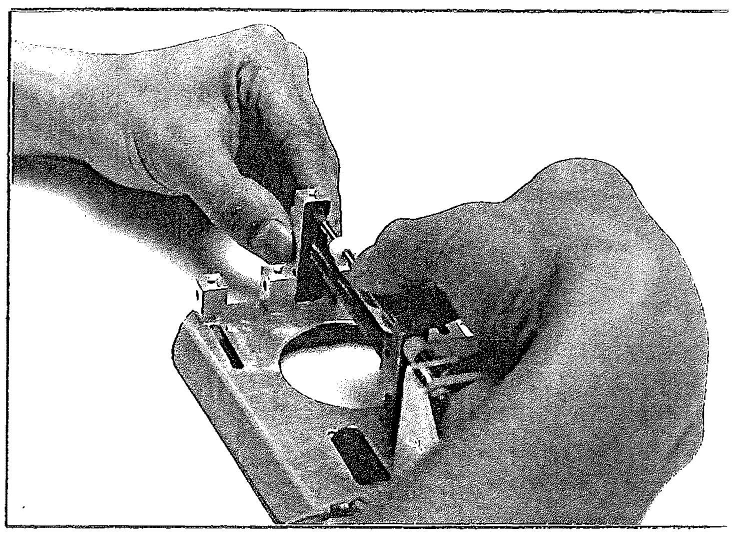
1) Select the cursor-shaft-block.



2) Hold the cursor-shaft-block so that the black side is facing the motor unit.



3) At the same time, slot the hole located in the middle of the cursor-shaft-block into the cursor shaft and the top hole into the switch rod.



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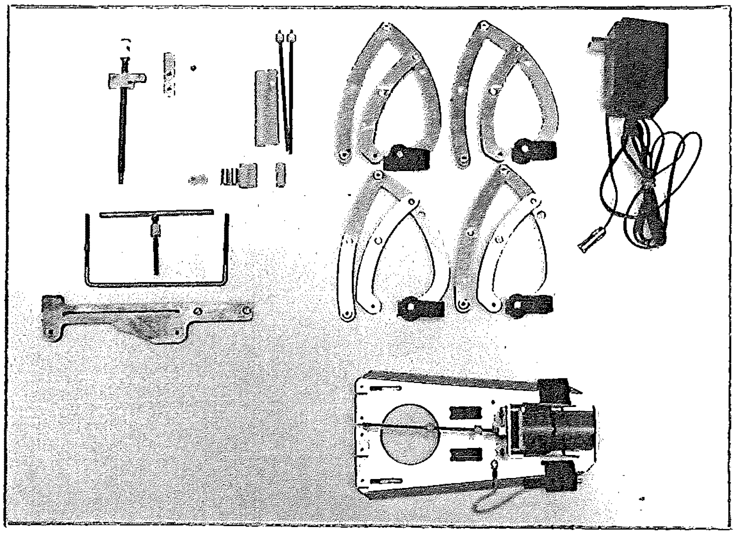
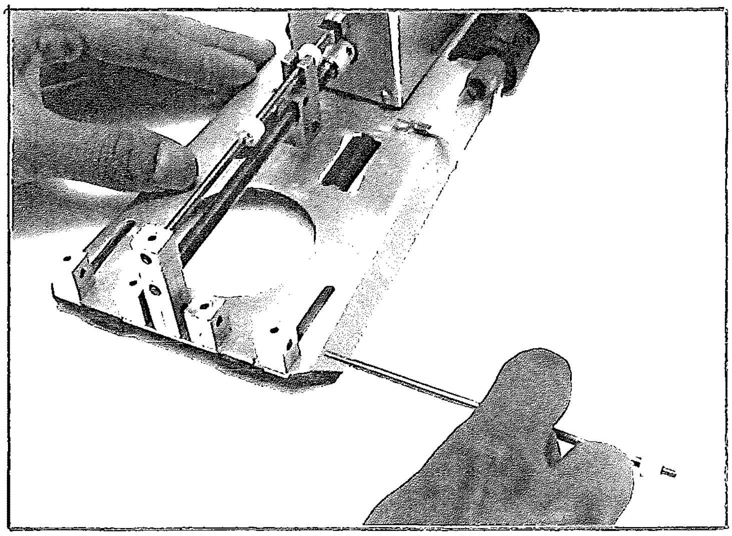
4) Select one of the bolt rods.



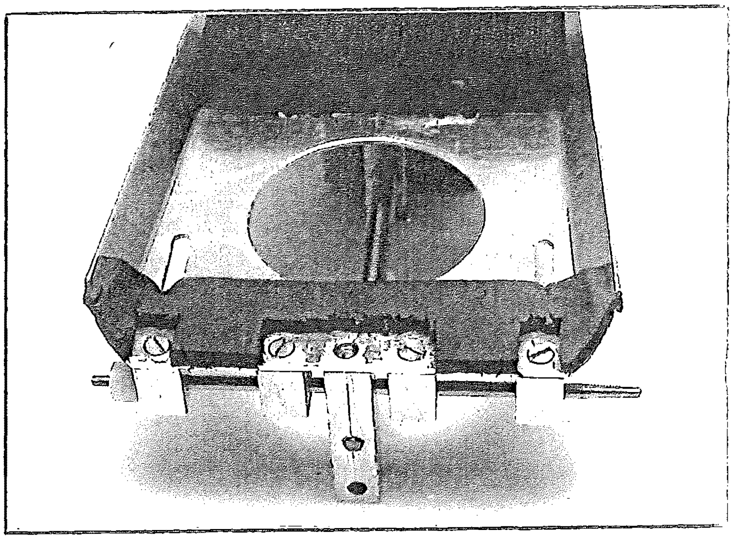
5) Starting from the right-most attachment block, insert the bolt rod through the side holes of the linkage attachment block.



(**Note:** The bolt rod should slide through the 4 attachment blocks and the cursor-shaft-block.)

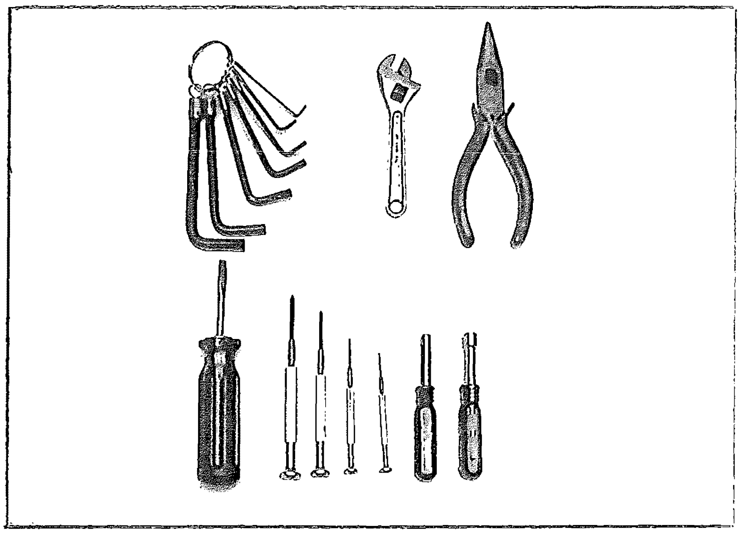
Proceed to the next page.

6) Turn the CPM unit over and rest the unit on the table.

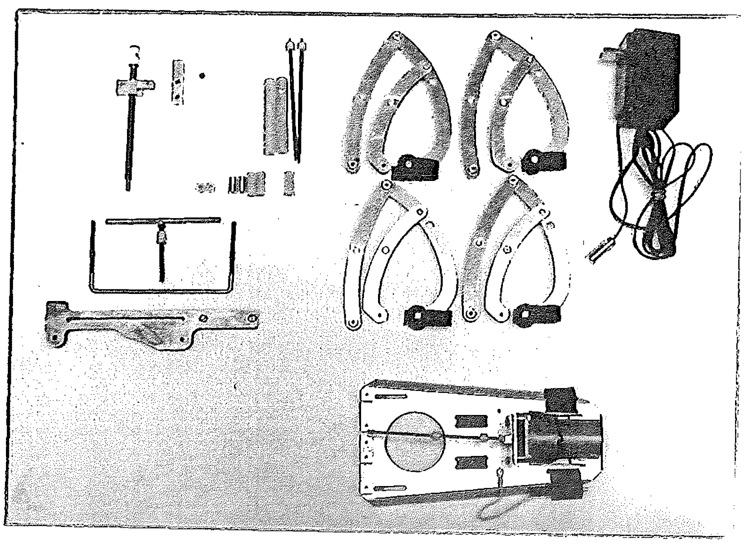


(**Note:** The cursor-shaft-block should be positioned upright, touching the table.)

7) Select a standard screwdriver.



8) Select the screw.



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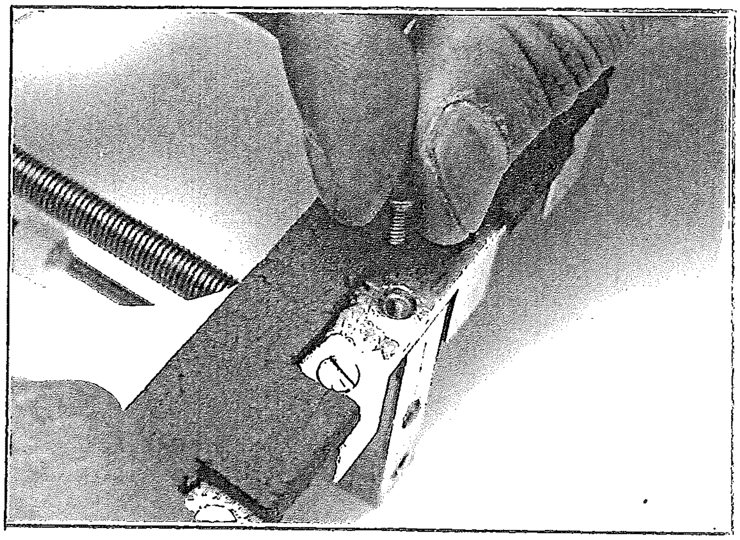
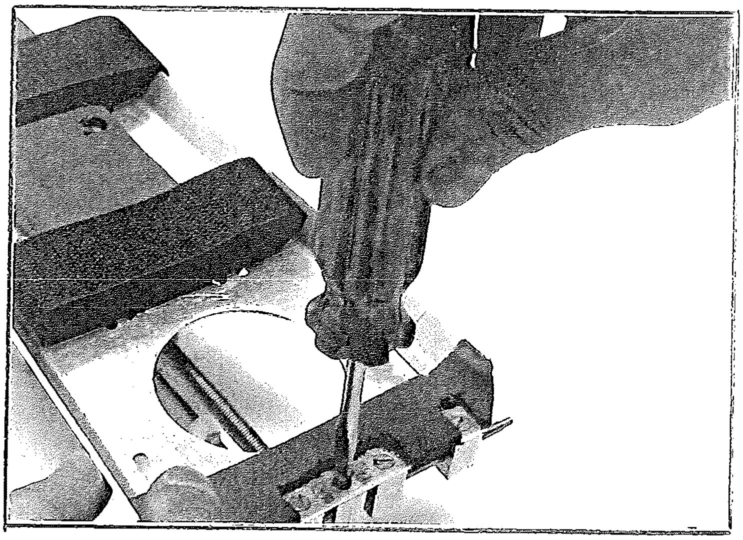
9) Hold the CPM unit firmly and ensure that the cursor-shaft-block is touching the table.

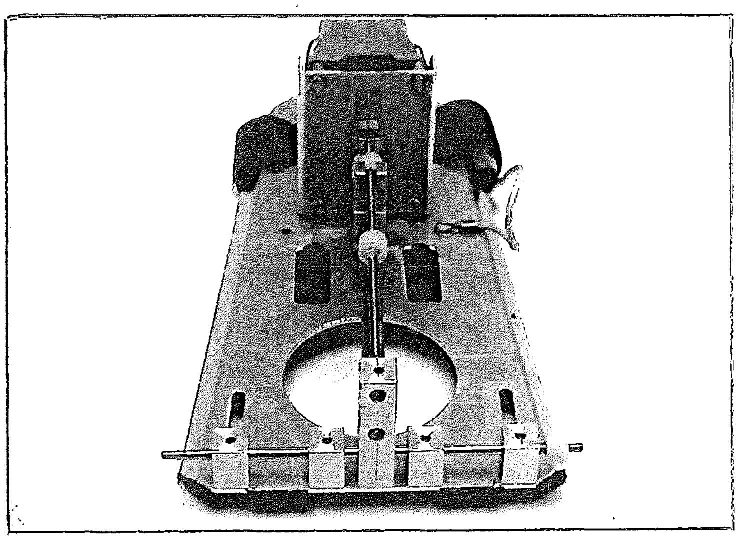
10) With the screw, secure the cursor-shaft-block to the CPM unit base-plate.



11) Using the screwdriver, tighten the screw.



12) Turn the unit back over and position the CPM base unit so that the 4 attachment blocks are facing you.



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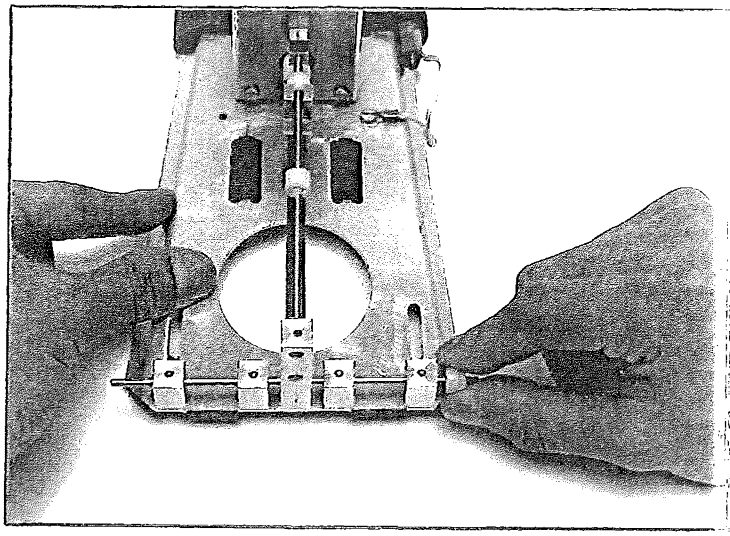
13) Remove the bolt rod from the attachment blocks.



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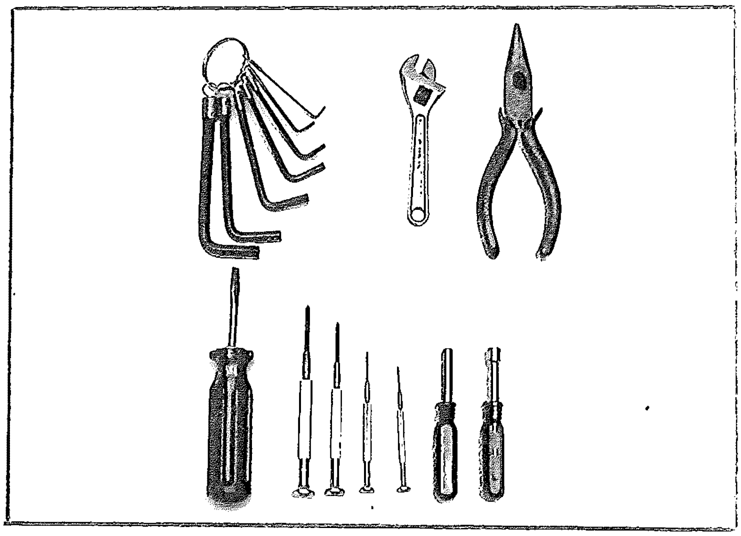
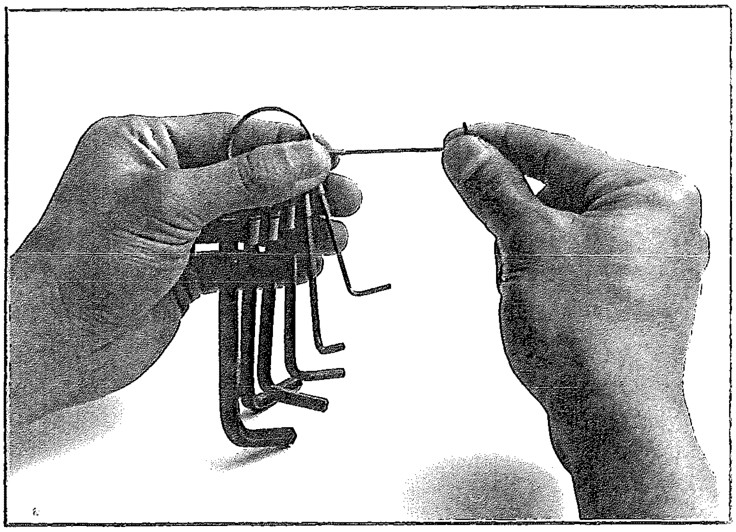
2.3) Removing the Allen key from its holder:

1) Select the Allen keys and locate the 1mm. Allen key.



2) With one hand, hold the spring-like holder.

3) With your other hand, pull the 1mm. Allen key from the spring-like holder.



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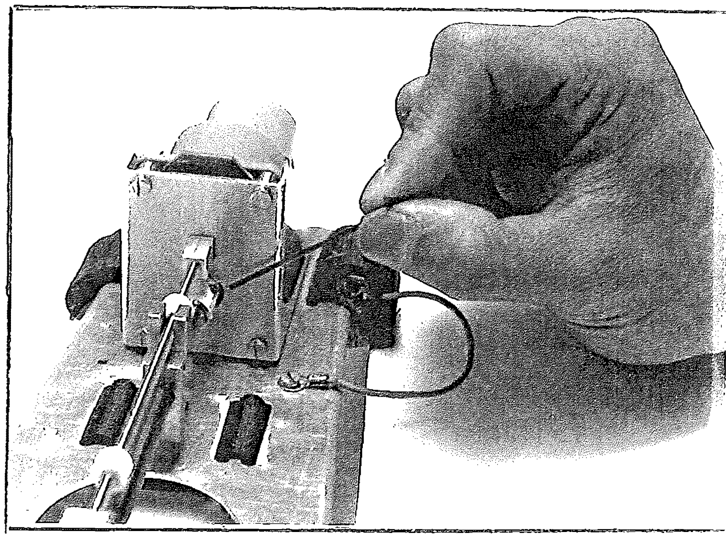
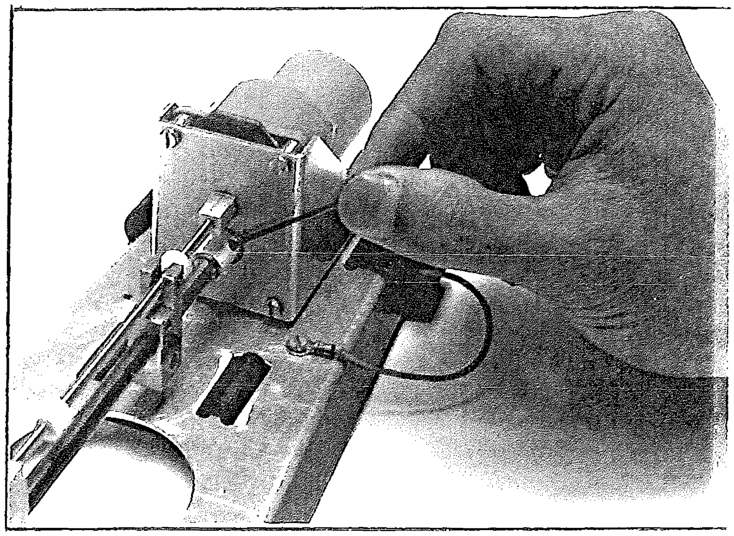
2.4) Tightening Allen Screw:

1) Slot the long-end of the Allen key into the Allen screw.



2) Tighten the Allen screw.



You have finished the cursor shaft assembly.

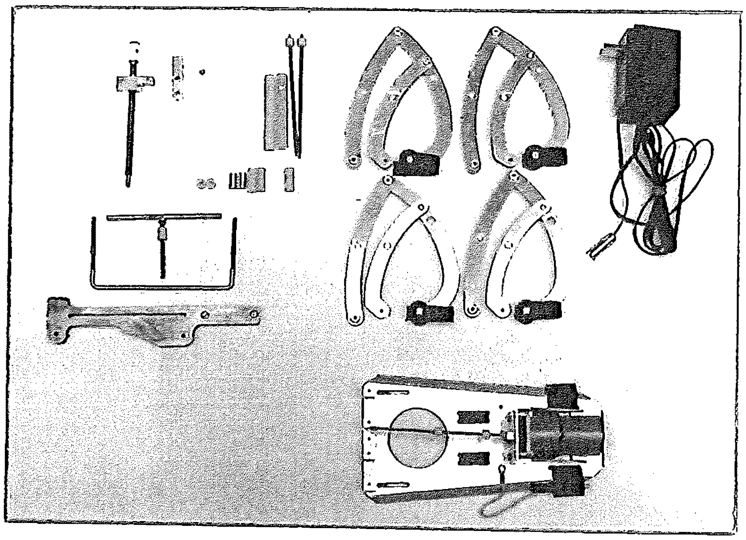
Proceed to the next step.

3.0) Hand Rod Assembly

The hand rod functions as a hand rest which supports the patient's hand while the hand and/or finger muscles are being exercised.

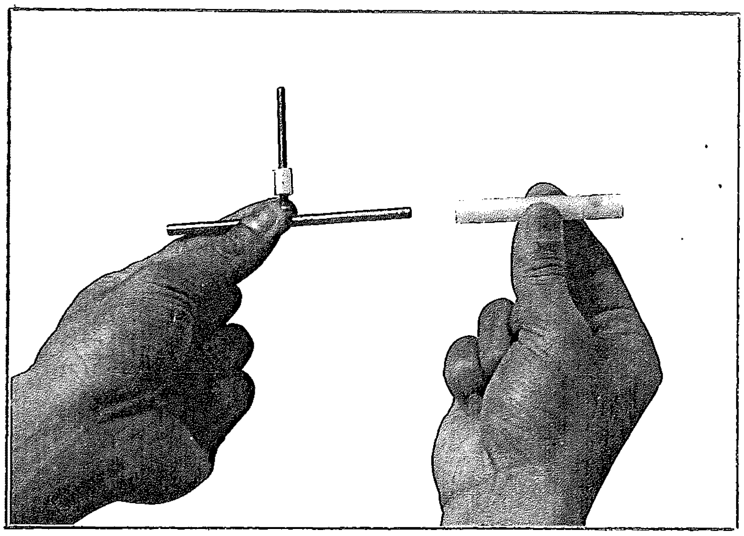
3.1) Hand rod assembly:

1) Select the T-bar.



2) Select the 2 plastic sleeves.

3) Slide the length of the 2 plastic sleeves onto the T-bar.



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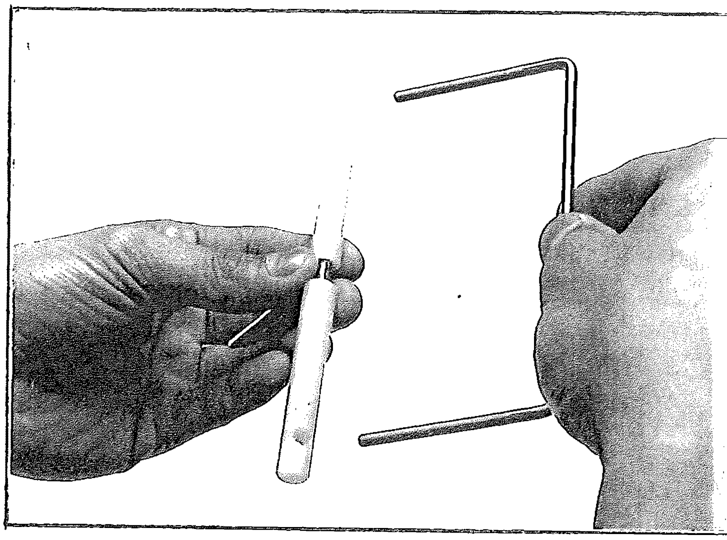
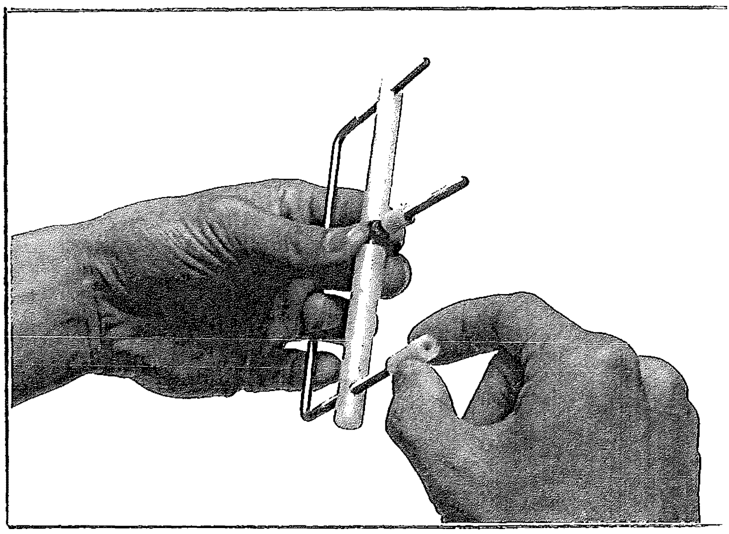
4) Hold the T-bar so that it represents the alphabetical letter 'T'.



5) Position the U-bar above the T-bar.

6) Slot both ends of the U-bar into the holes on the plastic sleeves.

7) Secure the U-bar onto the T-bar with a long plastic nut at each end.

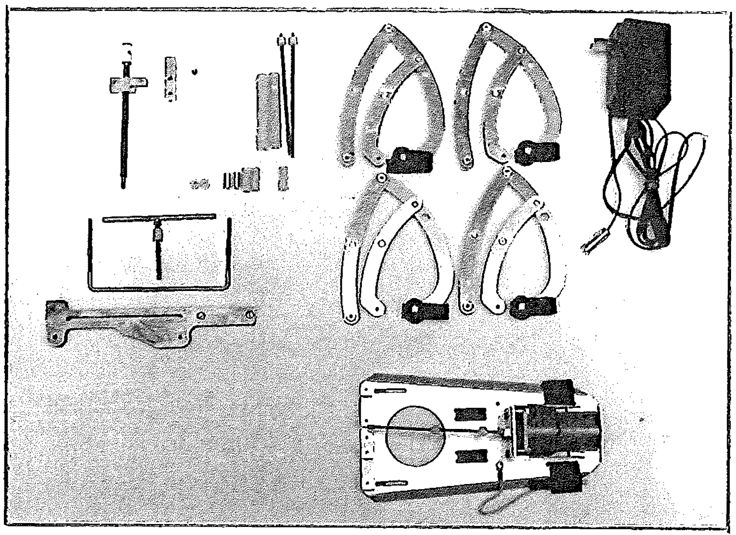


8) Tighten both nuts until they stop.

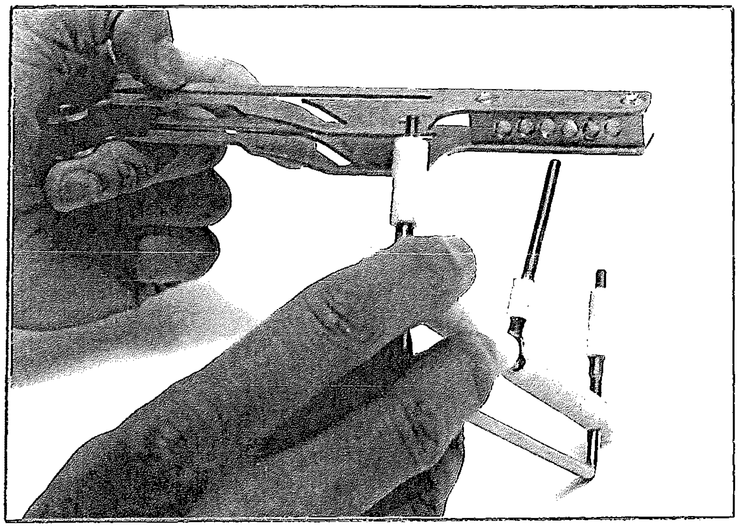
Proceed to the next page.

3.2) Fastening hand rod onto cursor casing:

1) Select the cursor casing.



2) With one hand, hold the cursor casing so that the straightest edge of the cursor casing is on top.



3) With your other hand, position the T-bar underneath the cursor casing.

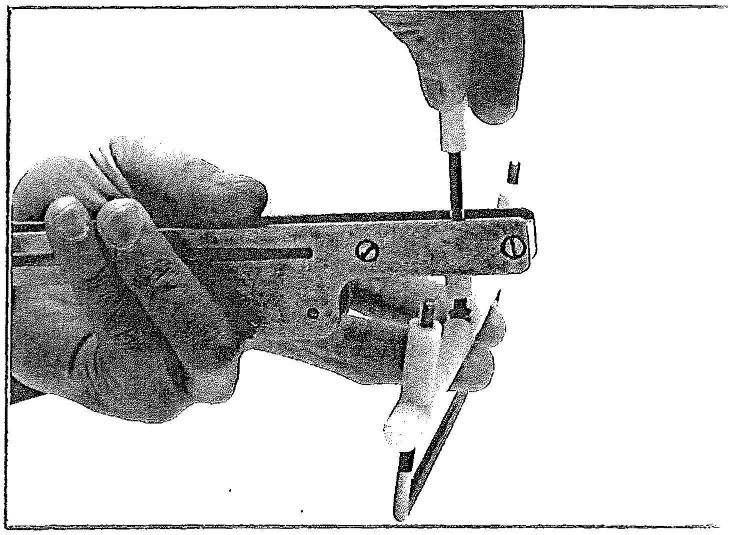
4) Insert the T-bar of the hand rod into the 3rd hole from the front of the cursor casing.

(**Note:** The T-bar should be positioned at a 'cross-angle' with the cursor casing.)

Proceed to the next page.

5) Fasten the T-bar in place with the remaining long plastic nut.

6) Tighten the nut until it stops.



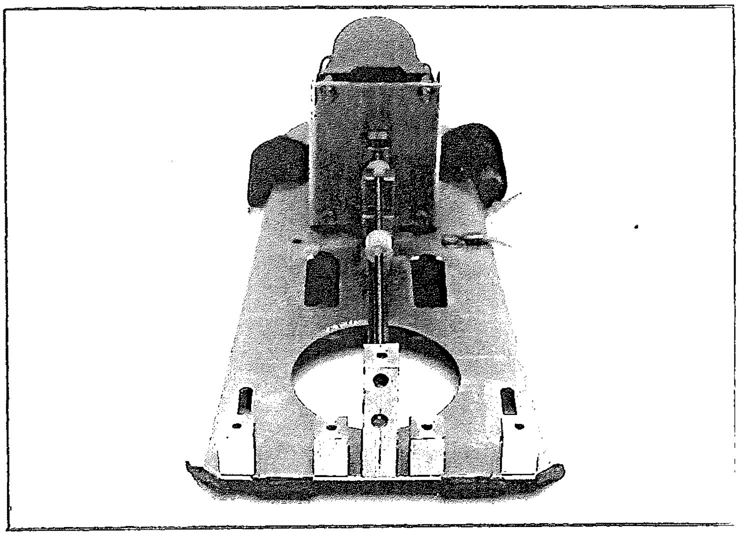
You have finished the hand rod assembly.

Proceed to the next step.

4.0) Cursor Casing Assembly

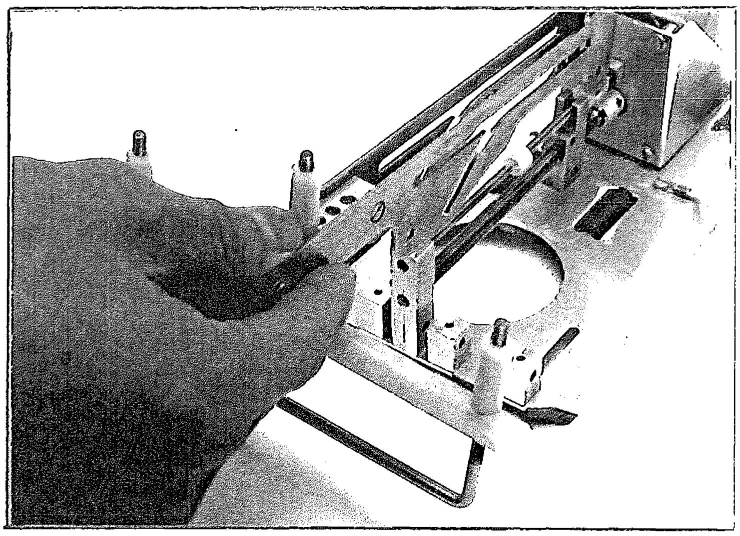
The cursor casing functions as a guide rail for the cursor which ensures the correct movement of the finger linkages.

1) Locate the black square of the aluminium block (connected to the switch rod).



2) Hold the cursor casing so that the straightest edge of the cursor casing is on top.

3) Slot the cursor casing onto the cursor-shaft-block and the cursor.



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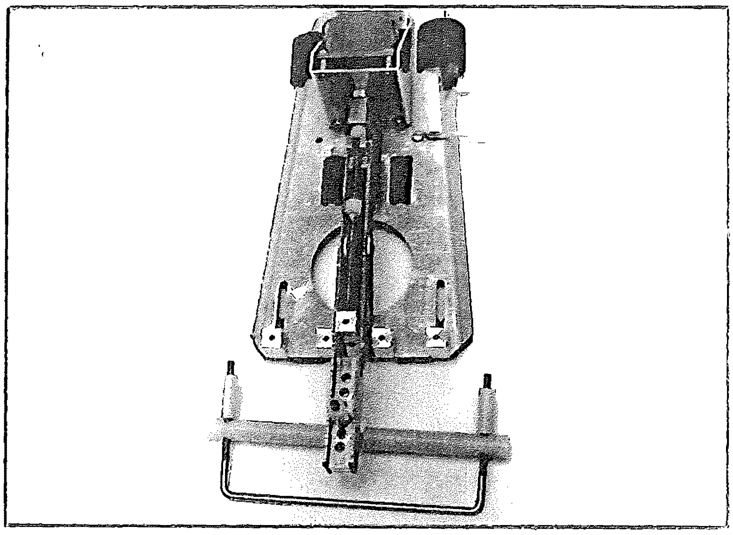
4) Align the back of the cursor casing so that it covers the black square of the aluminium block, leaving a gap between the cursor casing and the motor casing.



(**Note:** This will allow for easier assembly of the finger linkages.)

You have finished the cursor casing assembly.

Proceed to the next step.

5.0) Finger Linkage Assembly

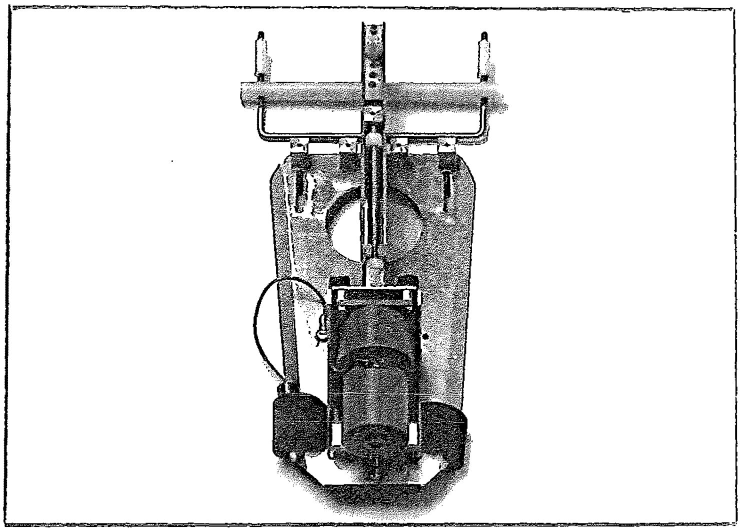
The finger linkages are attached to the CPM base unit in 2 places:

1) The linkage attachment blocks located at the front of the CPM unit base-plate.

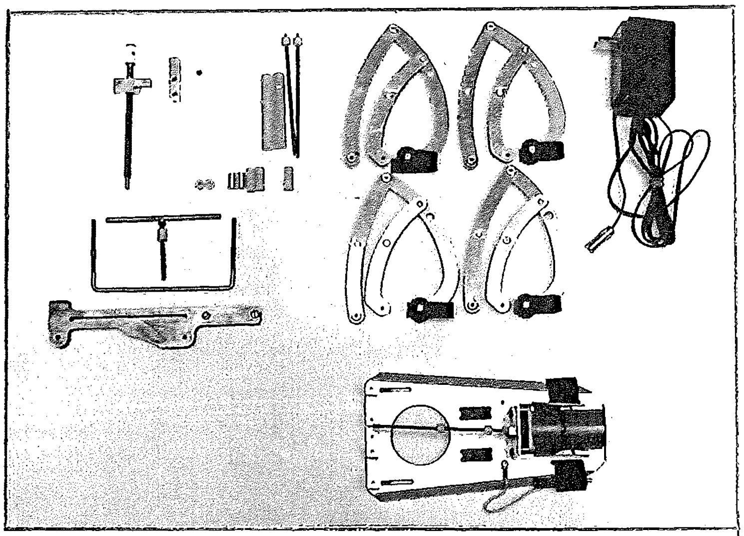
2) The cursor.

5.1) Fastening the (front) finger linkage attachment to the blocks:

1) Position the CPM base unit so that the back of the motor faces towards you.



2) Select one of the finger linkages.



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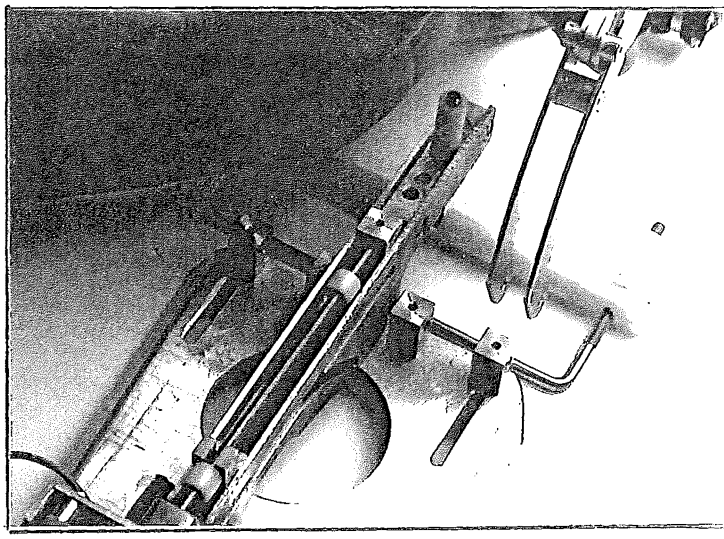
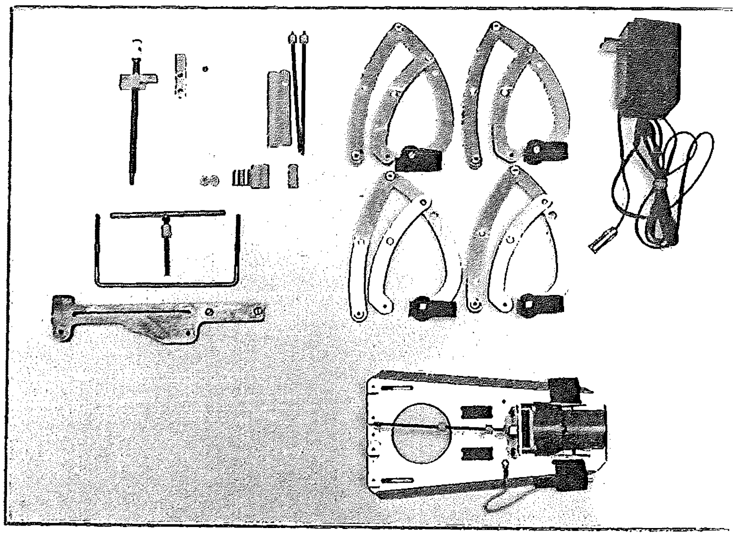
4) Slot the front finger linkage attachment onto the 1st attachment block,located at the right front of the CPM unit.



(**Note:** a) The velcro strip should be positioned in front of the hand rod.

b) The back linkage attachment should be positioned behind the attachment block.)

5) Select one of the bolt rods.



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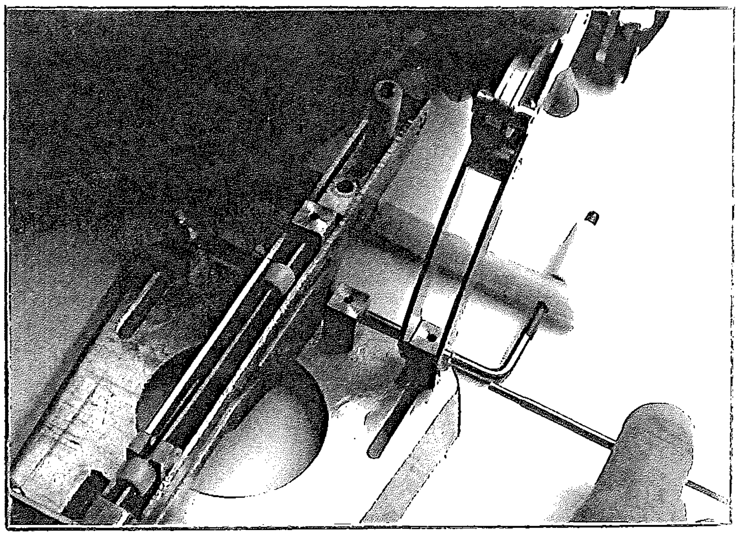
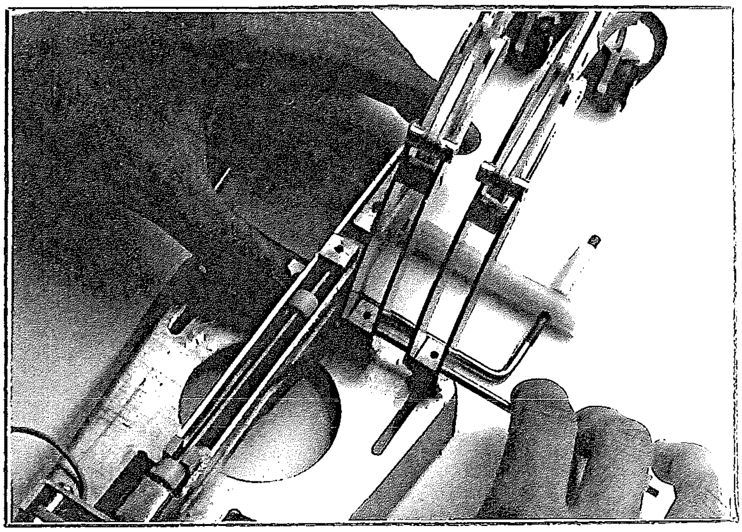
6) Insert the bolt-rod through the hole on the side of the front linkage until it protrudes slightly on the other side of the 1st linkage.

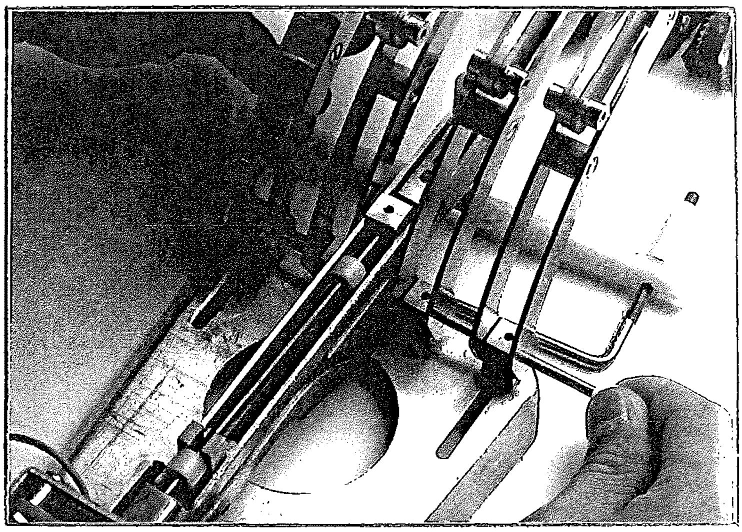


7) Slot a 2nd linkage onto the next block.

8) Push the cursor casing slowly towards the motor at the same time you are inserting the bolt-rod through the 2nd linkage.



9) Continue to fasten the remaining 3rd and 4th linkages.



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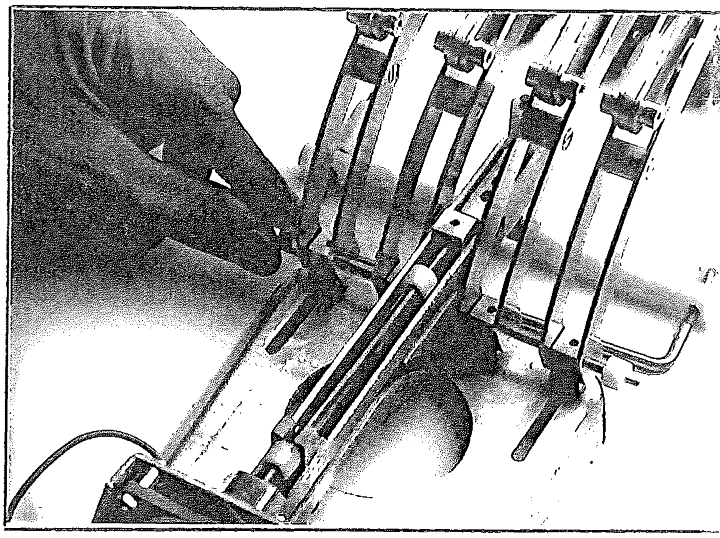
10) Fasten the bolt-rod with one of the plastic nuts.

11) Tighten the nut until it stops.



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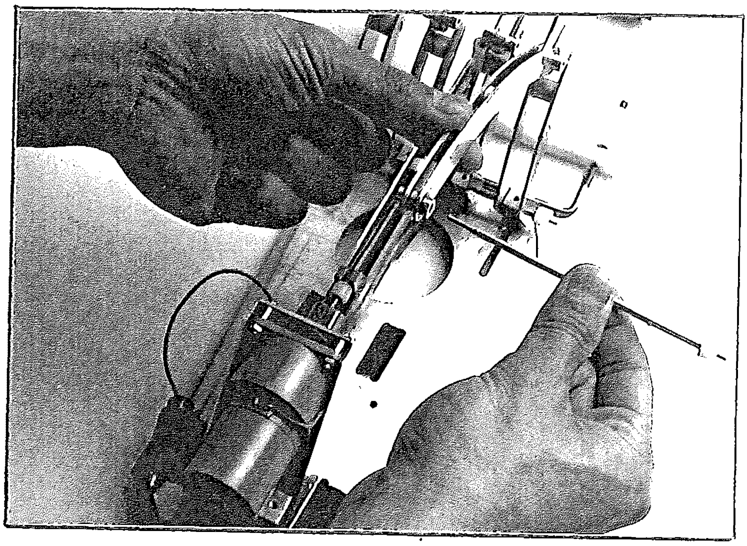
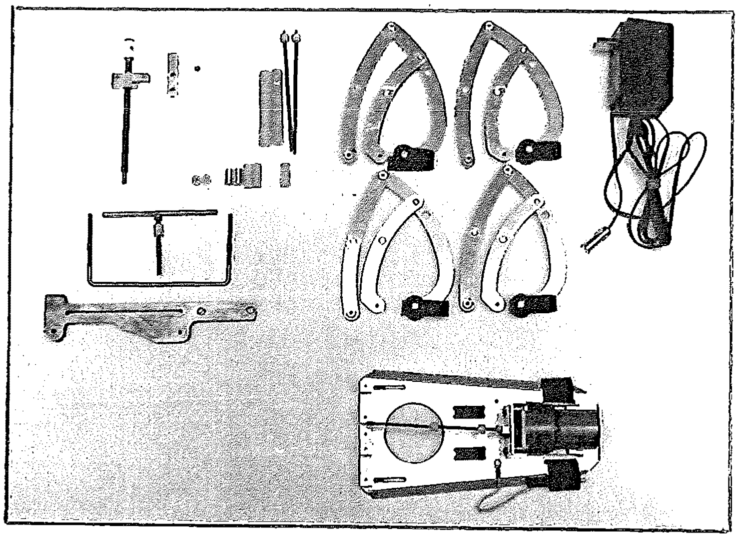
5.2) Fastening the (back) finger linkage attachment to the cursor:

(**Note:** Begin with the right-most finger linkage.)

1) Insert the bolt-rod through the hole at the back-end of the linkage.



2) Select one of the aluminium spacers.



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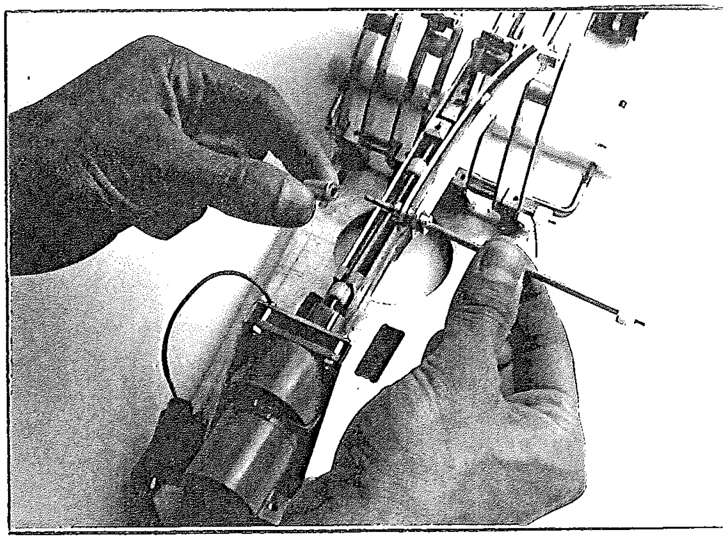
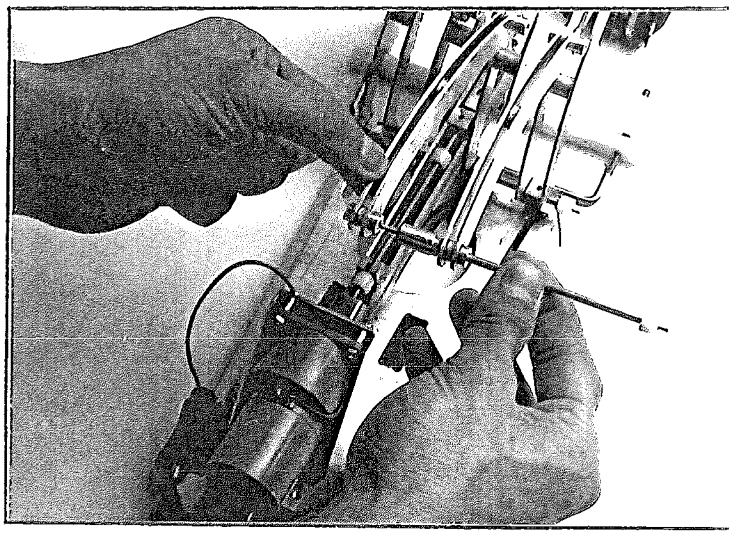
3) Insert the bolt-rod through the aluminium spacer.

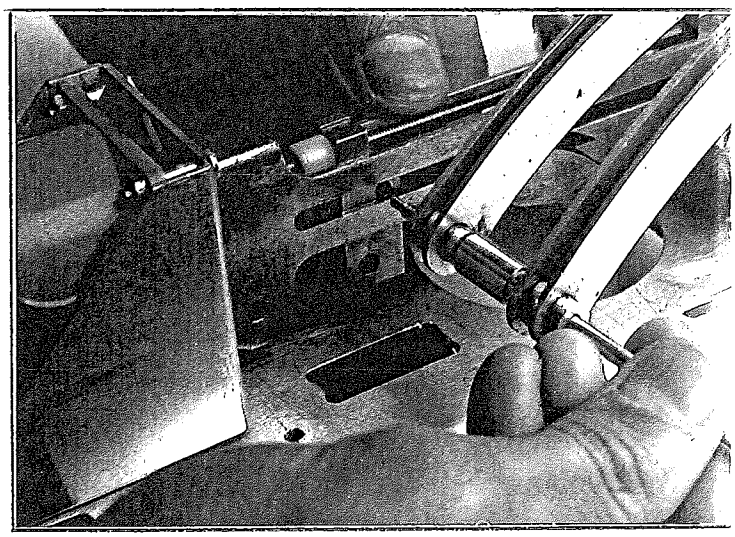


4) Insert the bolt-rod through the hole of the next linkage.



5) Lift the cursor casing slightly and hold it in a position where you can see a 2nd hole on the cursor.

6) Insert the bolt-rod through (both) the gap on the cursor casing and the 2nd hole on the cursor.



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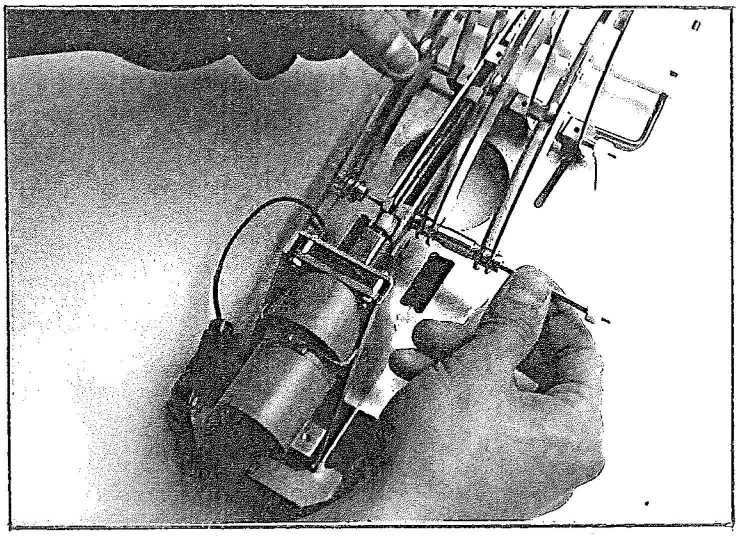
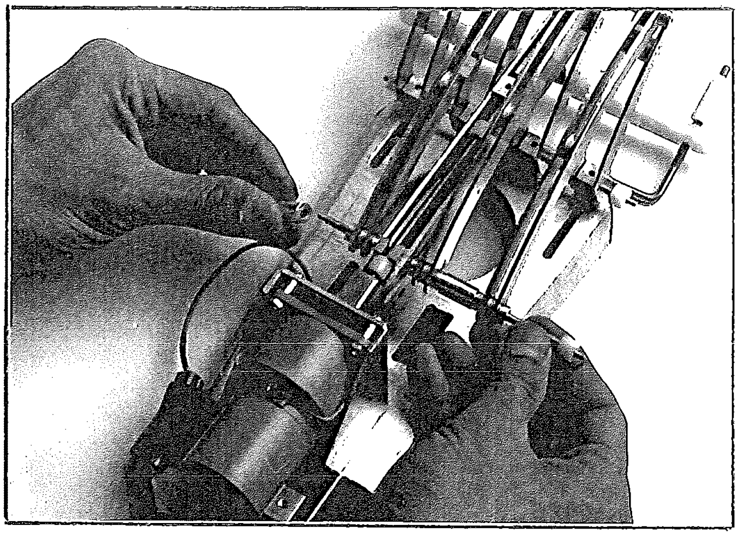
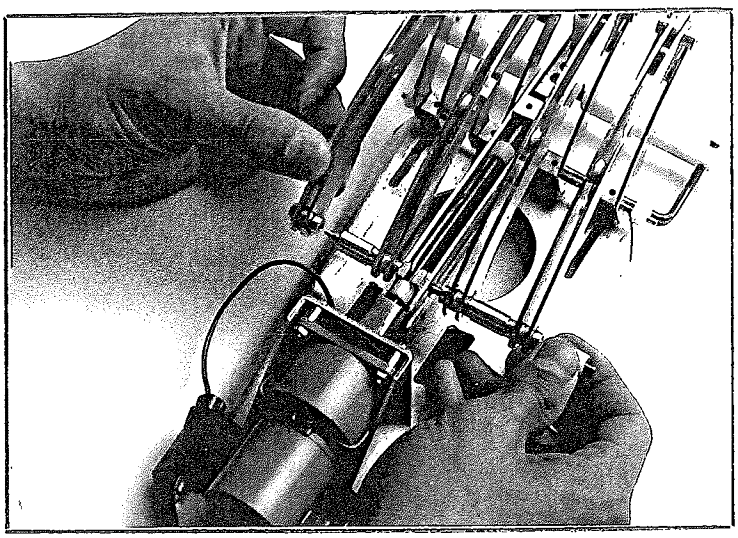
7) Insert the bolt-rod through the next linkage.



8) Insert the bolt-rod through the remaining aluminium spacer.



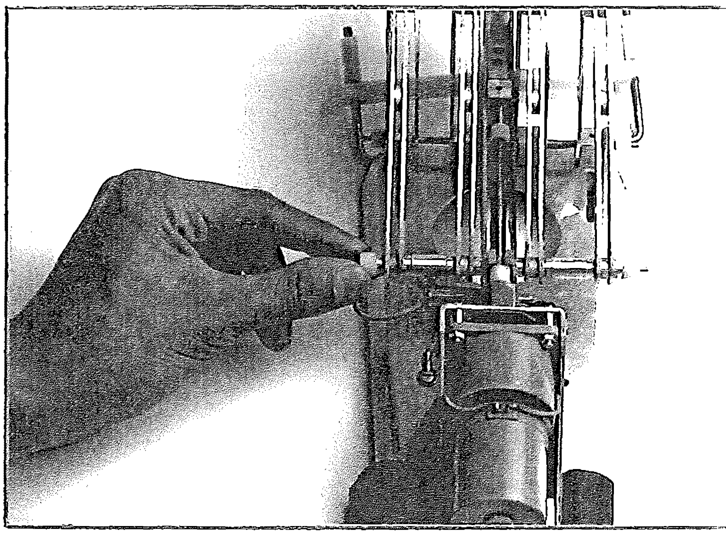
9) Insert the bolt-rod through the last linkage.



Proceed to the next page.

10) Fasten the bolt rod with the remaining plastic nut.

11) Tighten the nut until it stops.



Proceed to the next page.

You have completed the assembly procedure.

Please close the instruction manual.

Testing Procedures

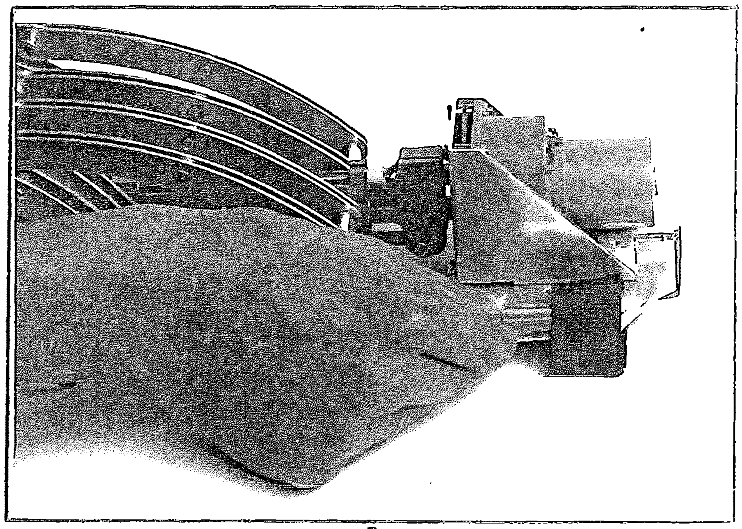
6.0) Testing Procedures

The following procedures allow you to operate and test the finger linkage movements of the CPM unit.

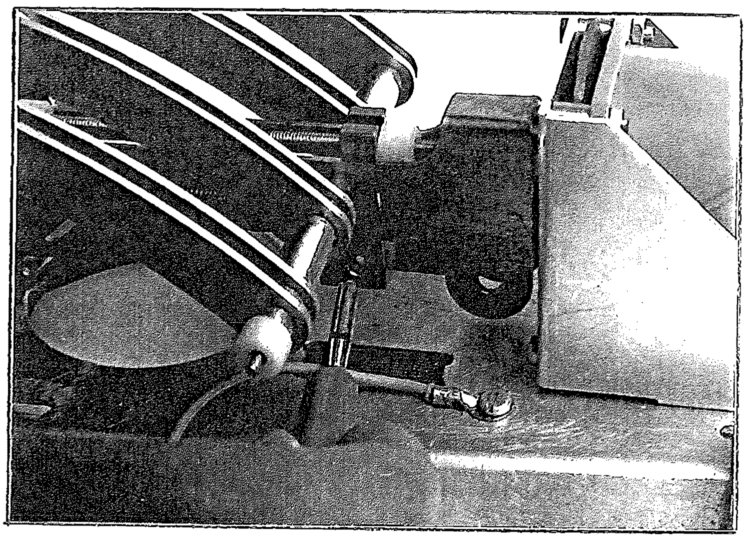
6.1) Inserting the plug into the cursor:

(Note: Ensure that the back of the motor unit is facing you).

1) Remove the plug from the velcro strap.



2) Insert the plug through the hole on the cursor up to the black line of the plug.



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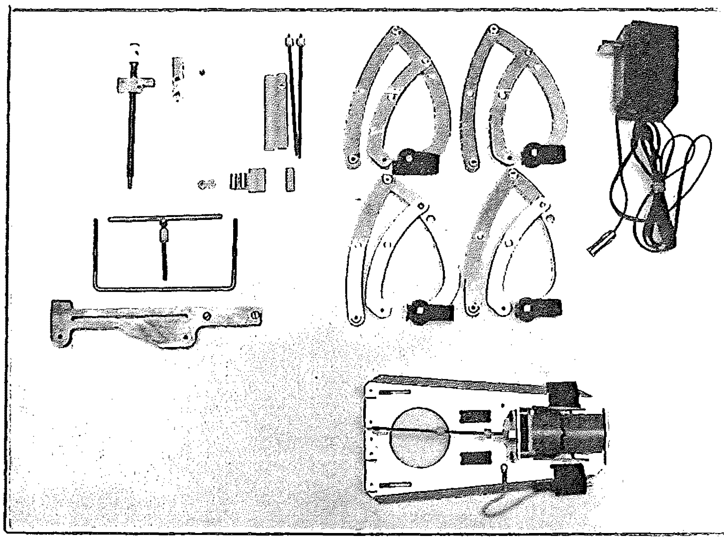
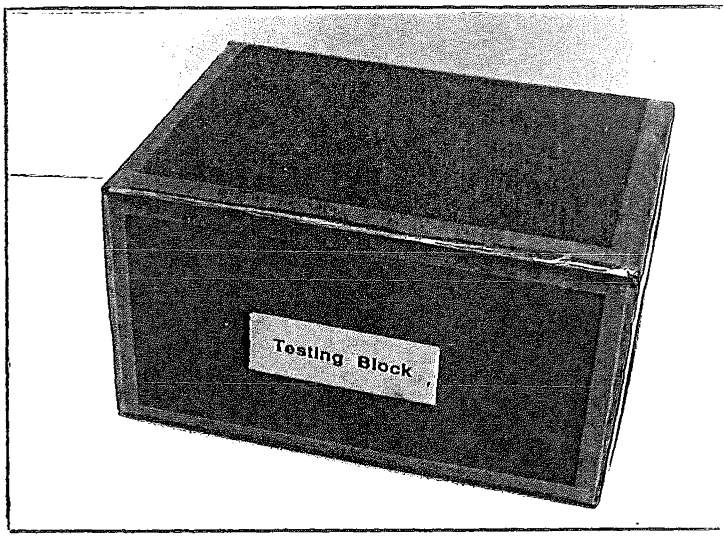
6.2) Testing cursor movement:

1) Select the adapter.



2) Position in front of you the box marked 'TESTING BLOCK'.



(**Note:** The label should be facing you.)

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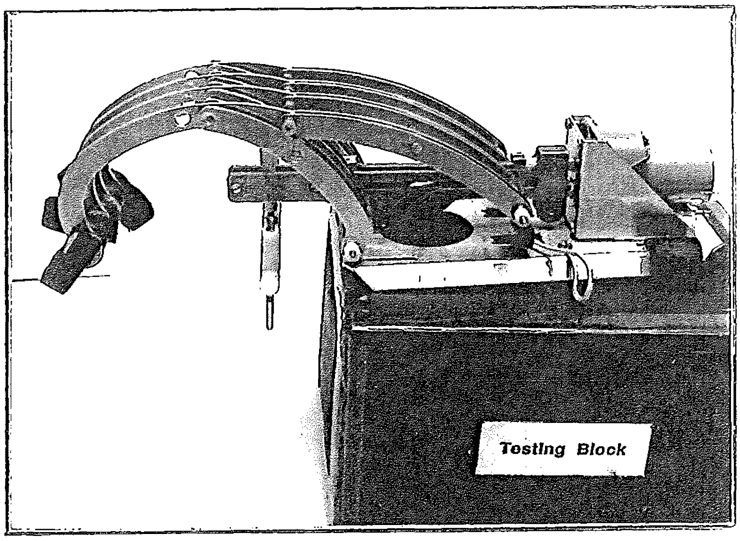
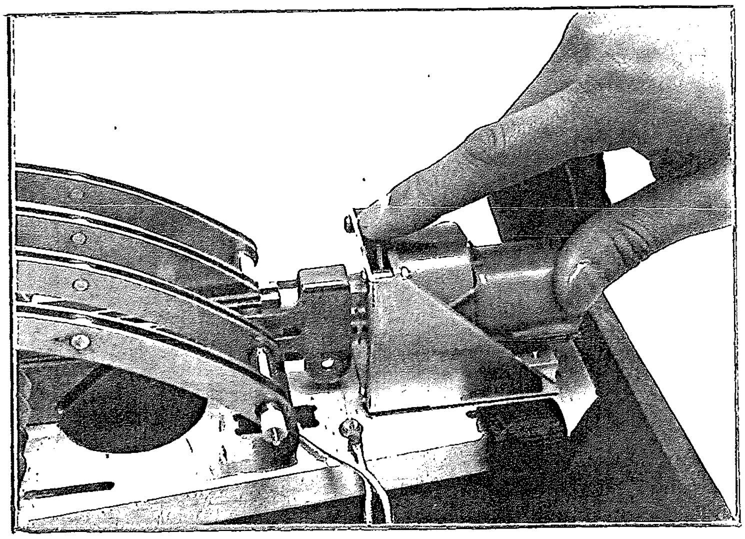
3) Place the CPM unit on top of the testing block and align the front edge of the CPM unit base-plate with the edge of the block.



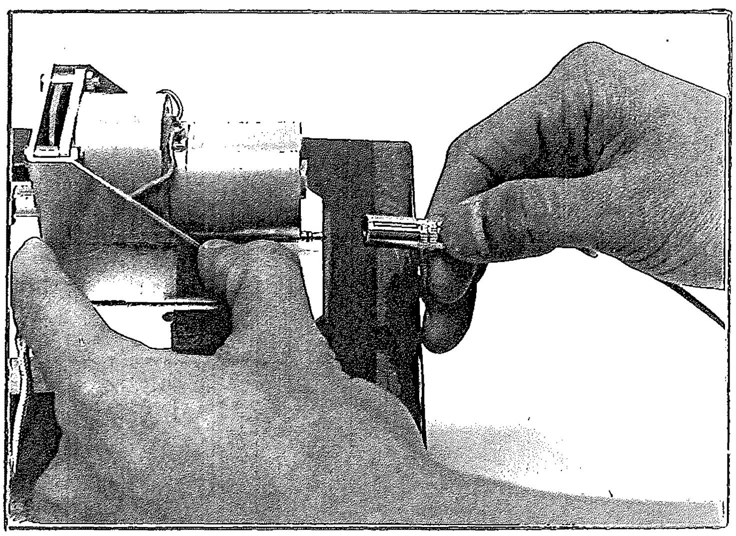
(**Note:** The hand rod should be hanging over the edge of the block.)

4) Pull back the direction switch located at the top of the motor unit until it 'clicks'.



5) With one hand, hold the CPM unit by its motor casing.

6) With your other hand, push the adapter socket into the adapter plug as far as you can (until it 'clicks').



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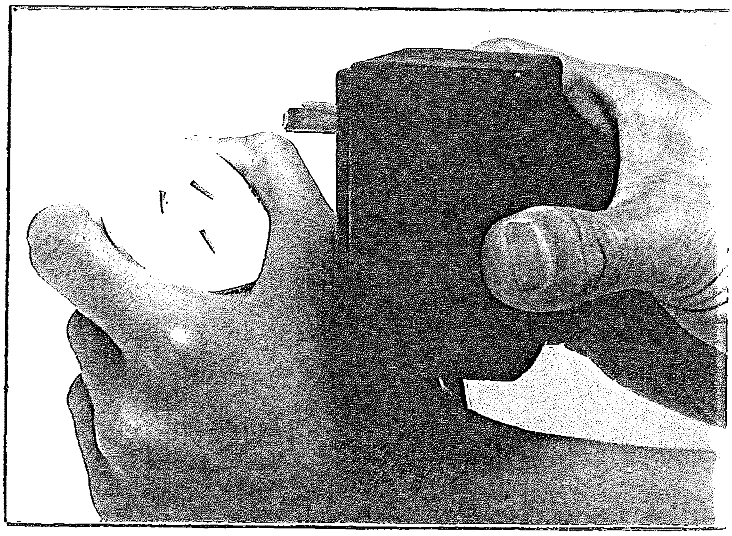
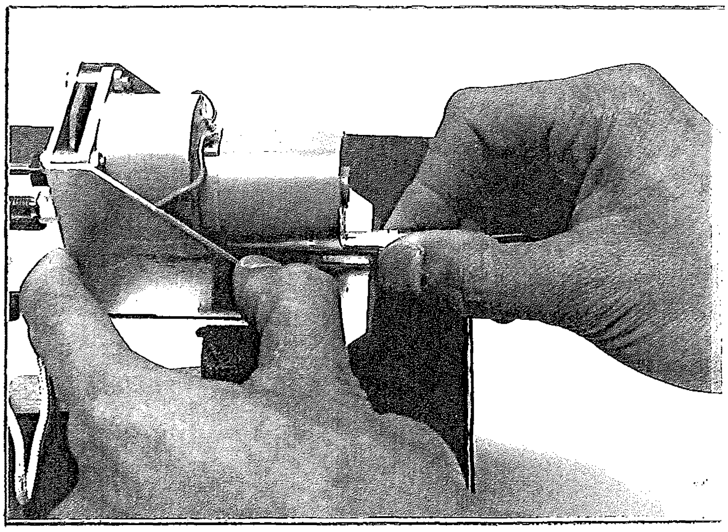
7) Plug the adapter into the extension cord (located on the top right-hand corner of the table.)



(**Note:** The CPM unit will make a 'roaring' sound as soon as the adapter is plugged into the extension cord.)

The cursor will move forward until it reaches the front (white) plastic nut on the switch rod. The cursor will automatically reverse the motor and move the cursor back towards its original position.

8) Disconnect the adapter socket when the cursor touches the plastic nut on the back end of the switch rod.

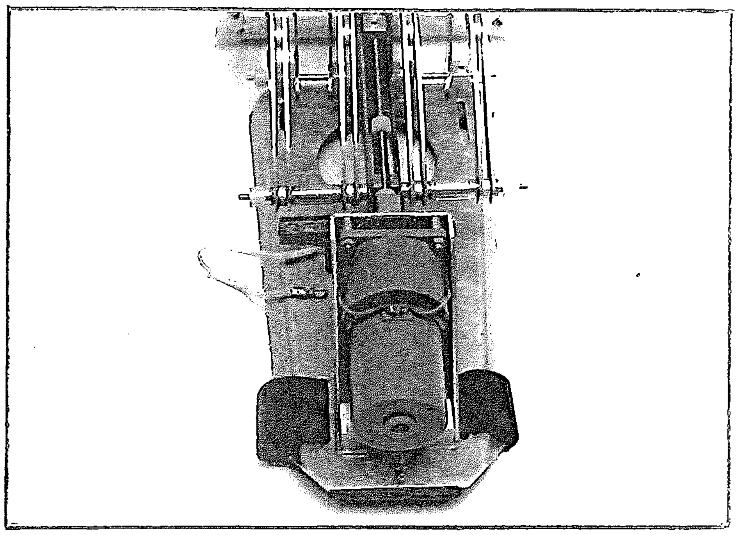


Proceed to the next step.

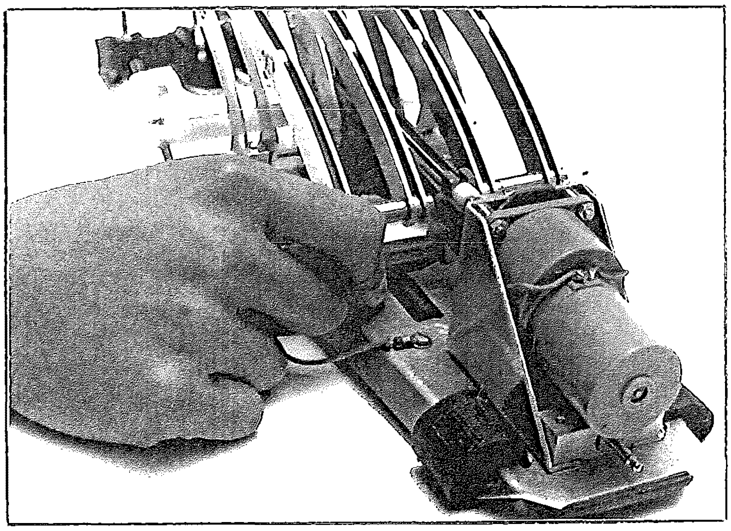
7.0) Test With Plug in Cursor Casing Position

7.1) Inserting plug into the cursor casing:

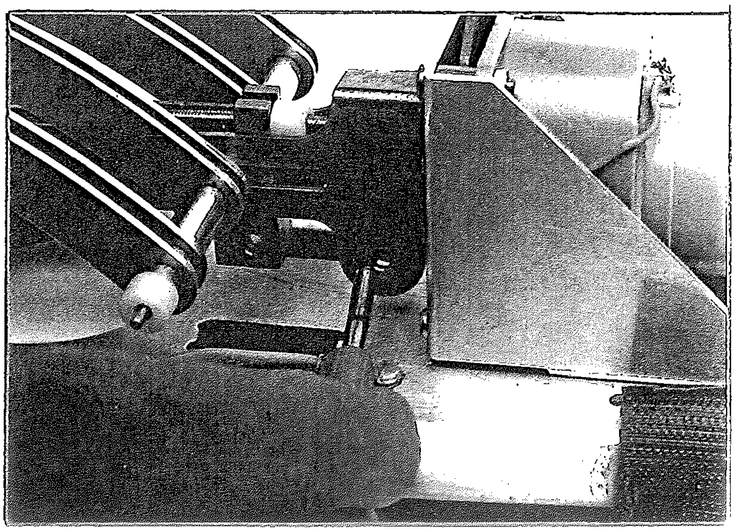
1) Place the CPM unit back on the table so that the back of the motor is facing you.



2) Remove the plug from the cursor.



3) Insert the plug through the hole on the back of the cursor casing up to the black line of the plug.



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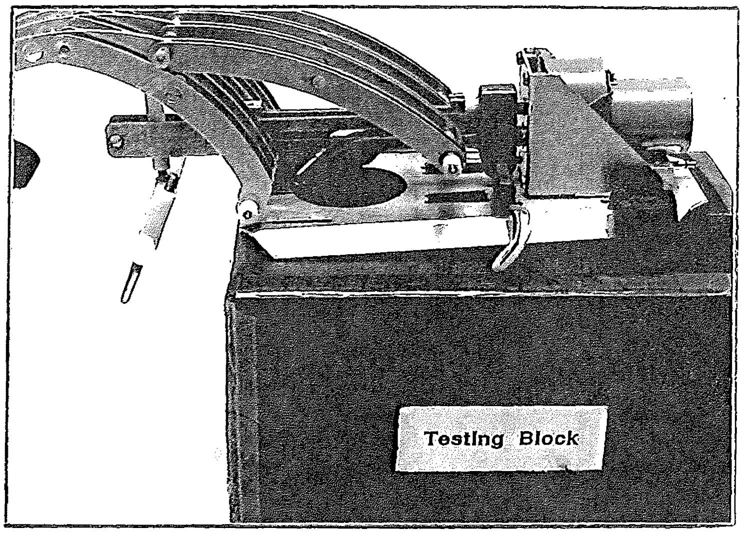
7.2) Testing cursor movement:

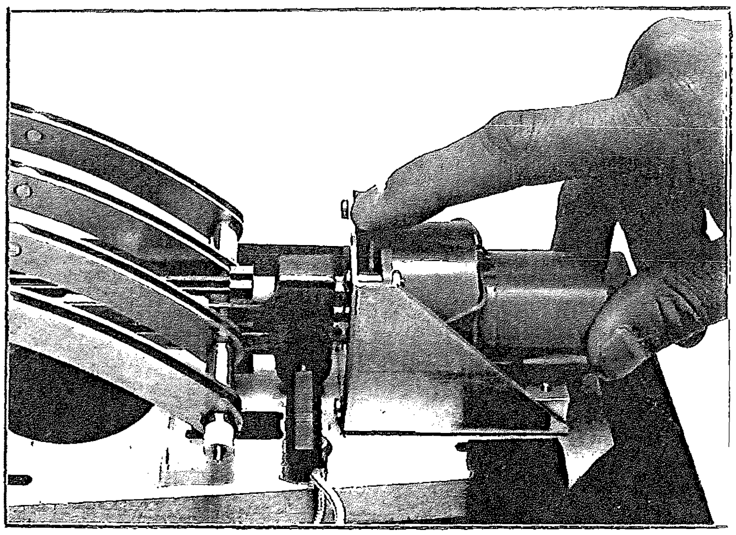
1) Position in front of you the box marked 'TESTING BLOCK'.



2) Place the CPM unit on top of the testing block and align the front edge of the CPM unit base-plate with the edge of the block.

(**Note:** The hand rod should be hanging over the edge of the block.)

3) Pull back the direction switch located at the top of the motor unit until it 'clicks'.



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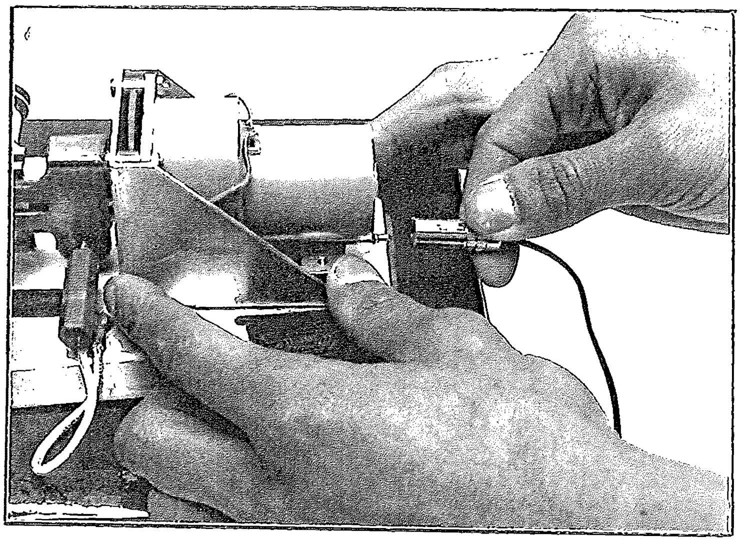
4) With one hand, hold the CPM unit by its motor casing.

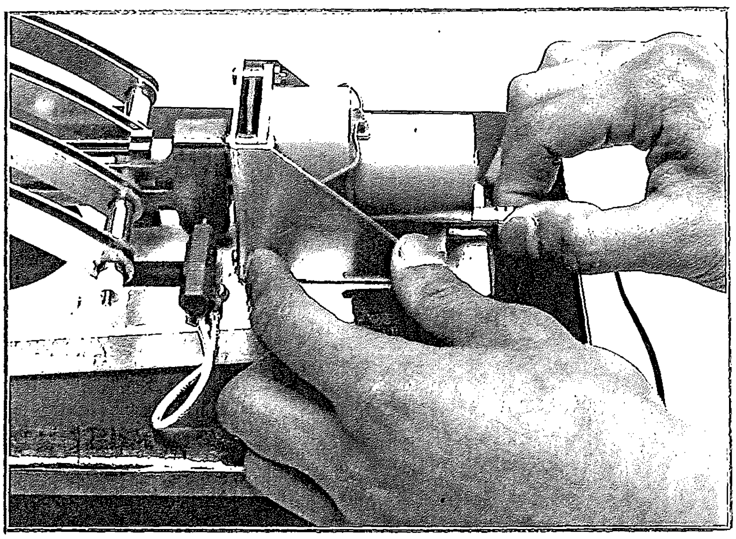


5) With your other hand, push the adapter socket into the adapter plug as far as you can (until it 'clicks').

(**Note:** The CPM unit will make a 'roaring' sound as soon as the adapter socket is pushed into the adapter plug.)

The cursor will move forward until it reaches the front (white) plastic nut on the switch rod. The cursor will automatically reverse the motor and move the cursor back towards its original position.

6) Disconnect the adapter socket when the cursor touches the plastic nut on the back end of the switch rod.



Proceed to the next page.

You have completed the testing procedures.

Please close the instruction manual.

Thank you for your participation.

Appendix 4.

Instruction manual Conditions 5 and 6.

Note: A picture of the CPM unit on page 1 of the manual was absent in instruction manual Condition-5.

THE CPM UNIT:

ASSEMBLY AND TESTING INSTRUCTIONS

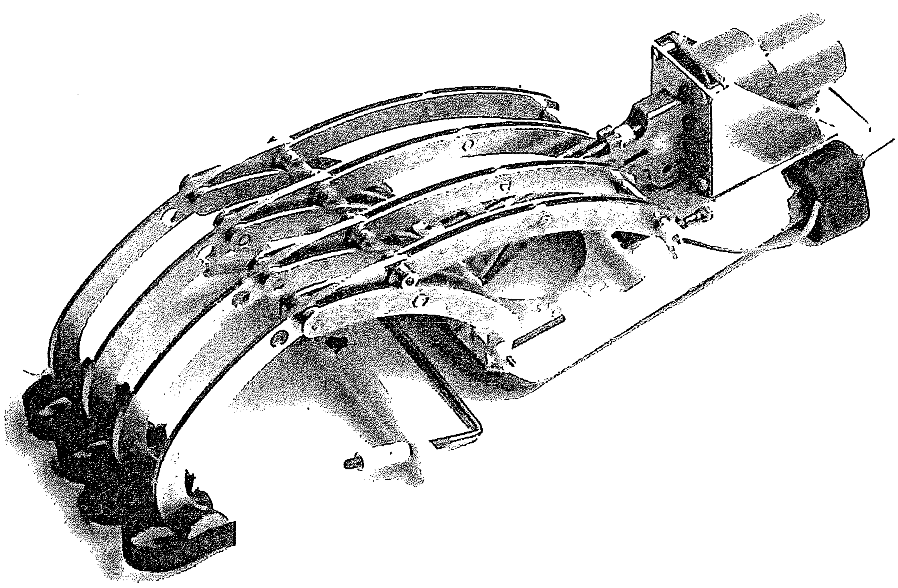
CONTENTS

The CPM Unit

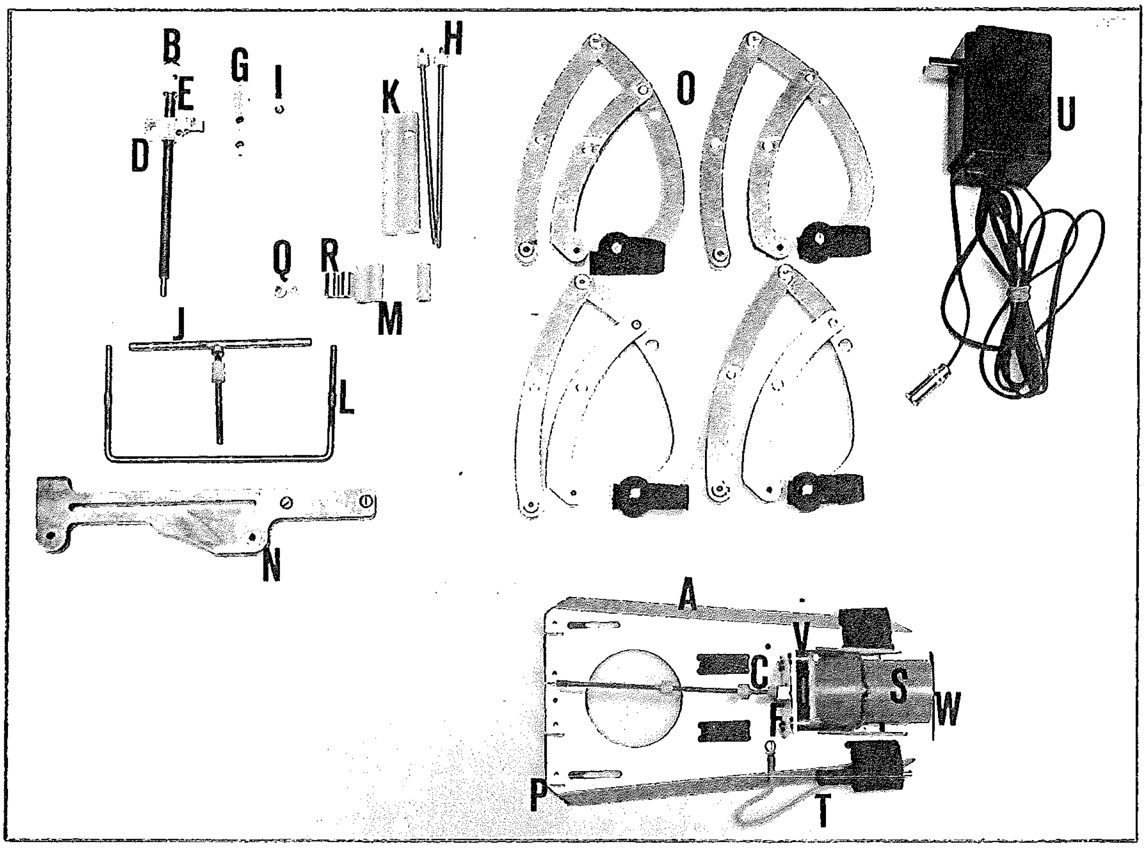
The portable continuous passive motion hand unit (CPM) is an orthopaedic hand exercise unit, designed to help the healing of the hand and/or finger muscles after injury. The lightweight design of the unit means the patient can take the unit home and supervise their own personal therapy for up to 24 hours.

The unit fits comfortably on top of the hand and wrist. It is secured with velcro binding for easy attachment to and release from the fingers and wrist.

A small motor operates the finger linkages of the CPM unit which helps the patient to exercise his/her hand without effort.



Names of CPM Parts



1.0) Names of CPM Parts

The following names refer to the names of the CPM parts and their location on the CPM unit. The order of presentation corresponds with the order of the procedural steps.

A) **The CPM Base Unit:** The CPM base unit is the largest sub-assembled component made up of an aluminium base-plate, a motor unit, a red plug, and 4 linkage attachment blocks.

B) **The Cursor Shaft:** The cursor shaft is the longest metal rod with a brass block threaded onto it. The cursor shaft is attached to the motor shaft.

C) **The Switch Rod:** The switch rod is the brass rod with 2 short plastic nuts threaded onto it. The switch rod is attached to the motor unit.

D) **The Cursor:** The cursor is the brass block with 2 holes and a groove. The cursor is threaded onto the cursor shaft.

E) **The Allen Screw:** The Allen screw is the screw threaded into the white portion of the cursor shaft.

F) **The Motor Shaft:** The motor shaft is the small metal rod protruding from the motor unit.

G) **The Cursor-Shaft-Block:** The cursor-shaft-block is the long rectangular, aluminium block with holes on it. The cursor-shaft-block is fastened onto the CPM unit base-plate.

H) **The Bolt Rod:** The bolt rod is the long brass rod with a short plastic nut threaded onto it. The bolt rod secures the finger linkages onto the CPM unit.

I) **The screw:** The screw is the smallest un-assembled CPM component. The screw secures the cursor-shaft-block onto the CPM unit base-plate.

Proceed to the next page.

J) **The T-Bar:** The T-bar is the metal component which represents the alphabetical letter 'T', a short plastic nut is threaded onto it. The T-bar is a sub-part of the hand rod unit fastened onto the cursor casing.

K) **The Plastic Sleeves:** The plastic sleeves are the longest plastic component of the CPM parts. Each plastic sleeve is partially hollow with a hole on one end. The plastic sleeves are a sub-part of the hand rod unit slotted onto the T-bar.

L) **The U-Bar:** The U-bar is the metal component which represents a very wide alphabetical letter 'U'. The U-bar is a sub-part of the hand rod unit and is fastened to the T-bar.

M) **The Long Plastic Nut:** The long plastic nut is the longest nut of the CPM parts. It is a sub-part of the hand rod unit which secures the U-bar to the T-bar.

N) **The Cursor Casing:** The cursor casing is the largest metal component of the CPM parts. The cursor casing is an aluminium block with 6 holes fixed between the metal at the front-end, with gaps in the mid-section and one hole at the back-end of the metal part. The cursor casing encases the cursor and the cursor-shaft-block.

O) **The Finger Linkages:** The finger linkages are the 3-pronged aluminium objects with a black velcro strip fastened at the front-end. The finger linkages are attached to the CPM base unit in 2 places: 1) the 4 linkage attachment blocks, 2) the cursor.

P) **The Attachment Blocks:** The attachment blocks are the 4 short aluminium blocks secured onto the front-end of the CPM unit base-plate.

Q) **The Plastic Nut:** The plastic nut is the shortest plastic component of the CPM parts. The nut secures the bolt rods attaching the finger linkages to the attachment blocks and the cursor.

R) **The Aluminium Spacer:** The aluminium spacer is the hollow, pipe-like aluminium component of the CPM parts. The aluminium spacer is slotted onto the bolt rod between the back finger linkage attachments.

Proceed to the next page.

S) The Motor Unit: The motor unit is the sub-assembled component secured to the back-end of the CPM unit base-plate.

T) The Plug: The (red) plug is attached to the black velcro strap located at the back-end of the CPM base unit.

U) The Adapter: The adapter is the black 'cubical' object with a silver socket attached to the black cord.

V) The Direction Switch: The direction switch is the brown PC board located on the top of the motor unit.

W) The Adapter Plug: The adapter plug is the silver metal rod that protrudes from the back end of the motor unit.

Proceed to the next page.

Assembly and Testing Procedure Instructions

All the parts and tools you will need to assemble and operate the CPM unit are in front of you.

1) Perform the task as accurately and as fast as you can.

2) Please follow the procedures and notes in a step-by-step manner

3) Please close the instruction manual.

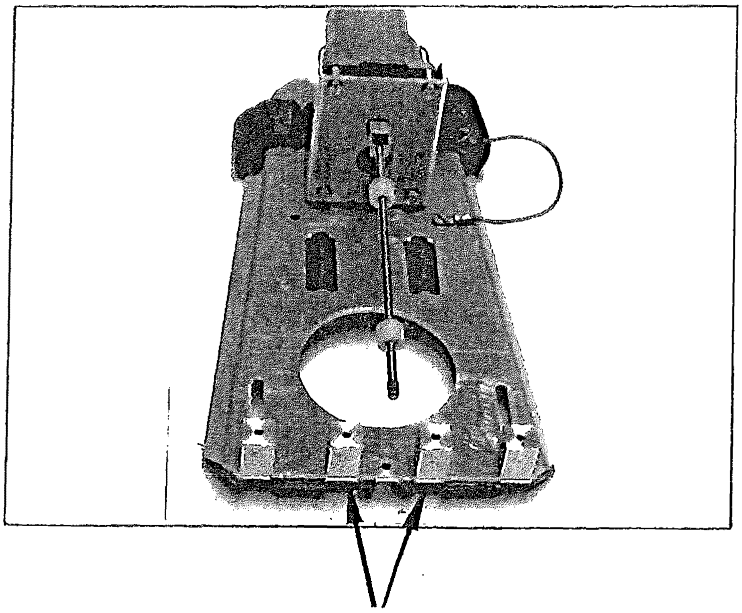
Assembly Procedures

2.0) Cursor Shaft Assembly

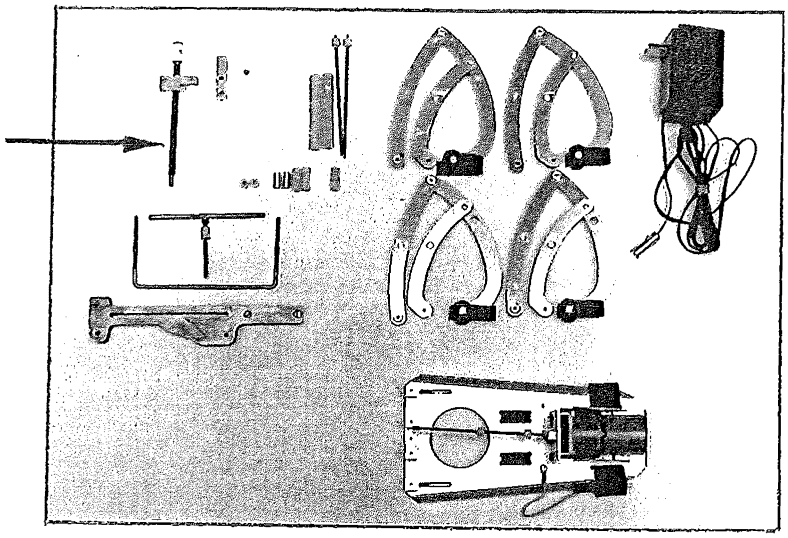
The cursor shaft is the metal shaft which is threaded through the cursor. When the motor is operating, the cursor allows for forward and backward motion of the finger linkages.

2.1) Positioning the cursor shaft into the motor shaft:

1) Position the CPM base unit so that the 4 linkage attachment blocks are facing you.



2) Select the cursor shaft.



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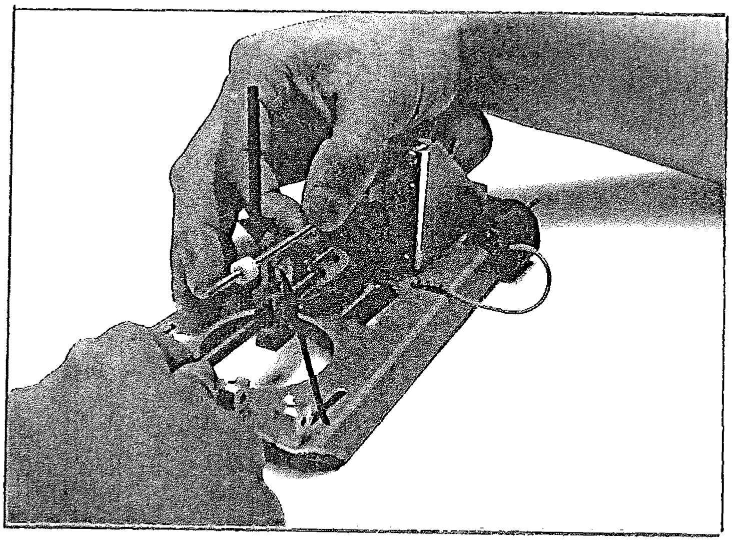
3) With one hand, lift the switch rod.

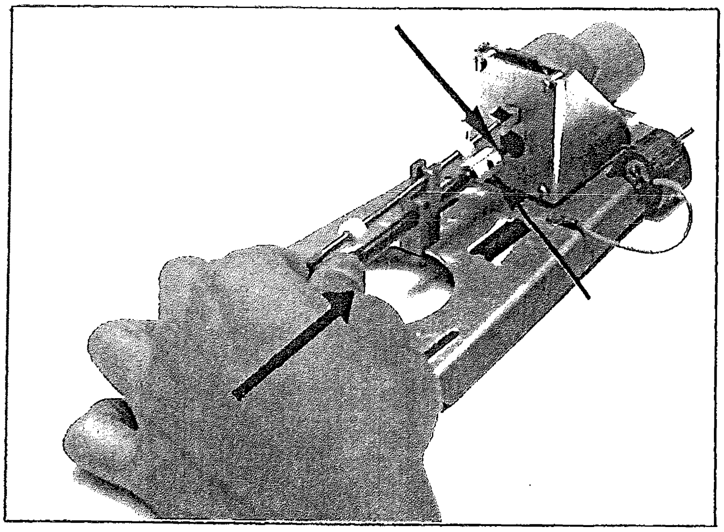


4) With your other hand, position the cursor shaft below the switch rod.

5) Place the switch rod in the groove of the cursor.

(**Note:** The cursor should be positioned between the 2 plastic nuts.)

6) Turn the cursor shaft so that the Allen screw is aligned with the flat side of the motor shaft.

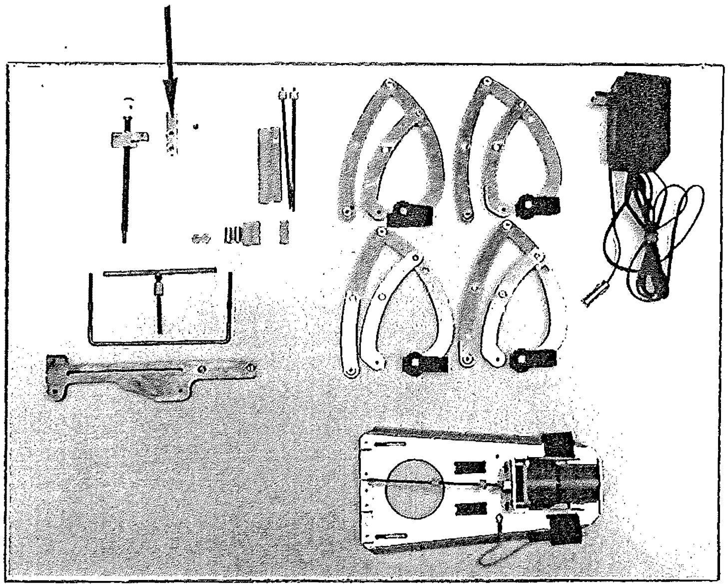


7) Insert the cursor shaft into the motor shaft as far as you can.

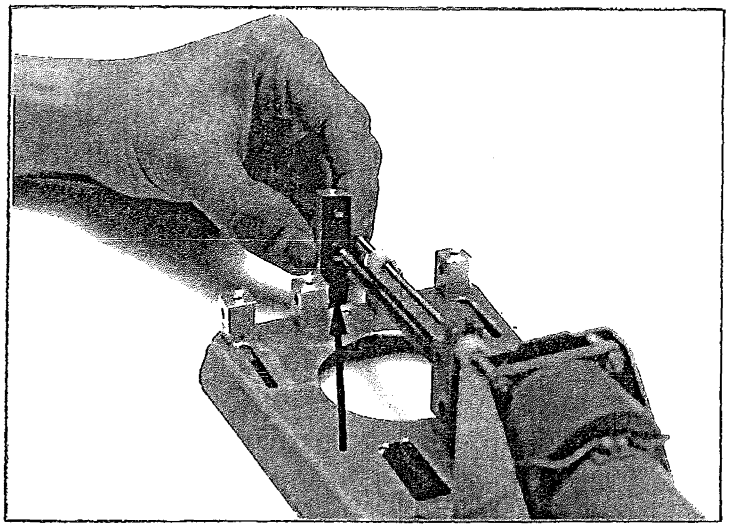
Proceed to the next page.

2.2) Mounting the cursor-shaft-block onto the CPM base unit:

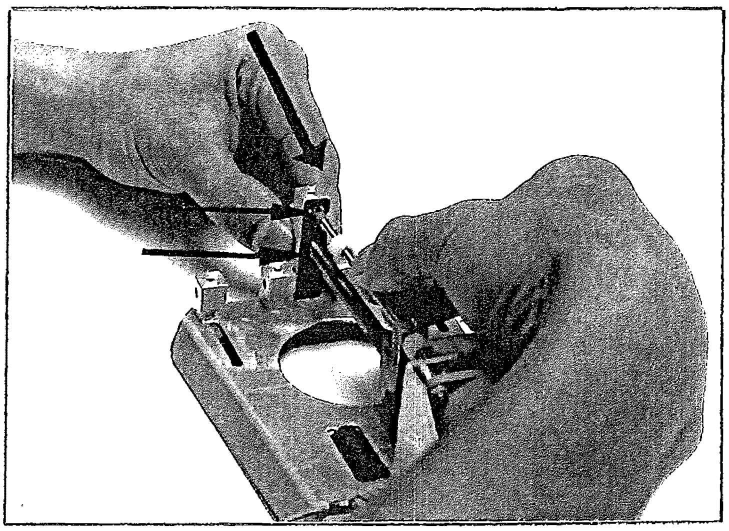
1) Select the cursor-shaft-block.



2) Hold the cursor-shaft-block so that the black side is facing the motor unit.



3) At the same time, slot the hole located in the middle of the cursor-shaft-block into the cursor shaft and the top hole into the switch rod.



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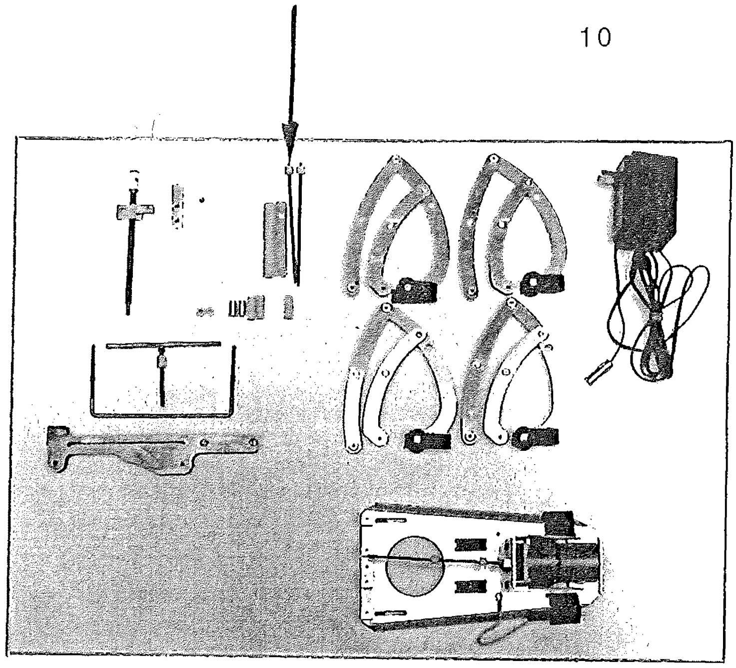
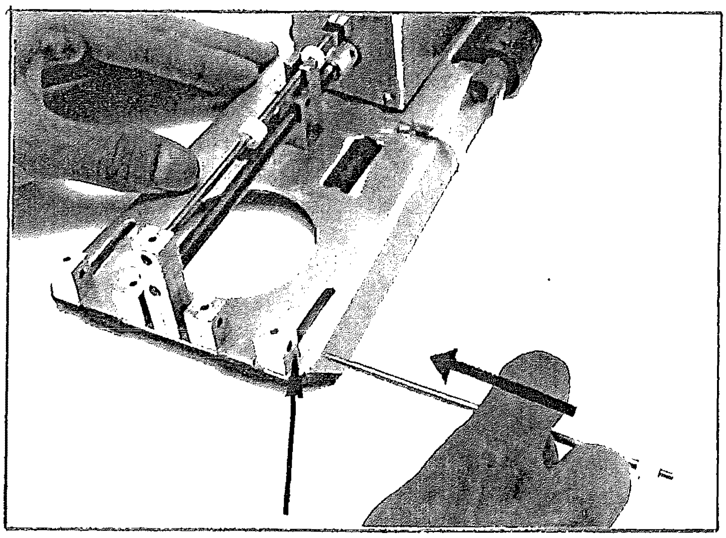
4) Select one of the bolt rods.



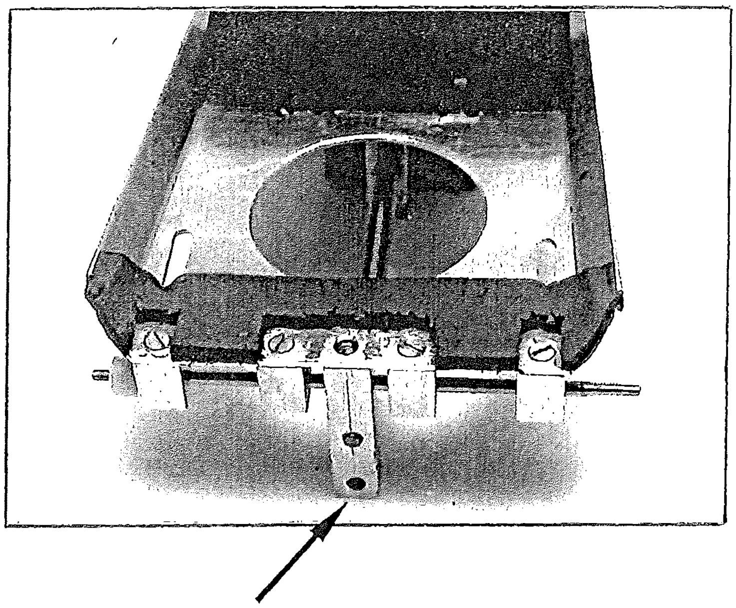
5) Starting from the right-most attachment block, insert the bolt rod through the side holes of the linkage attachment block.



(**Note:** The bolt rod should slide through the 4 attachment blocks and the cursor-shaft-block.)

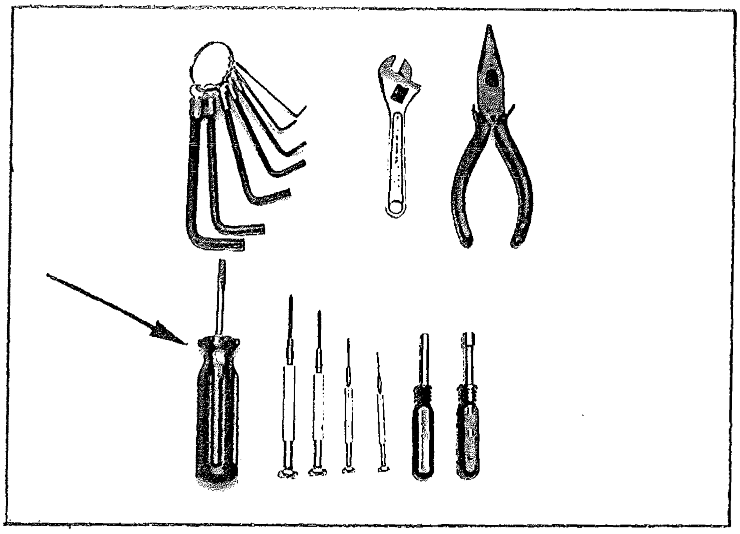
Proceed to the next page.

6) Turn the CPM unit over and rest the unit on the table.

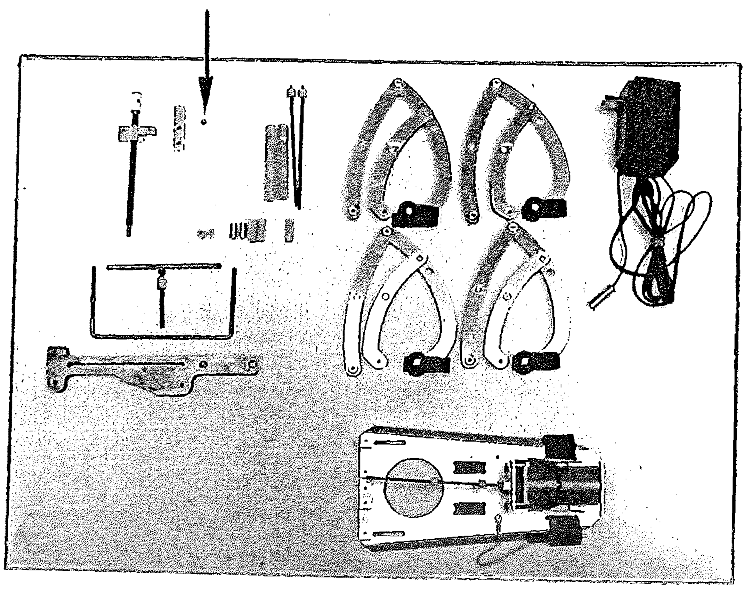


(**Note:** The cursor-shaft-block should be positioned upright, touching the table.)

7) Select a standard screwdriver.

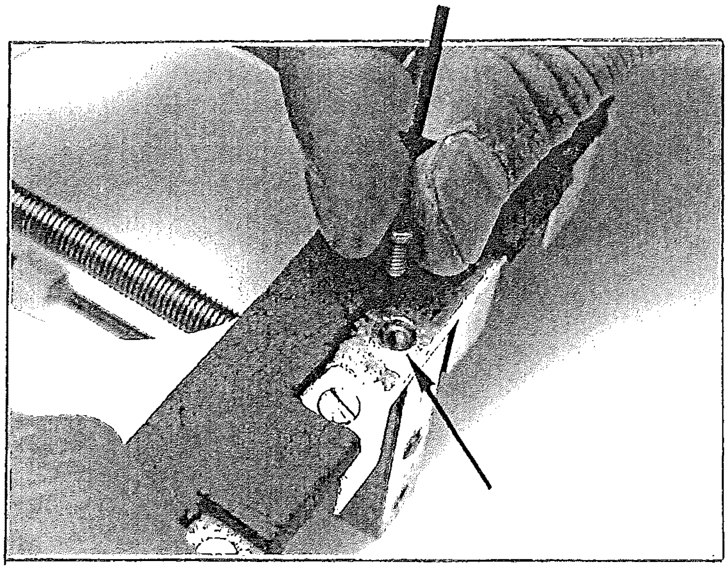


8) Select the screw.

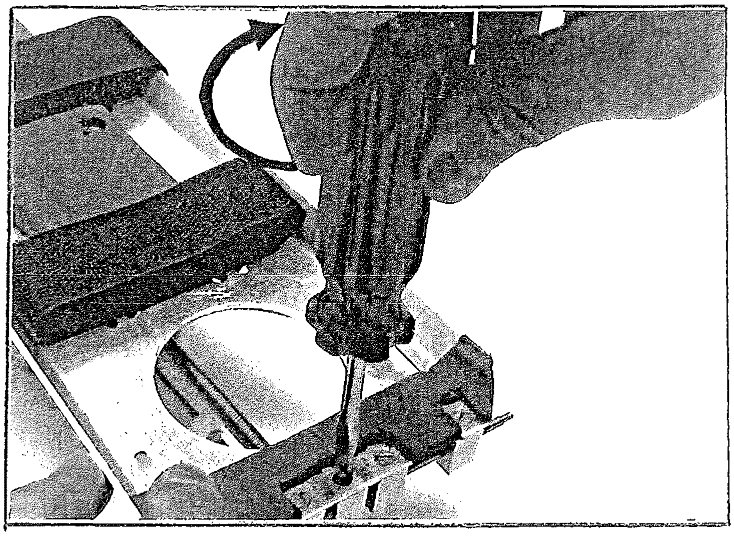


9) Hold the CPM unit firmly and ensure that the cursor-shaft-block is touching the table.

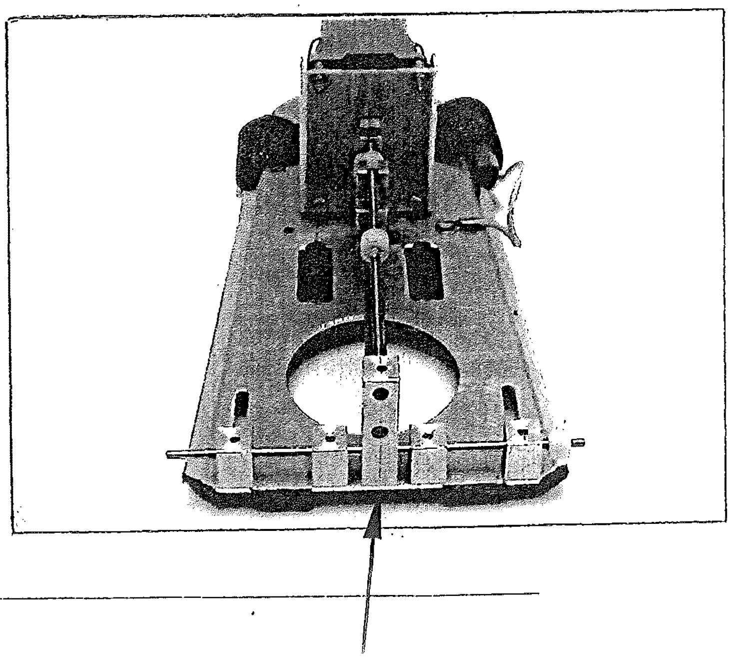
10) With the screw, secure the cursor-shaft-block to the CPM unit base-plate.



11) Using the screwdriver, tighten the screw.



12) Turn the unit back over and position the CPM base unit so that the 4 attachment blocks are facing you.



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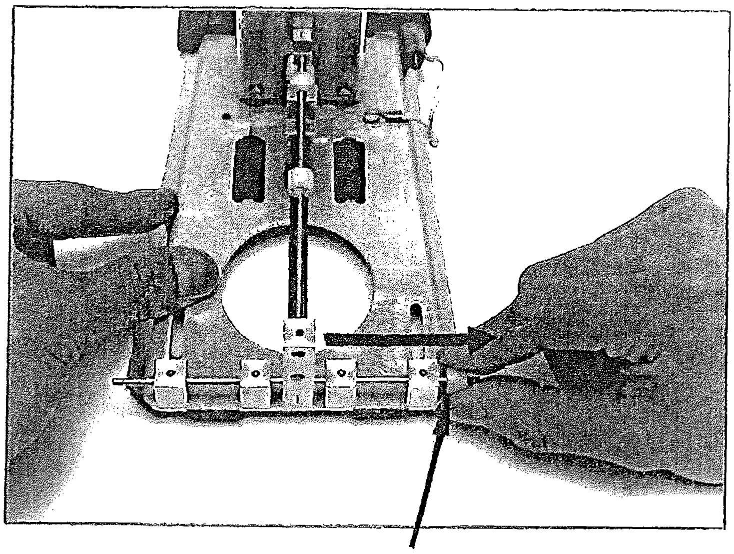
13) Remove the bolt rod from the attachment blocks.



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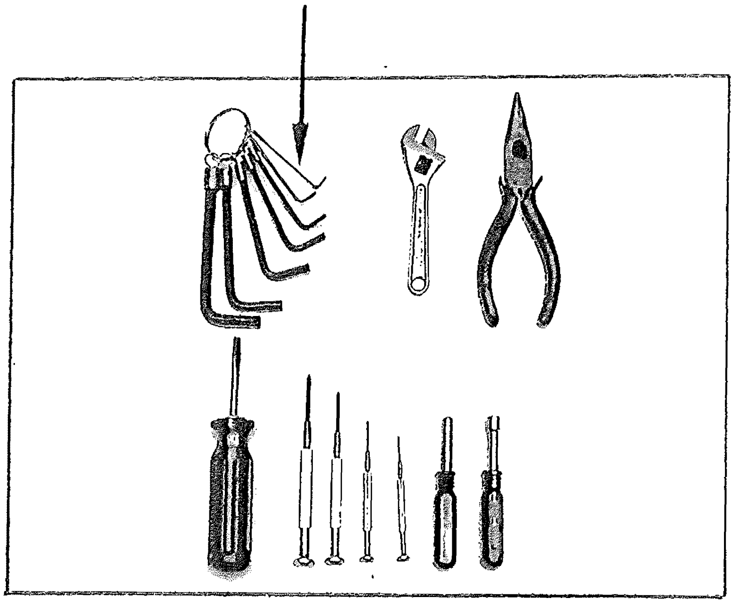
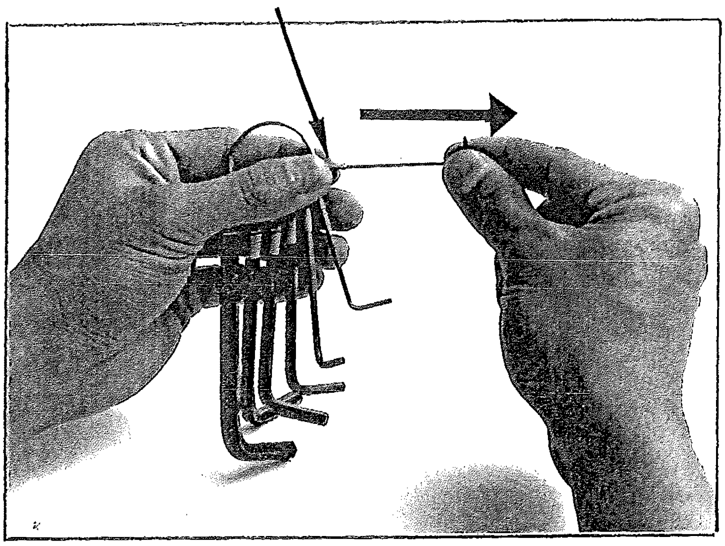
2.3) Removing the Allen key from its holder:

1) Select the Allen keys and locate the 1mm. Allen key.



2) With one hand, hold the spring-like holder.

3) With your other hand, pull the 1mm. Allen key from the spring-like holder.



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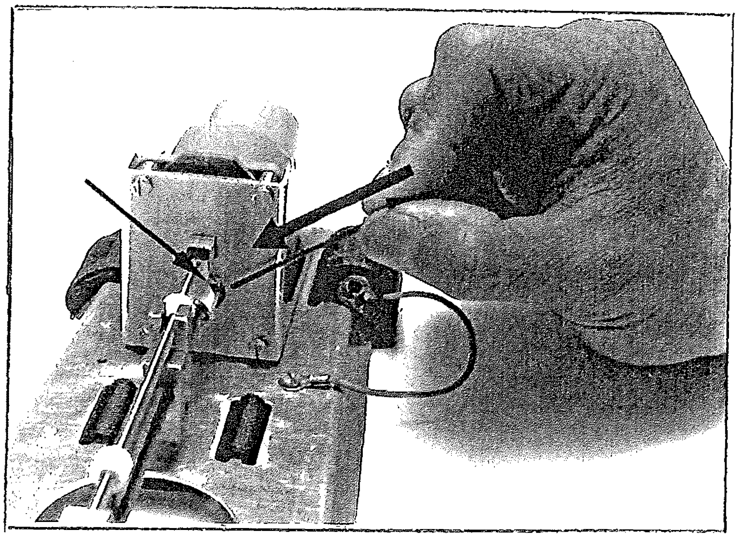
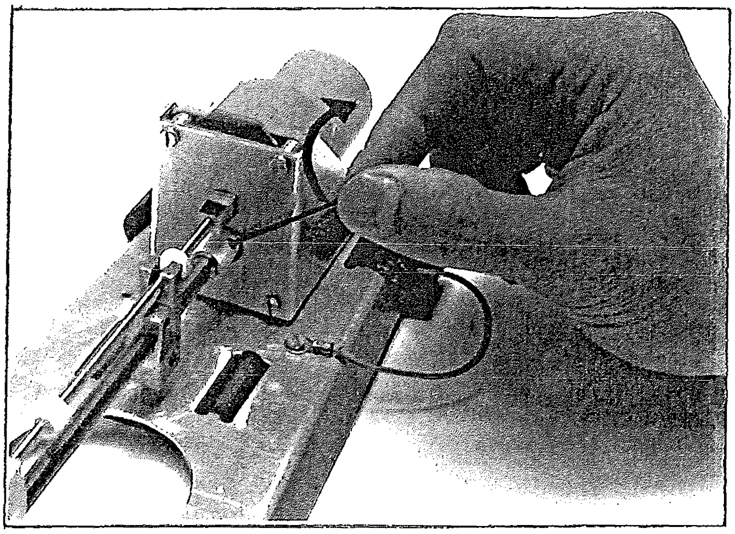
2.4) Tightening Allen Screw:

1) Slot the long-end of the Allen key into the Allen screw.



2) Tighten the Allen screw.



You have finished the cursor shaft assembly.

Proceed to the next step.

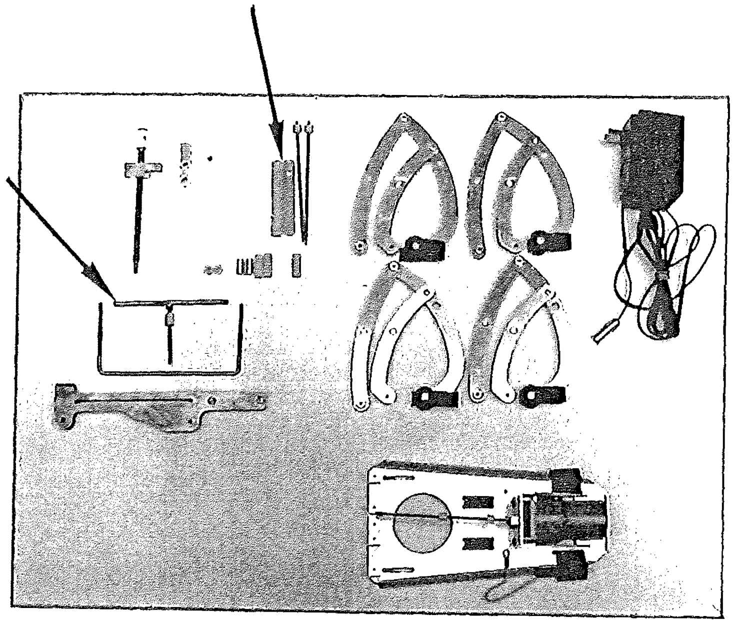
3.0) Hand Rod Assembly

The hand rod functions as a hand rest which supports the patient's hand while the hand and/or finger muscles are being exercised.

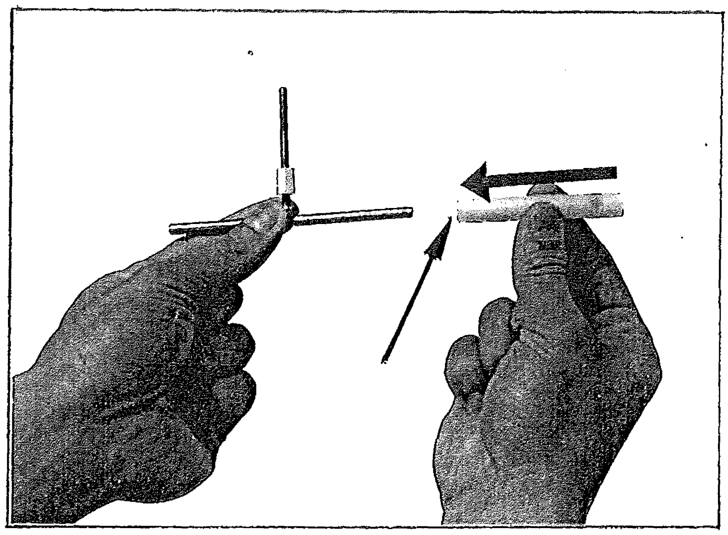
3.1) Hand rod assembly:

1) Select the T-bar.

2) Select the 2 plastic sleeves.



3) Slide the length of the 2 plastic sleeves onto the T-bar.



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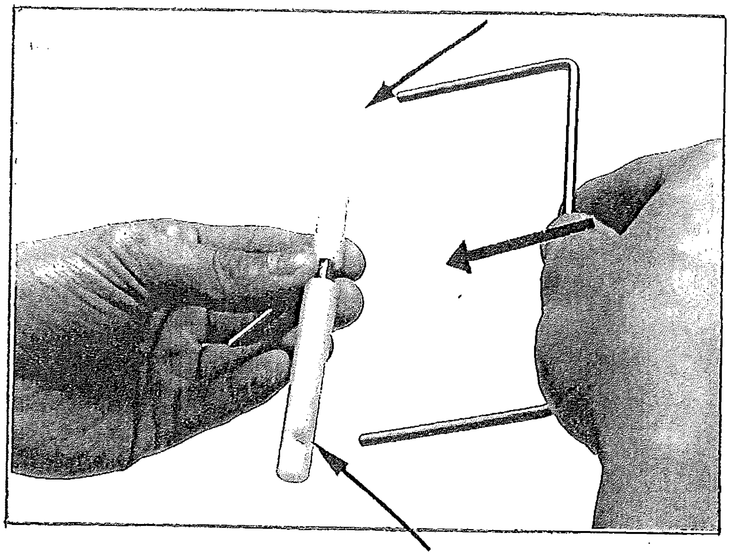
4) Hold the T-bar so that it represents the alphabetical letter 'T'.

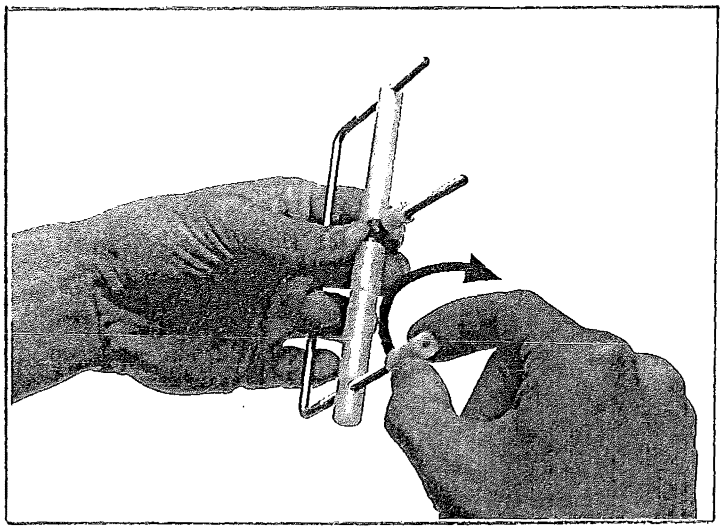
5) Position the U-bar above the T-bar.

6) Slot both ends of the U-bar into the holes on the plastic sleeves.



7) Secure the U-bar onto the T-bar with a long plastic nut at each end.

8) Tighten both nuts until they stop.



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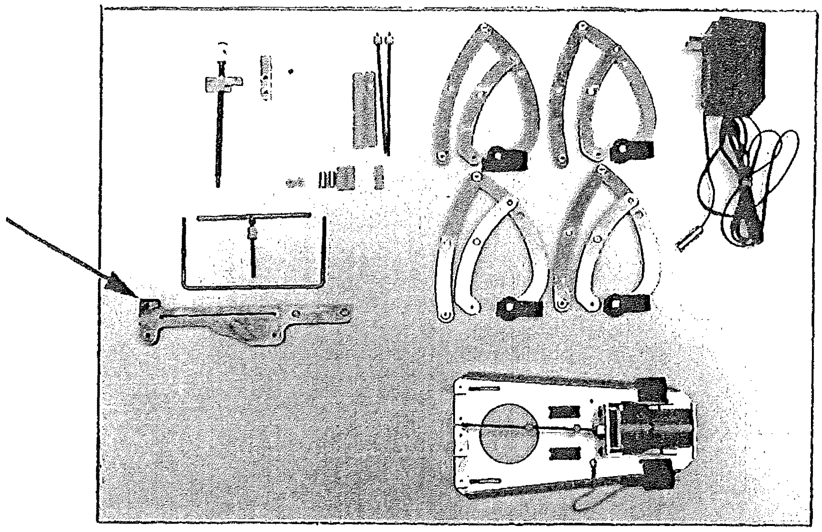
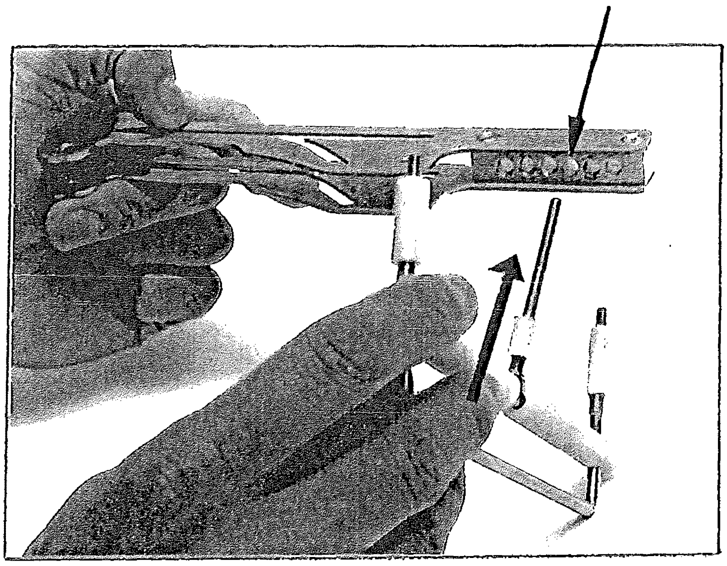
3.2) Fastening hand rod onto cursor casing:

1) Select the cursor casing.



2) With one hand, hold the cursor casing so that the straightest edge of the cursor casing is on top.



3) With your other hand, position the T-bar underneath the cursor casing.

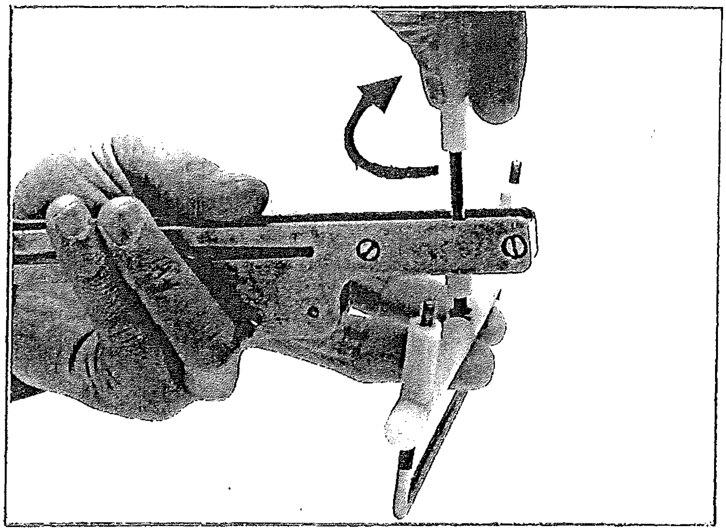
4) Insert the T-bar of the hand rod into the 3rd hole from the front of the cursor casing.

(**Note:** The T-bar should be positioned at a 'cross-angle' with the cursor casing.)

Proceed to the next page.

5) Fasten the T-bar in place with the remaining long plastic nut.

6) Tighten the nut until it stops.



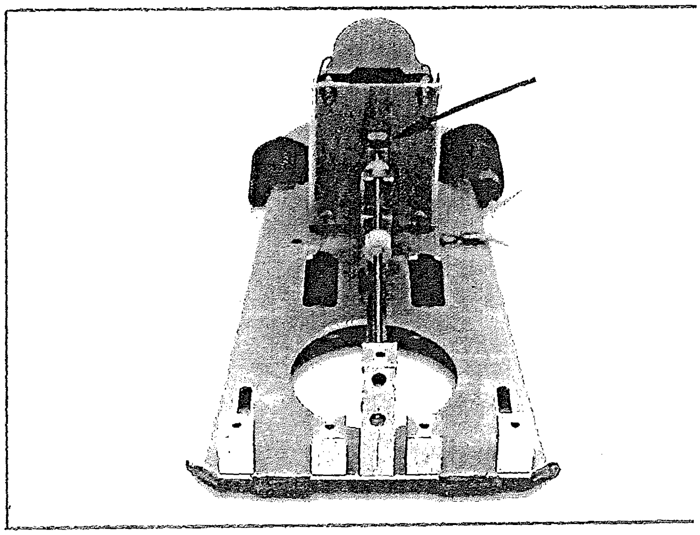
You have finished the hand rod assembly.

Proceed to the next step.

4.0) Cursor Casing Assembly

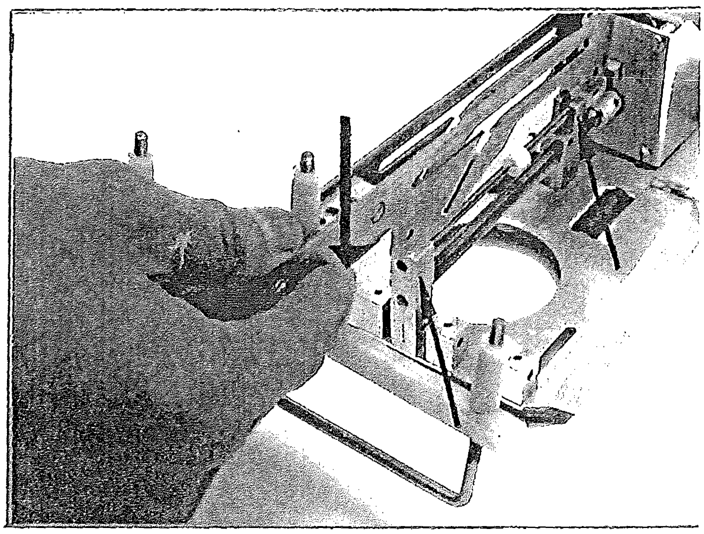
The cursor casing functions as a guide rail for the cursor which ensures the correct movement of the finger linkages.

1) Locate the black square of the aluminium block (connected to the switch rod).



2) Hold the cursor casing so that the straightest edge of the cursor casing is on top.

3) Slot the cursor casing onto the cursor-shaft-block and the cursor.



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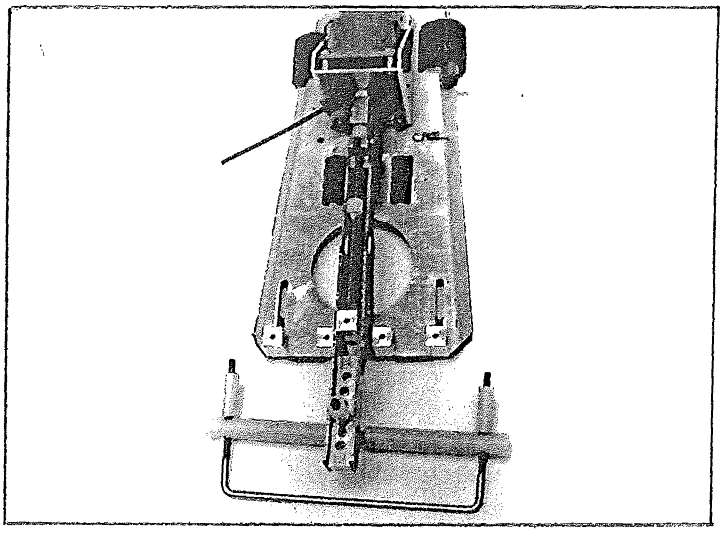
4) Align the back of the cursor casing so that it covers the black square of the aluminium block, leaving a gap between the cursor casing and the motor casing.



(**Note:** This will allow for easier assembly of the finger linkages.)

You have finished the cursor casing assembly.

Proceed to the next step.

5.0) Finger Linkage Assembly

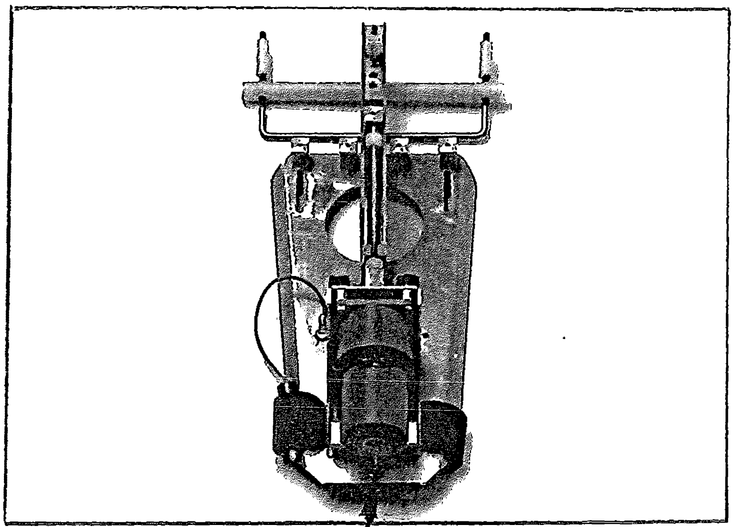
The finger linkages are attached to the CPM base unit in 2 places:

1) The linkage attachment blocks located at the front of the CPM unit base-plate.

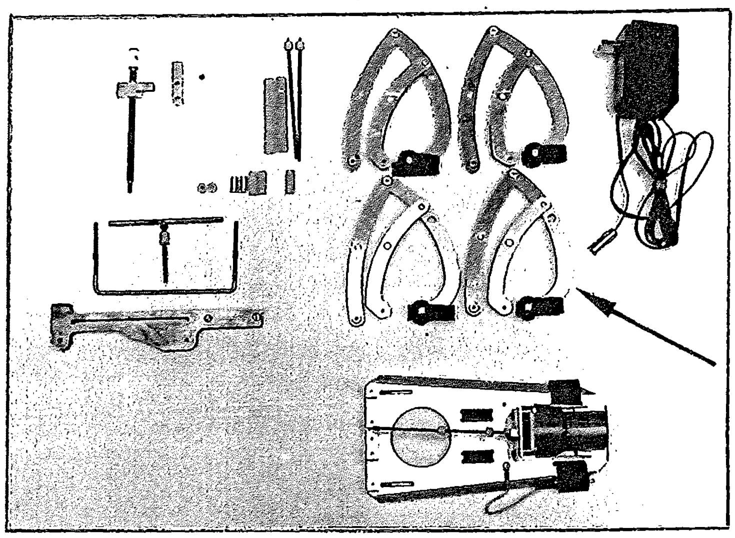
2) The cursor.

5.1) Fastening the (front) finger linkage attachment to the blocks:

1) Position the CPM base unit so that the back of the motor faces towards you.



2) Select one of the finger linkages.



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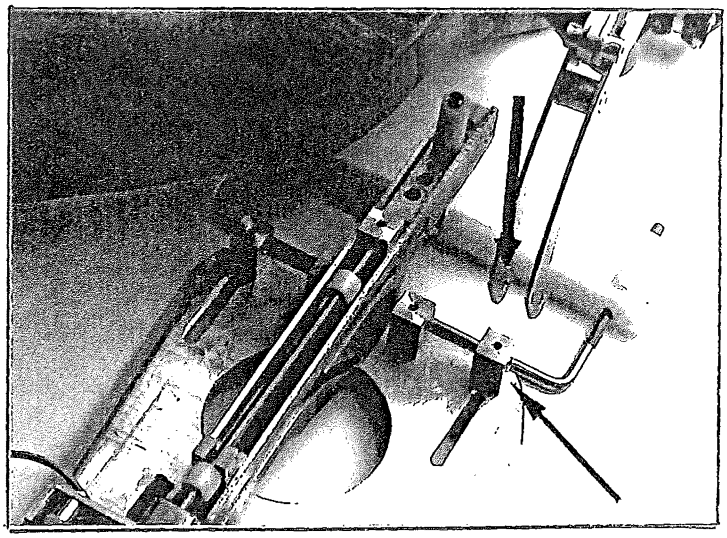
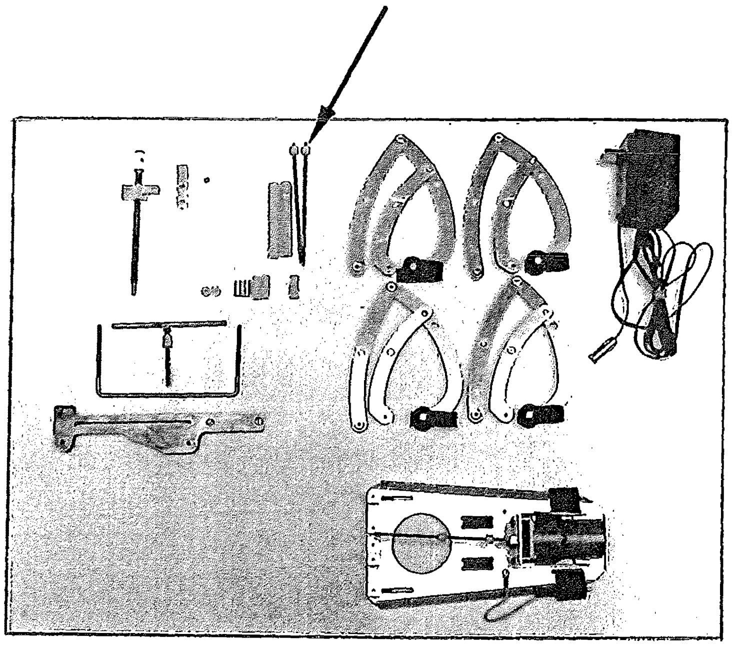
4) Slot the front finger linkage attachment onto the 1st attachment block,located at the right front of the CPM unit.



(Note: a) The velcro strip should be positioned in front of the hand rod.

b) The back linkage attachment should be positioned behind the attachment block.)

5) Select one of the bolt rods.



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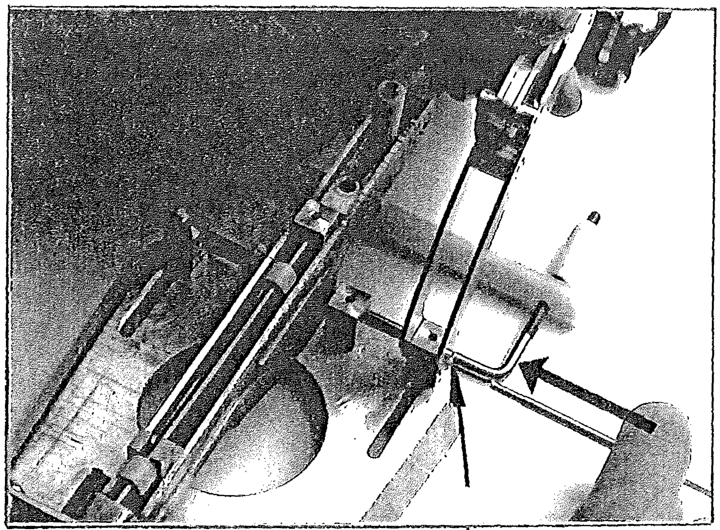
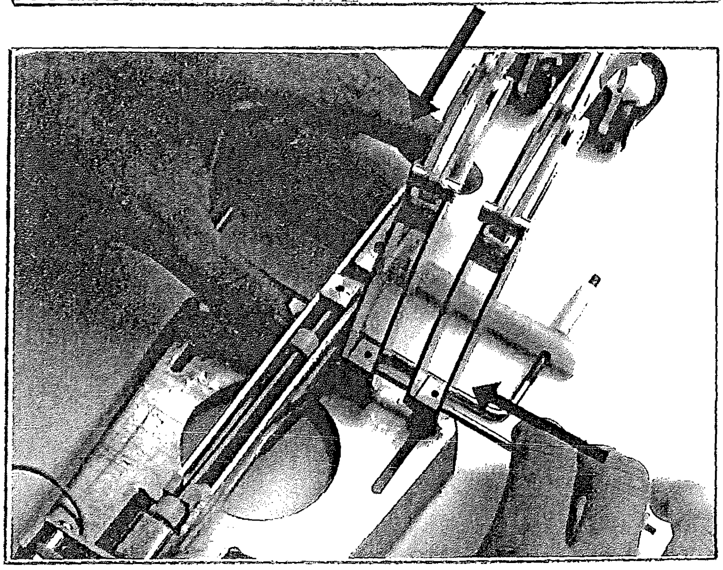
6) Insert the bolt-rod through the hole on the side of the front linkage until it protrudes slightly on the other side of the 1st linkage.

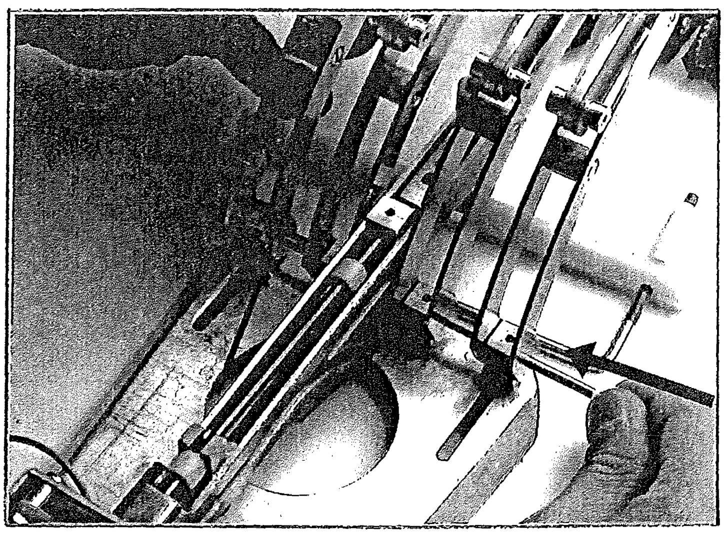


7) Slot a 2nd linkage onto the next block.

8) Push the cursor casing slowly towards the motor at the same time you are inserting the bolt-rod through the 2nd linkage.



9) Continue to fasten the remaining 3rd and 4th linkages.



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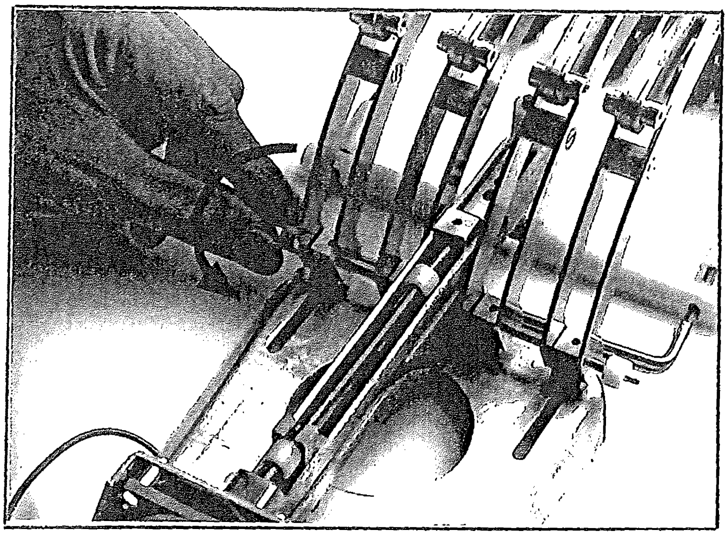
10) Fasten the bolt-rod with one of the plastic nuts.

11) Tighten the nut until it stops.



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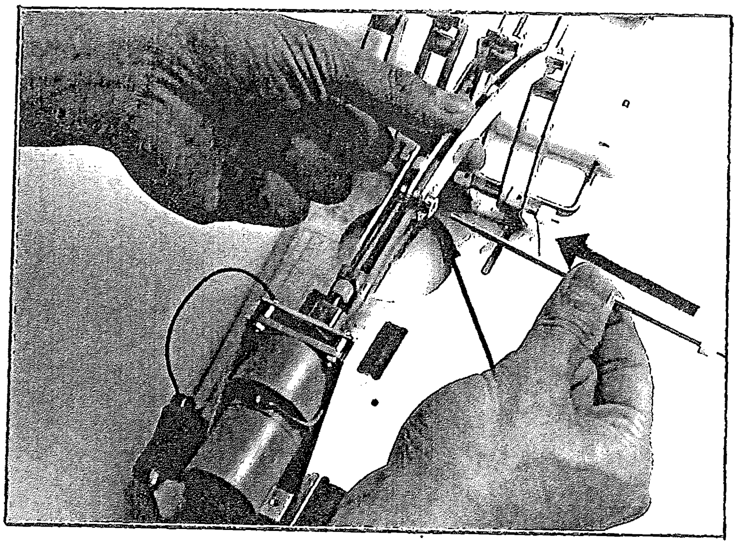
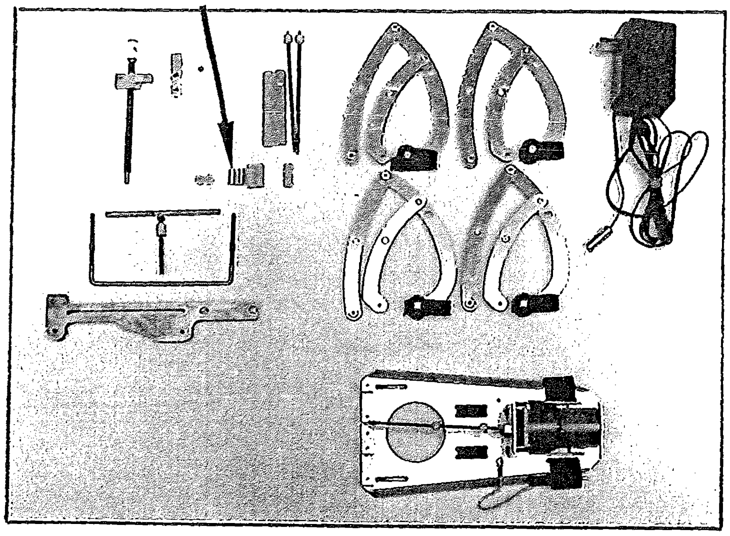
5.2) Fastening the (back) finger linkage attachment to the cursor:

(**Note:** Begin with the right-most finger linkage.)

1) Insert the bolt-rod through the hole at the back-end of the linkage.



2) Select one of the aluminium spacers.



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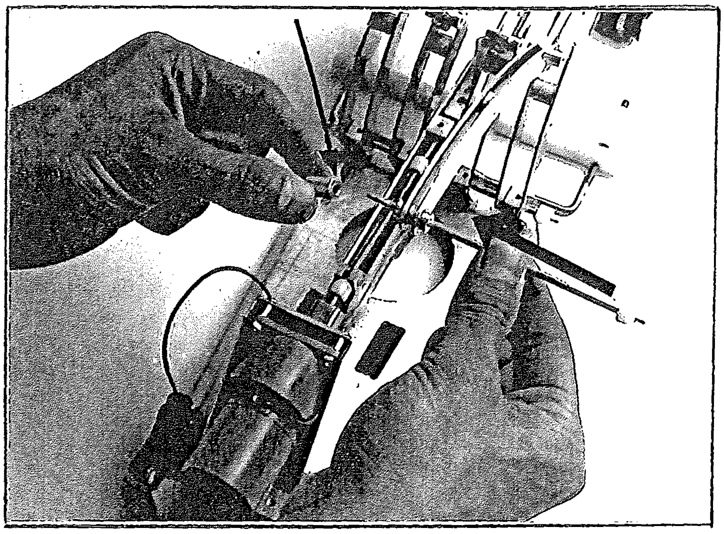
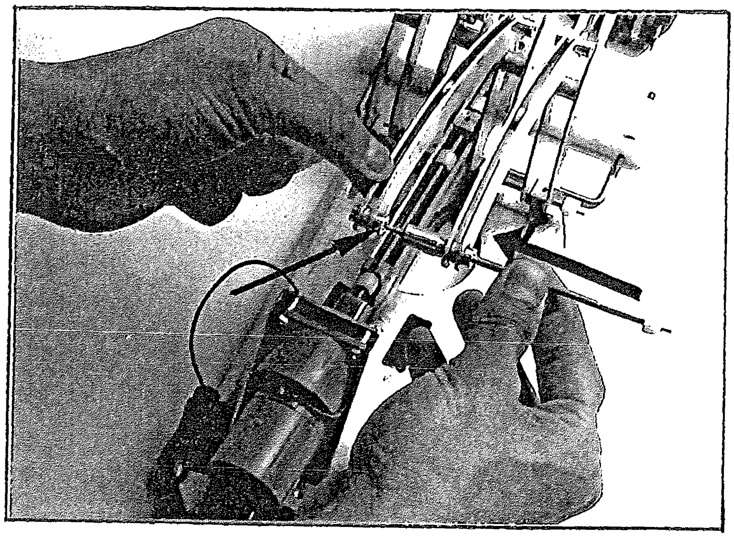
3) Insert the bolt-rod through the aluminium spacer.

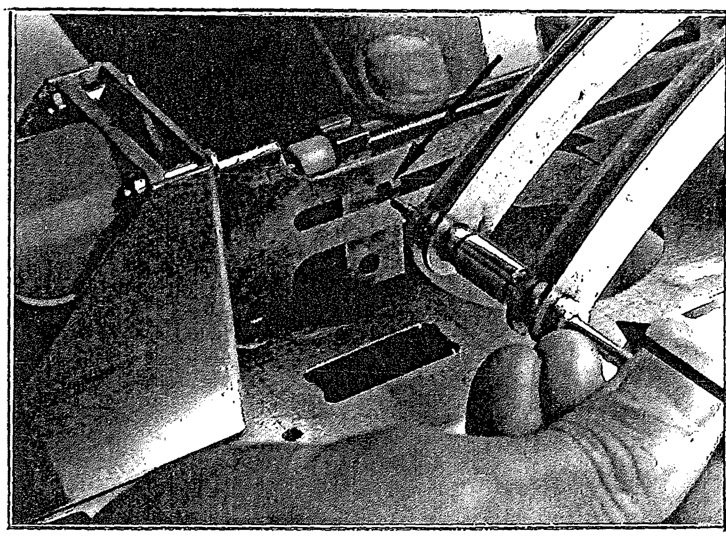


4) Insert the bolt-rod through the hole of the next linkage.



5) Lift the cursor casing slightly and hold it in a position where you can see a 2nd hole on the cursor.

6) Insert the bolt-rod through (both) the gap on the cursor casing and the 2nd hole on the cursor.



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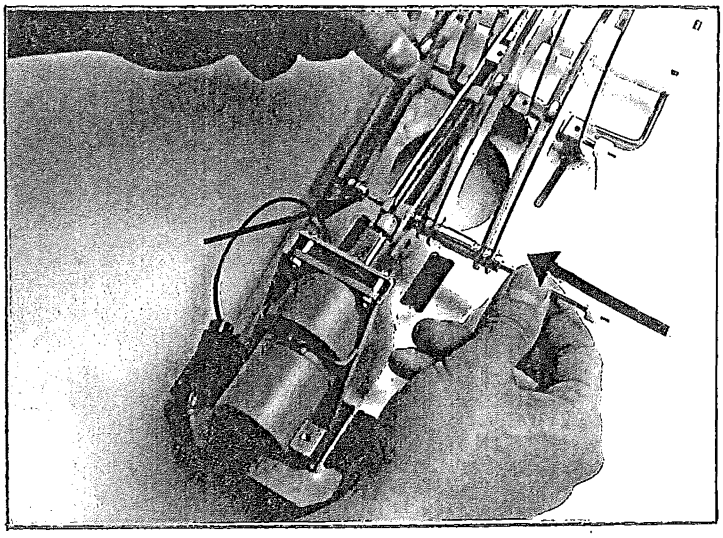
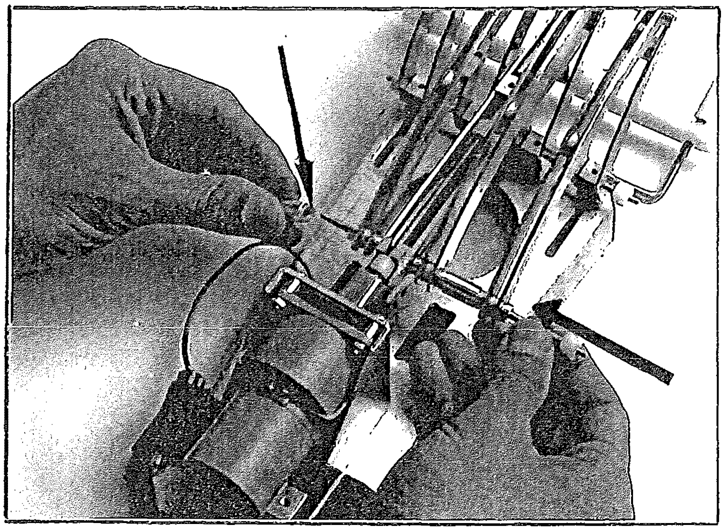
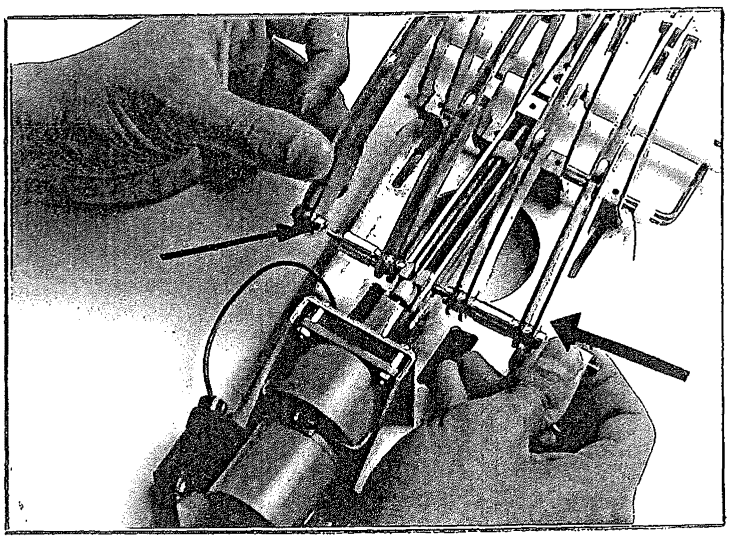
7) Insert the bolt-rod through the next linkage.



8) Insert the bolt-rod through the remaining aluminium spacer.



9) Insert the bolt-rod through the last linkage.



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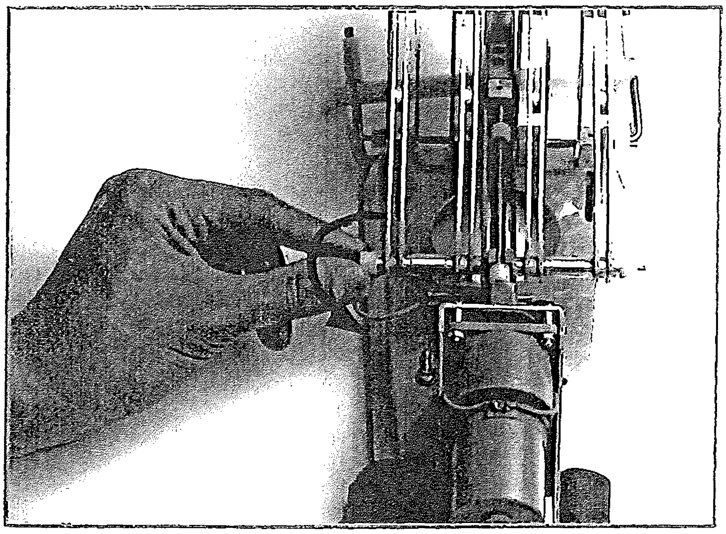
10) Fasten the bolt rod with the remaining plastic nut.

11) Tighten the nut until it stops.



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You have completed the assembly procedure.

Please close the instruction manual.

Testing Procedures

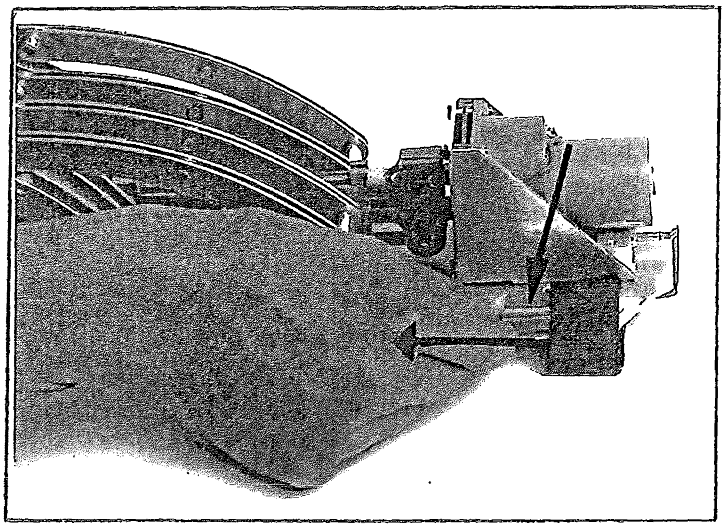
6.0) Testing Procedures

The following procedures allow you to operate and test the finger linkage movements of the CPM unit.

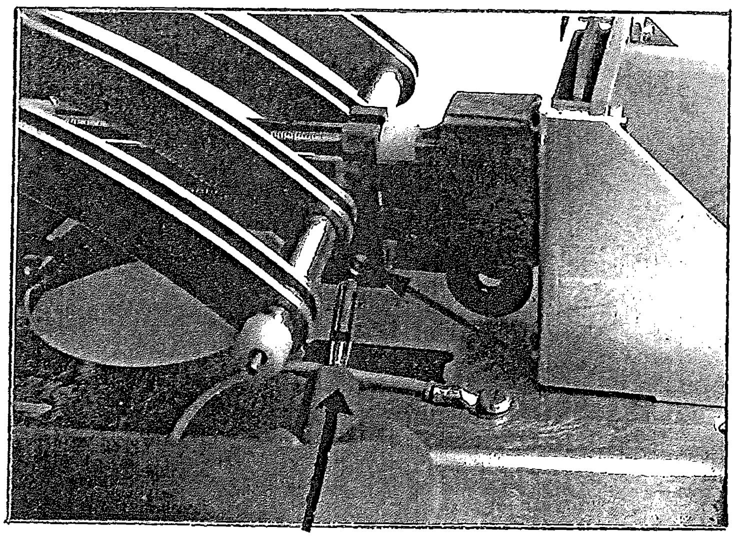
6.1) Inserting the plug into the cursor:

(**Note:** Ensure that the back of the motor unit is facing you).

1) Remove the plug from the velcro strap.



2) Insert the plug through the hole on the cursor up to the black line of the plug.



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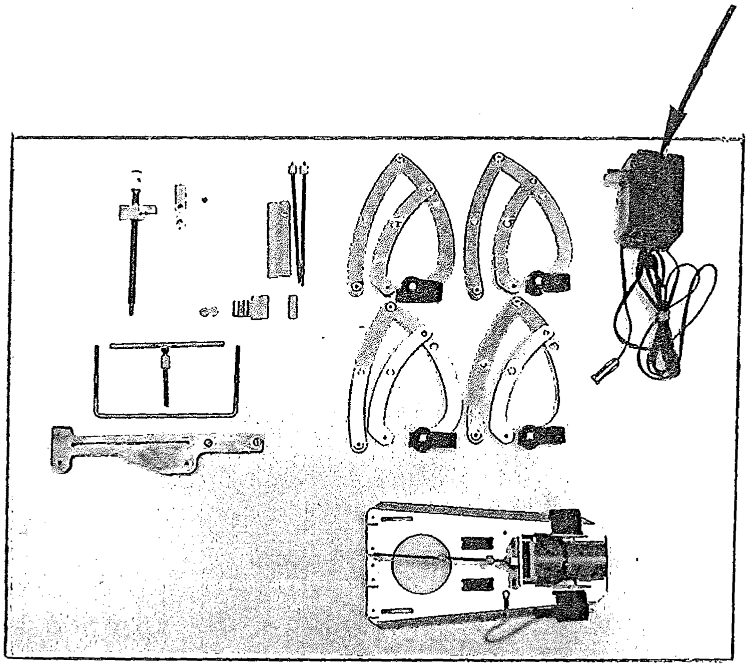
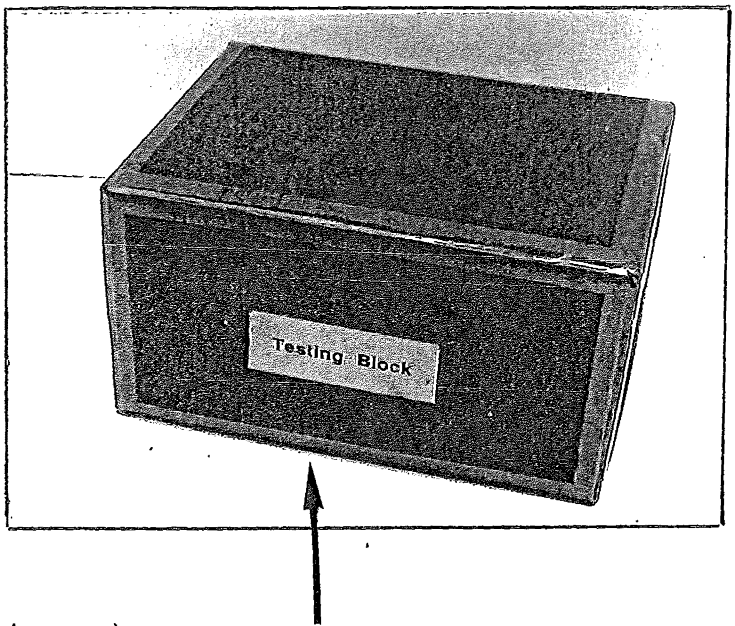
6.2) Testing cursor movement:

1) Select the adapter.



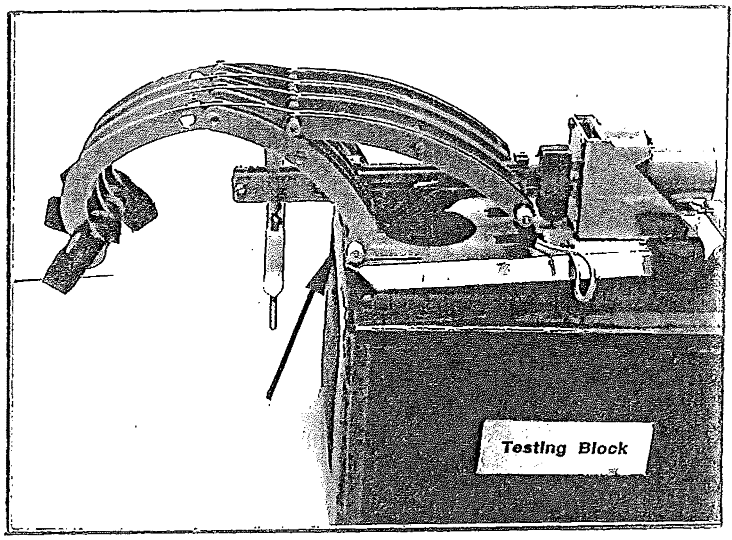
2) Position in front of you the box marked 'TESTING BLOCK'.



(**Note:** The label should be facing you.)

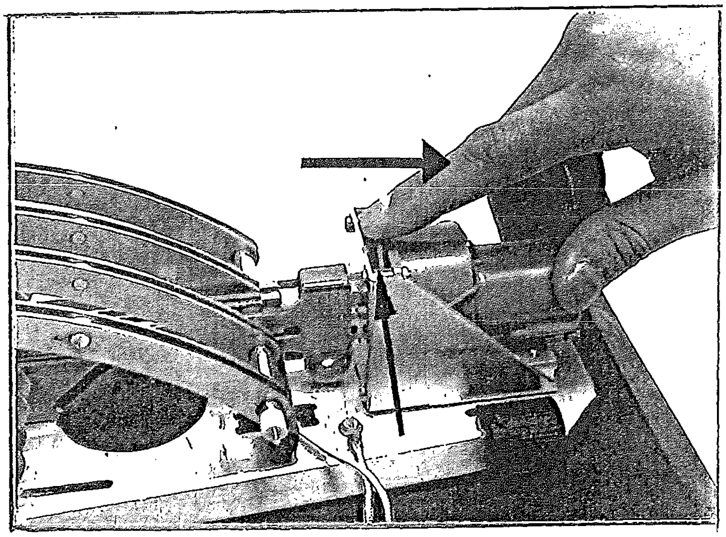
Proceed to the next page.

3) Place the CPM unit on top of the testing block and align the front edge of the CPM unit base-plate with the edge of the block.



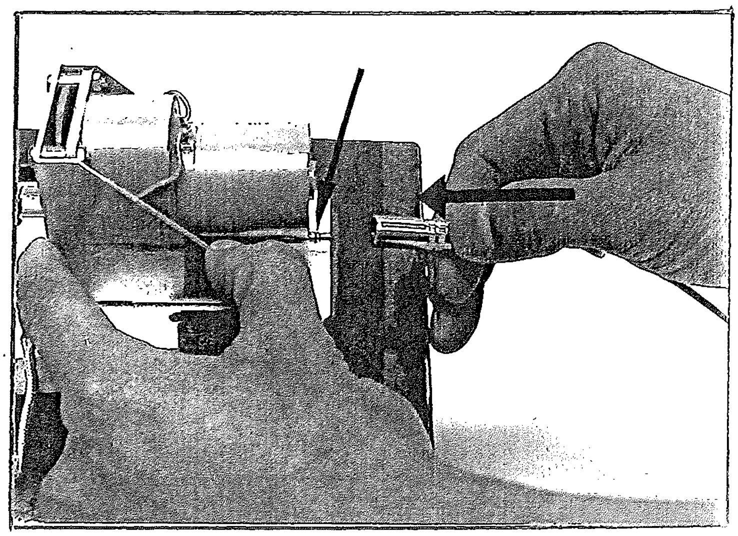
(**Note:** The hand rod should be hanging over the edge of the block.)

4) Pull back the direction switch located at the top of the motor unit until it 'clicks'.



5) With one hand, hold the CPM unit by its motor casing.

6) With your other hand, push the adapter socket into the adapter plug as far as you can (until it 'clicks').



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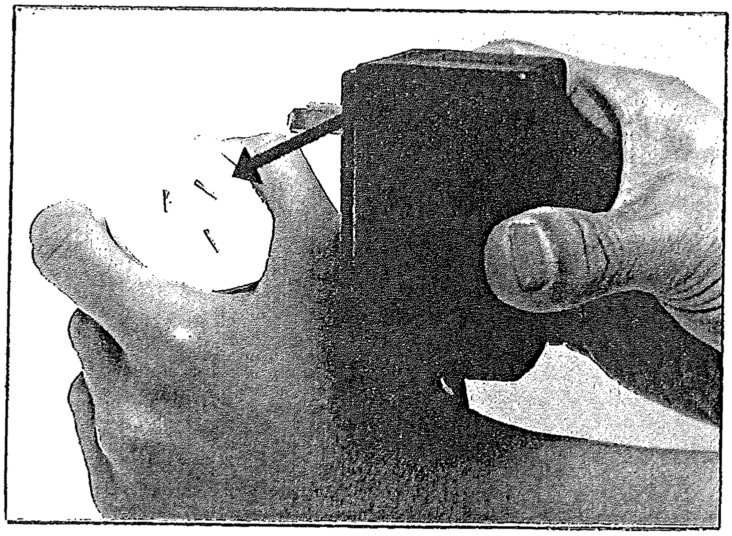
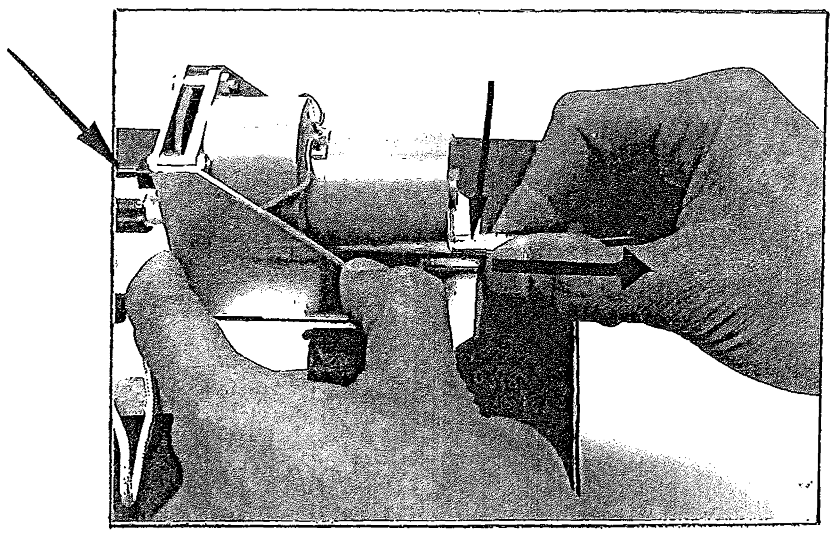
7) Plug the adapter into the extension cord (located on the top right-hand corner of the table.)



(**Note:** The CPM unit will make a 'roaring' sound as soon as the adapter is plugged into the extension cord.)

The cursor will move forward until it reaches the front (white) plastic nut on the switch rod. The cursor will automatically reverse the motor and move the cursor back towards its original position.

8) Disconnect the adapter socket when the cursor touches the plastic nut on the back end of the switch rod.

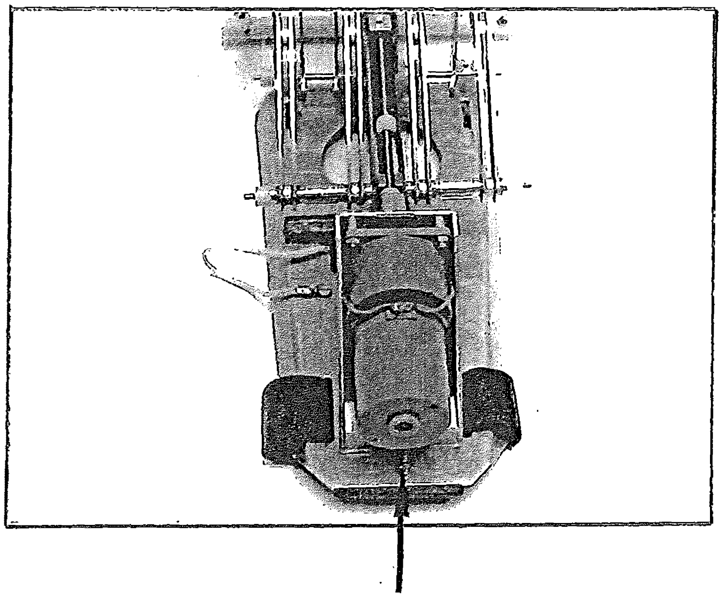


Proceed to the next step.

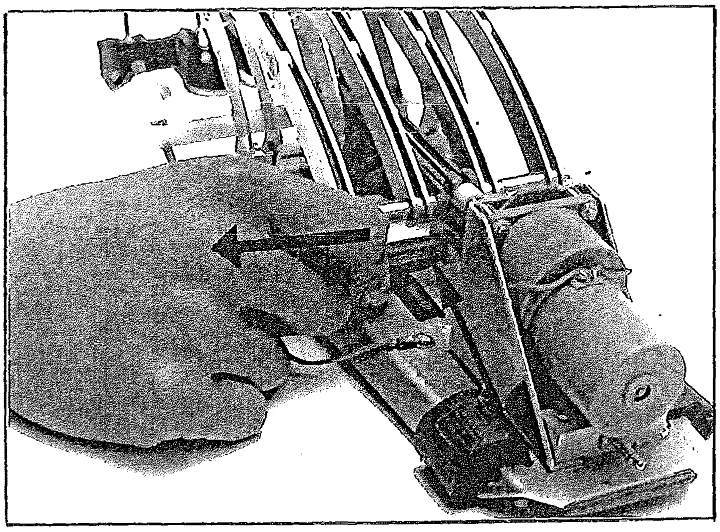
7.0) Test With Plug in Cursor Casing Position

7.1) Inserting plug into the cursor casing:

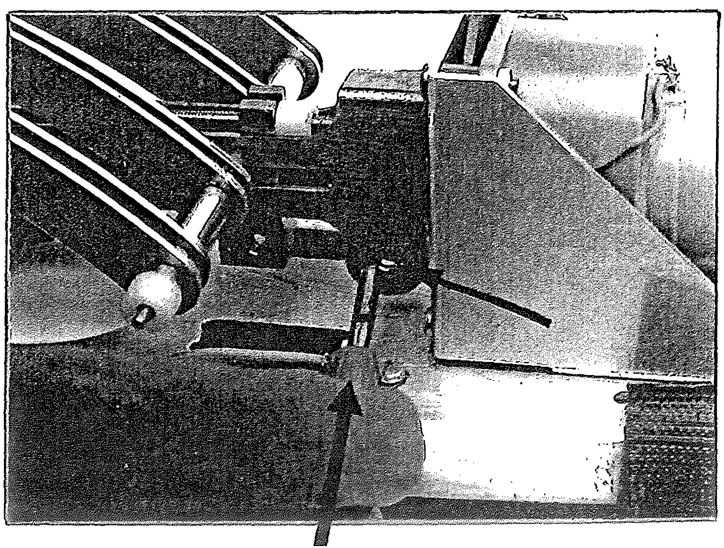
1) Place the CPM unit back on the table so that the back of the motor is facing you.



2) Remove the plug from the cursor.

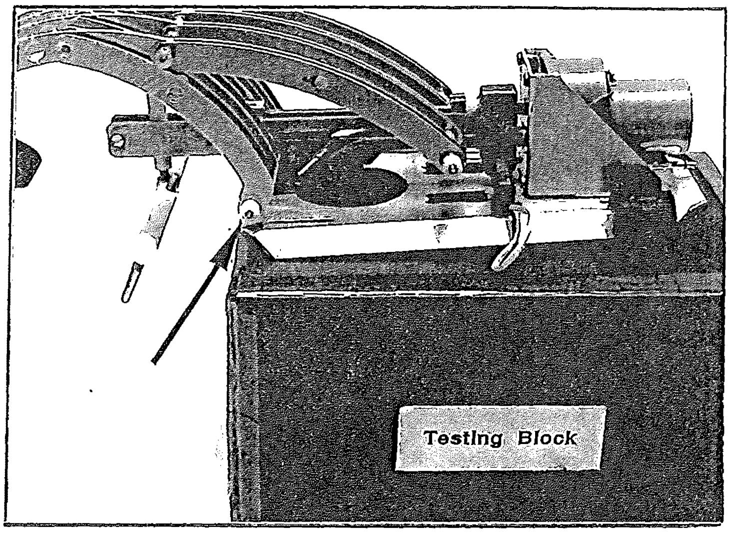


3) Insert the plug through the hole on the back of the cursor casing up to the black line of the plug.



7.2) Testing cursor movement:

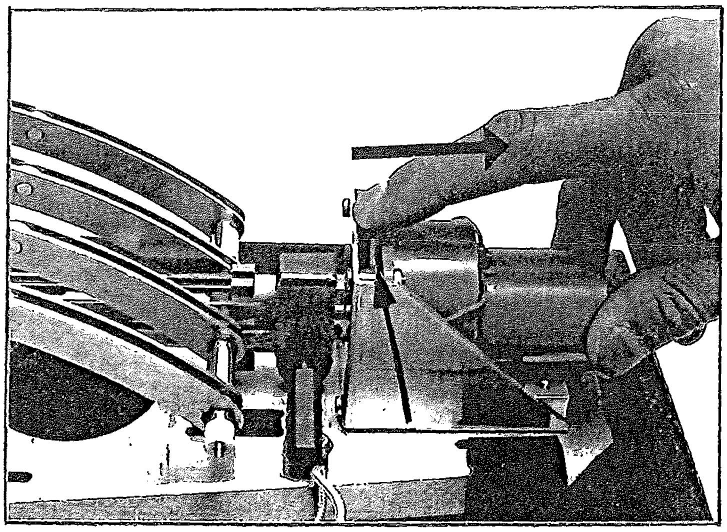
1) Position in front of you the box marked 'TESTING BLOCK'.



2) Place the CPM unit on top of the testing block and align the front edge of the CPM unit base-plate with the edge of the block.

(**Note:** The hand rod should be hanging over the edge of the block.)

3) Pull back the direction switch located at the top of the motor unit until it 'clicks'.



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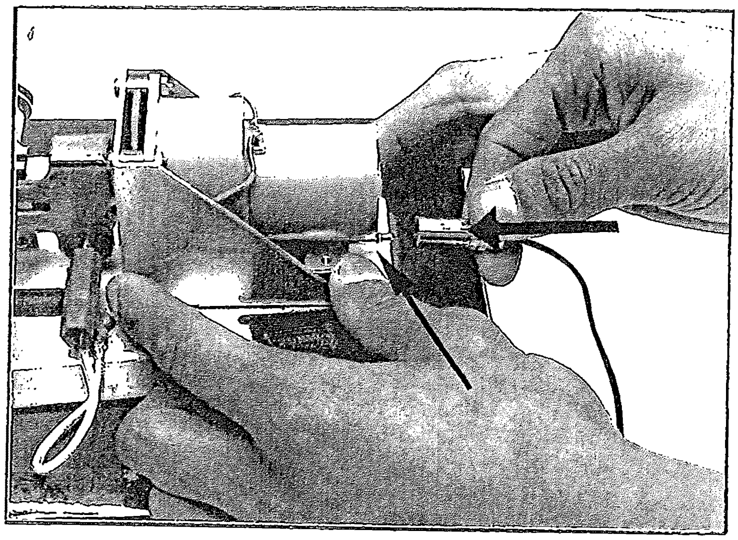
4) With one hand, hold the CPM unit by its motor casing.

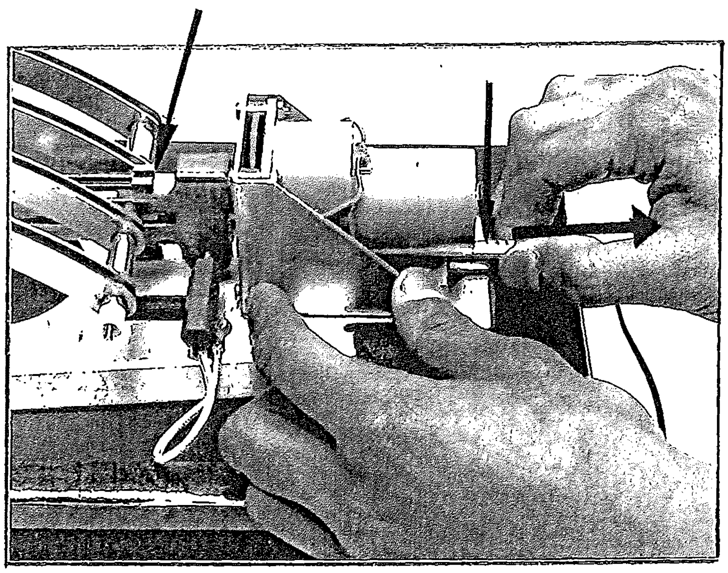
5) With your other hand, push the adapter socket into the adapter plug as far as you can (until it 'clicks').



(**Note:** The CPM unit will make a 'roaring' sound as soon as the adapter socket is pushed into the adapter plug.)

The cursor will move forward until it reaches the front (white) plastic nut on the switch rod. The cursor will automatically reverse the motor and move the cursor back towards its original position.

6) Disconnect the adapter socket when the cursor touches the plastic nut on the back end of the switch rod.



Proceed to the next page.

You have completed the testing procedures.

Please close the instruction manual.

Thank you for your participation.

Appendix 5.

Instruction manual Condition-7.

THE CPM UNIT:

ASSEMBLY AND TESTING INSTRUCTIONS

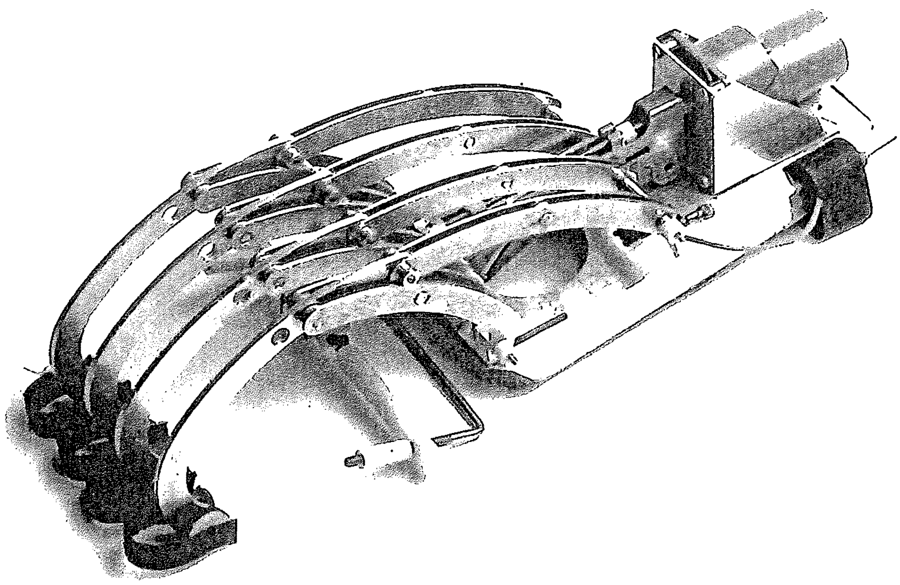
CONTENTS

The CPM Unit

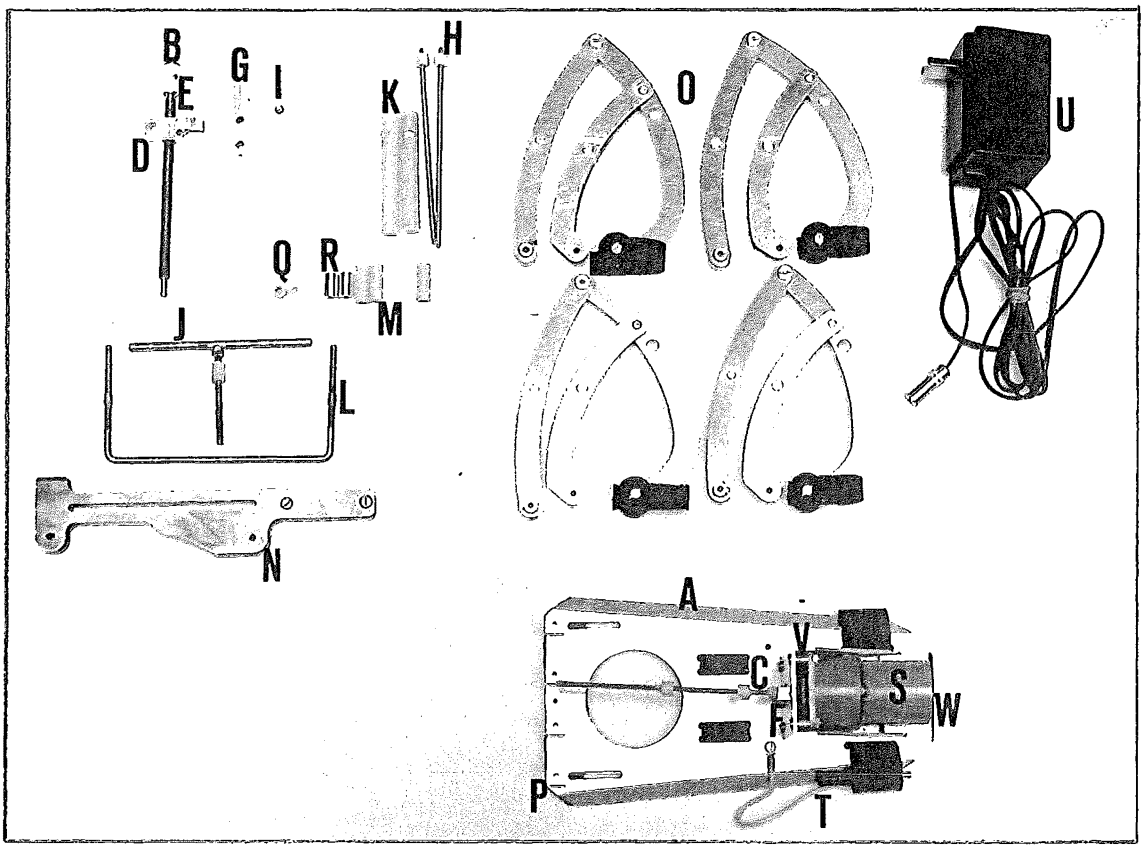
The portable continuous passive motion hand unit (CPM) is an orthopaedic hand exercise unit, designed to help the healing of the hand and/or finger muscles after injury. The lightweight design of the unit means the patient can take the unit home and supervise their own personal therapy for up to 24 hours.

The unit fits comfortably on top of the hand and wrist. It is secured with velcro binding for easy attachment to and release from the fingers and wrist.

A small motor operates the finger linkages of the CPM unit which helps the patient to exercise his/her hand without effort.



Names of CPM Parts



1.0) Names of CPM Parts

The following names refer to the names of the CPM parts and their location on the CPM unit. The order of presentation corresponds with the order of the procedural steps.

A) **The CPM Base Unit:** The CPM base unit is the largest sub-assembled component made up of an aluminium base-plate, a motor unit, a red plug, and 4 linkage attachment blocks.

B) **The Cursor Shaft:** The cursor shaft is the longest metal rod with a brass block threaded onto it. The cursor shaft is attached to the motor shaft.

C) **The Switch Rod:** The switch rod is the brass rod with 2 short plastic nuts threaded onto it. The switch rod is attached to the motor unit.

D) **The Cursor:** The cursor is the brass block with 2 holes and a groove. The cursor is threaded onto the cursor shaft.

E) **The Allen Screw:** The Allen screw is the screw threaded into the white portion of the cursor shaft.

F) **The Motor Shaft:** The motor shaft is the small metal rod protruding from the motor unit.

G) **The Cursor-Shaft-Block:** The cursor-shaft-block is the long rectangular, aluminium block with holes on it. The cursor-shaft-block is fastened onto the CPM unit base-plate.

H) **The Bolt Rod:** The bolt rod is the long brass rod with a short plastic nut threaded onto it. The bolt rod secures the finger linkages onto the CPM unit.

I) **The screw:** The screw is the smallest un-assembled CPM component. The screw secures the cursor-shaft-block onto the CPM unit base-plate.

Proceed to the next page.

J) The T-Bar: The T-bar is the metal component which represents the alphabetical letter 'T', a short plastic nut is threaded onto it. The T-bar is a sub-part of the hand rod unit fastened onto the cursor casing.

K) The Plastic Sleeves: The plastic sleeves are the longest plastic component of the CPM parts. Each plastic sleeve is partially hollow with a hole on one end. The plastic sleeves are a sub-part of the hand rod unit slotted onto the T-bar.

L) The U-Bar: The U-bar is the metal component which represents a very wide alphabetical letter 'U'. The U-bar is a sub-part of the hand rod unit and is fastened to the T-bar.

M) The Long Plastic Nut: The long plastic nut is the longest nut of the CPM parts. It is a sub-part of the hand rod unit which secures the U-bar to the T-bar.

N) The Cursor Casing: The cursor casing is the largest metal component of the CPM parts. The cursor casing is an aluminium block with 6 holes fixed between the metal at the front-end, with gaps in the mid-section and one hole at the back-end of the metal part. The cursor casing encases the cursor and the cursor-shaft-block.

O) The Finger Linkages: The finger linkages are the 3-pronged aluminium objects with a black velcro strip fastened at the front-end. The finger linkages are attached to the CPM base unit in 2 places: 1) the 4 linkage attachment blocks, 2) the cursor.

P) The Attachment Blocks: The attachment blocks are the 4 short aluminium blocks secured onto the front-end of the CPM unit base-plate.

Q) The Plastic Nut: The plastic nut is the shortest plastic component of the CPM parts. The nut secures the bolt rods attaching the finger linkages to the attachment blocks and the cursor.

R) The Aluminium Spacer: The aluminium spacer is the hollow, pipe-like aluminium component of the CPM parts. The aluminium spacer is slotted onto the bolt rod between the back finger linkage attachments.

Proceed to the next page.

S) **The Motor Unit:** The motor unit is the sub-assembled component secured to the back-end of the CPM unit base-plate.

T) **The Plug:** The (red) plug is attached to the black velcro strap located at the back-end of the CPM base unit.

U) **The Adapter:** The adapter is the black 'cubical' object with a silver socket attached to the black cord.

V) **The Direction Switch:** The direction switch is the brown PC board located on the top of the motor unit.

W) **The Adapter Plug:** The adapter plug is the silver metal rod that protrudes from the back end of the motor unit.

Proceed to the next page.

Assembly and Testing Procedure Instructions

All the parts and tools you will need to assemble and operate the CPM unit are in front of you.

1) Perform the task as accurately and as fast as you can.

2) Please follow the procedures and notes in a step-by-step manner

3) Please close the instruction manual.

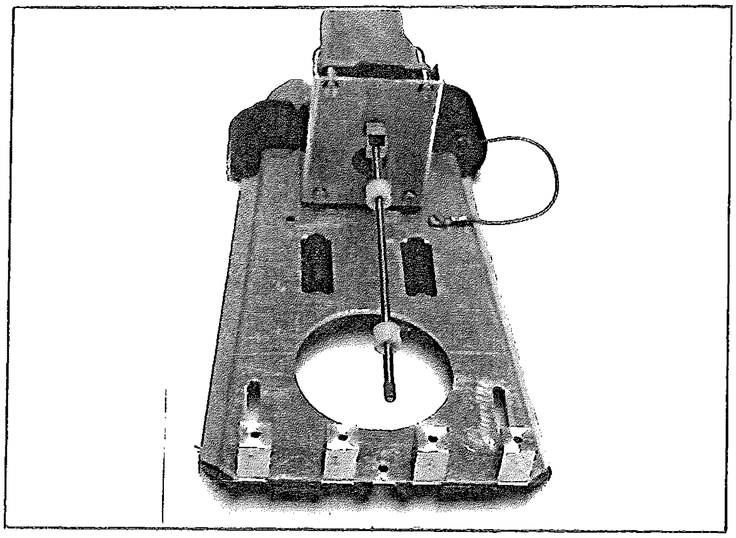
Assembly Procedures

2.0) Cursor Shaft Assembly

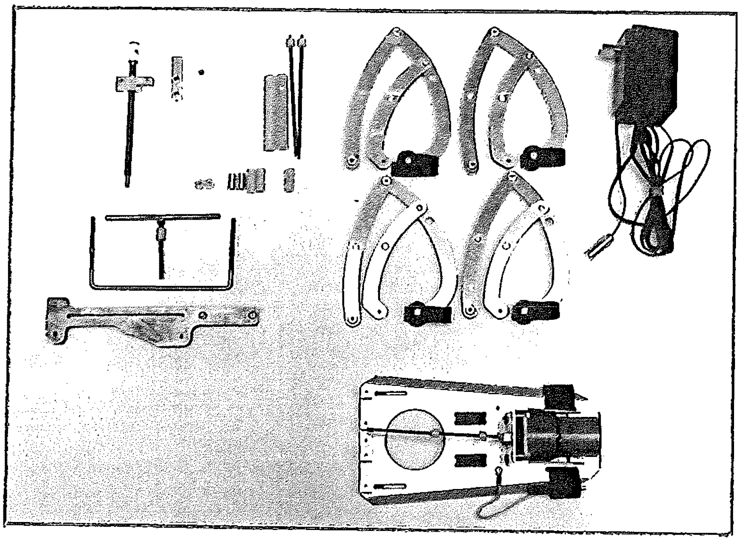
The cursor shaft is the metal shaft which is threaded through the cursor. When the motor is operating, the cursor allows for forward and backward motion of the finger linkages.

2.1) Positioning the cursor shaft into the motor shaft:

1) Position the CPM base unit so that the 4 linkage attachment blocks are facing you.



2) Select the cursor shaft.



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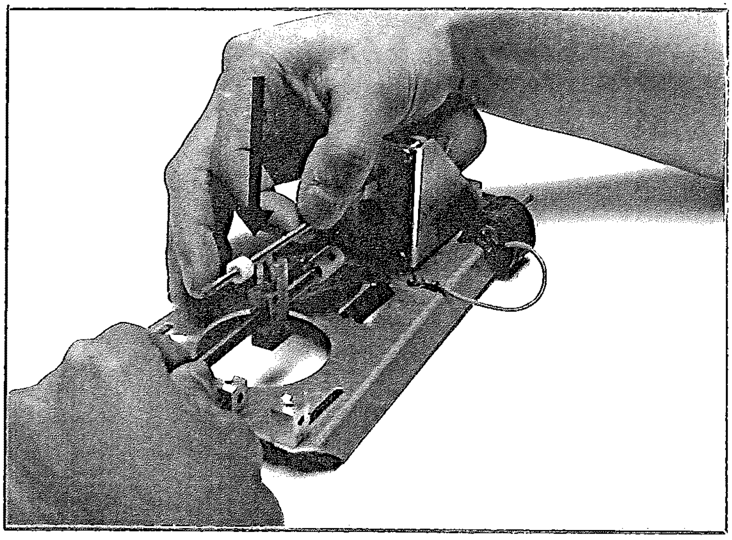
3) With one hand, lift the switch rod.

4) With your other hand, position the cursor shaft below the switch rod.

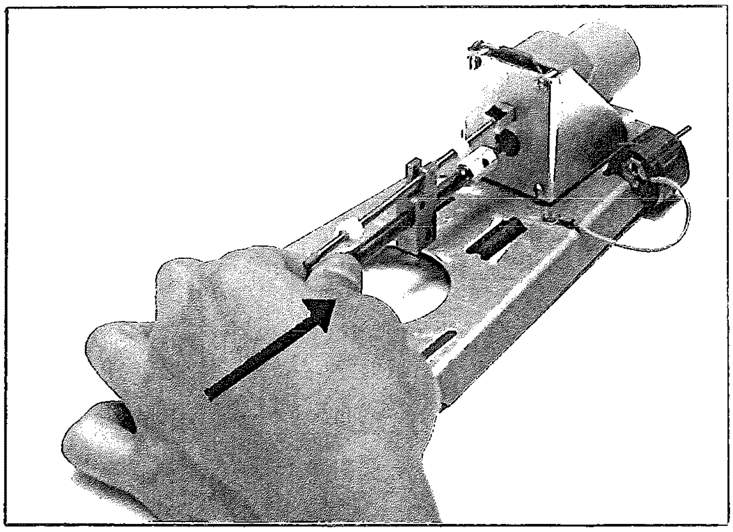
5) Place the switch rod in the groove of the cursor.



(**Note:** The cursor should be positioned between the 2 plastic nuts.)

6) Turn the cursor shaft so that the Allen screw is aligned with the flat side of the motor shaft.

7) Insert the cursor shaft into the motor shaft as far as you can.



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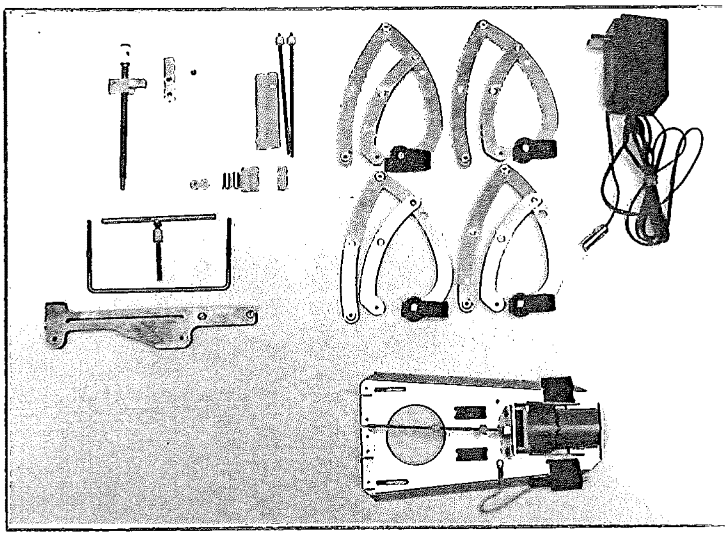
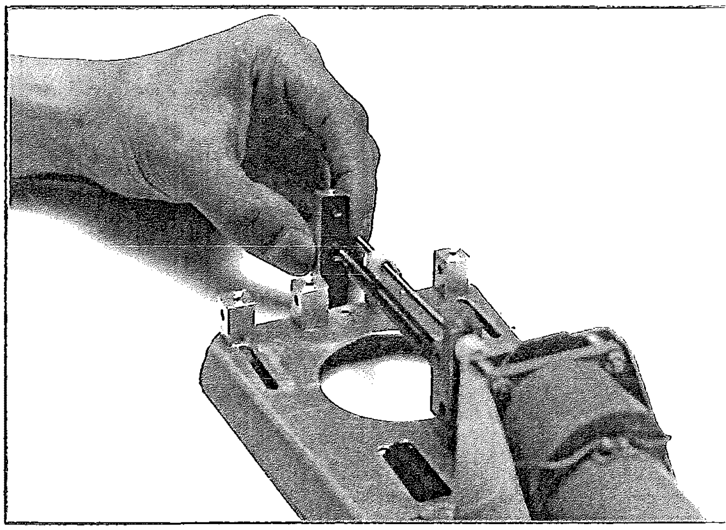
2.2) Mounting the cursor-shaft-block onto the CPM base unit:

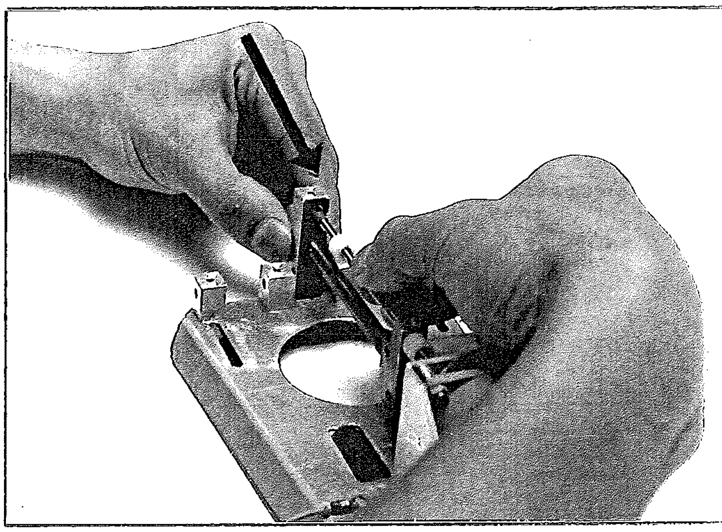
1) Select the cursor-shaft-block.



2) Hold the cursor-shaft-block so that the black side is facing the motor unit.



3) At the same time, slot the hole located in the middle of the cursor-shaft-block into the cursor shaft and the top hole into the switch rod.



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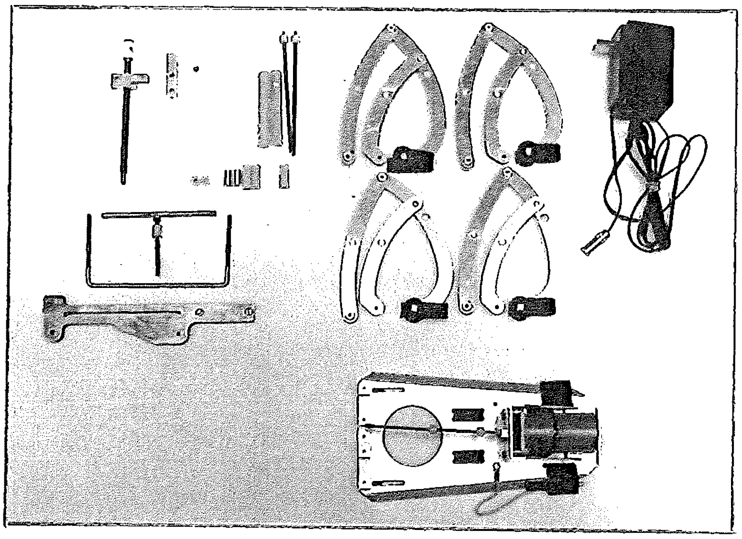
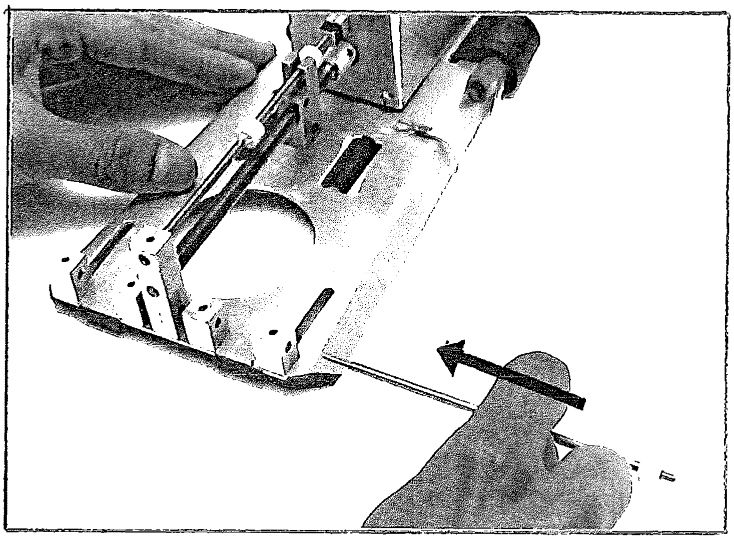
4) Select one of the bolt rods.



5) Starting from the right-most attachment block, insert the bolt rod through the side holes of the linkage attachment block.



(**Note:** The bolt rod should slide through the 4 attachment blocks and the cursor-shaft-block.)

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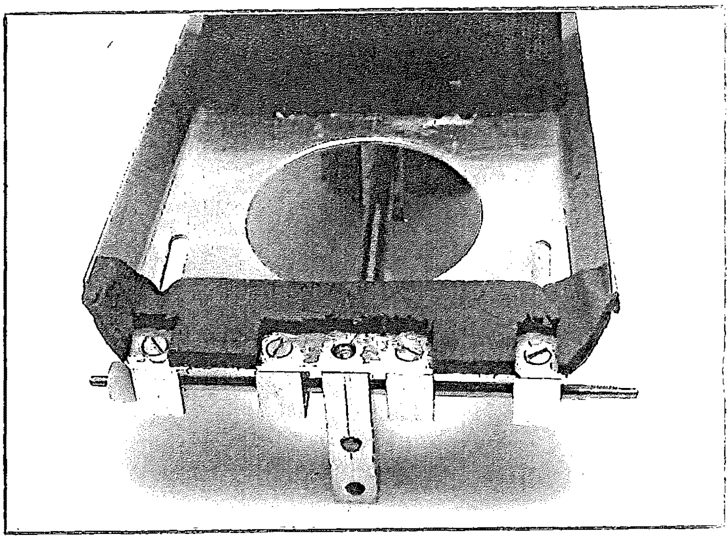
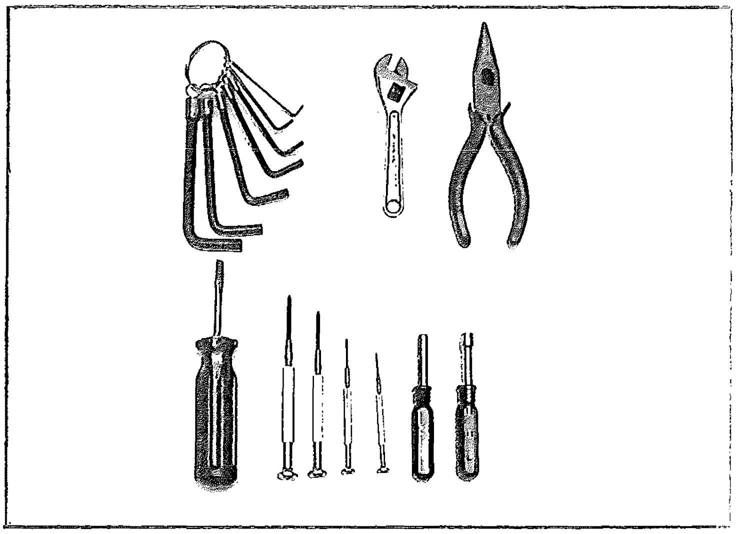
6) Turn the CPM unit over and rest the unit on the table.

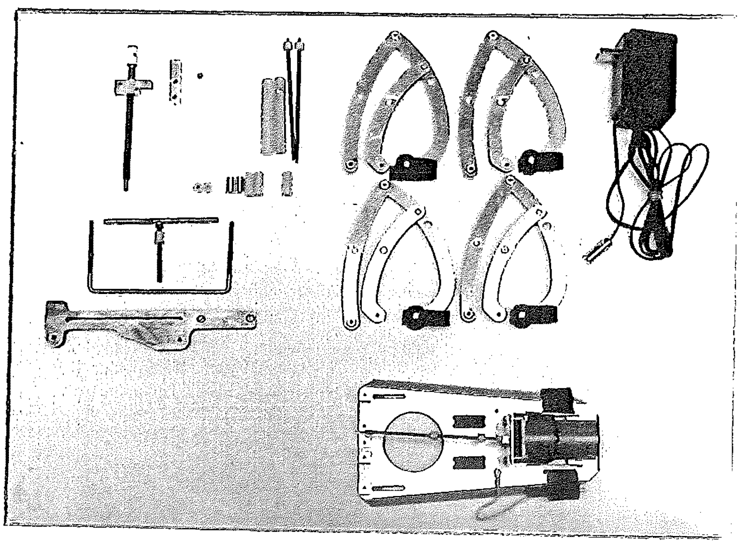


(Note: The cursor-shaft-block should be positioned upright, touching the table.)

7) Select a standard screwdriver.



8) Select the screw.



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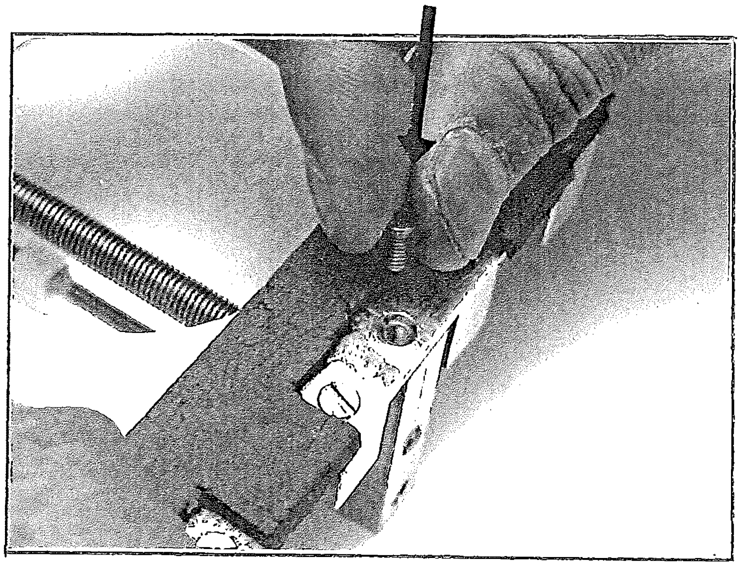
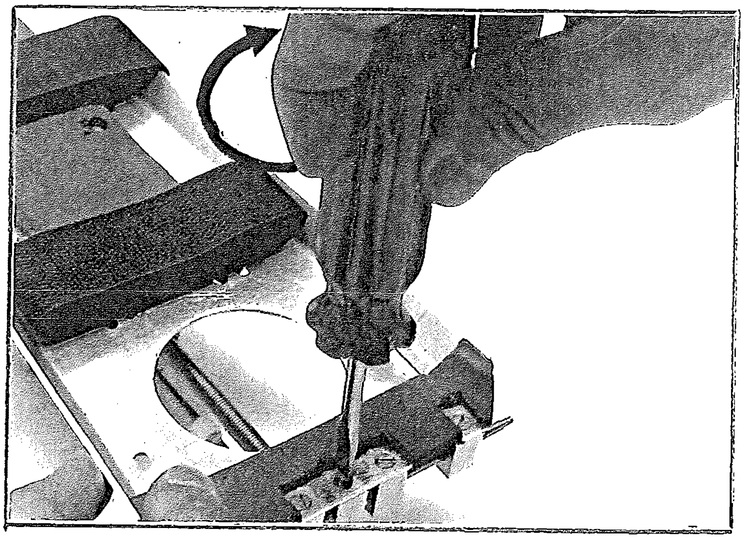
9) Hold the CPM unit firmly and ensure that the cursor-shaft-block is touching the table.

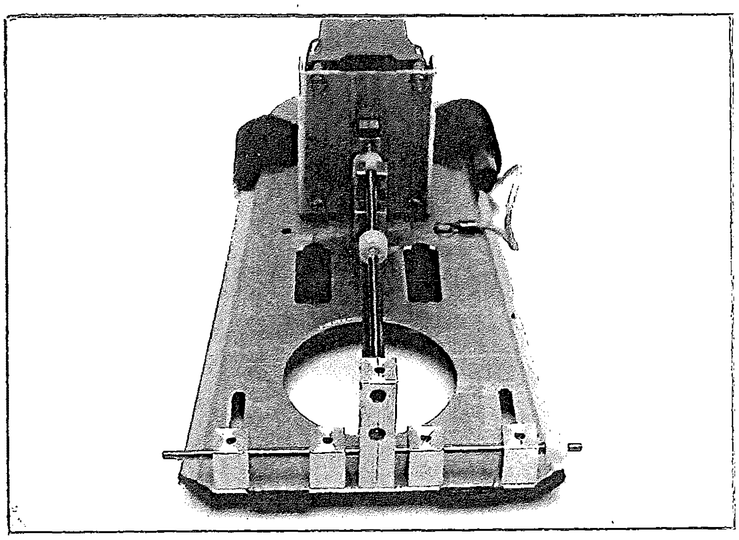


10) With the screw, secure the cursor-shaft-block to the CPM unit base-plate.

11) Using the screwdriver, tighten the screw.



12) Turn the unit back over and position the CPM base unit so that the 4 attachment blocks are facing you.



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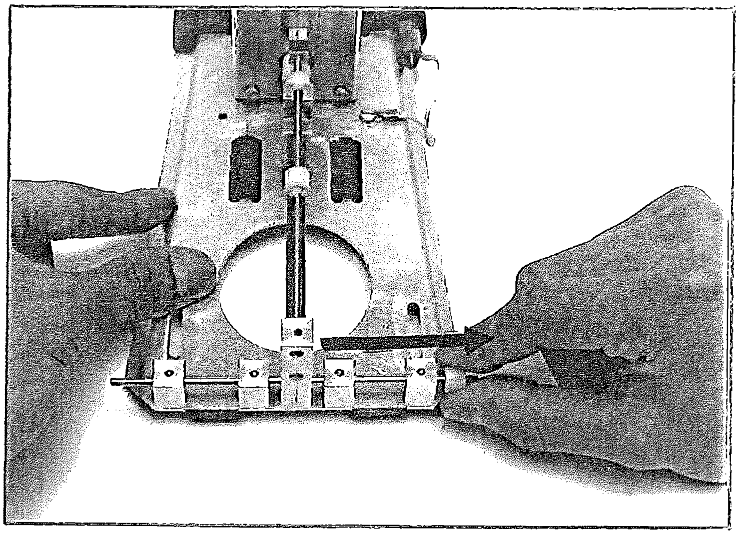
13) Remove the bolt rod from the attachment blocks.



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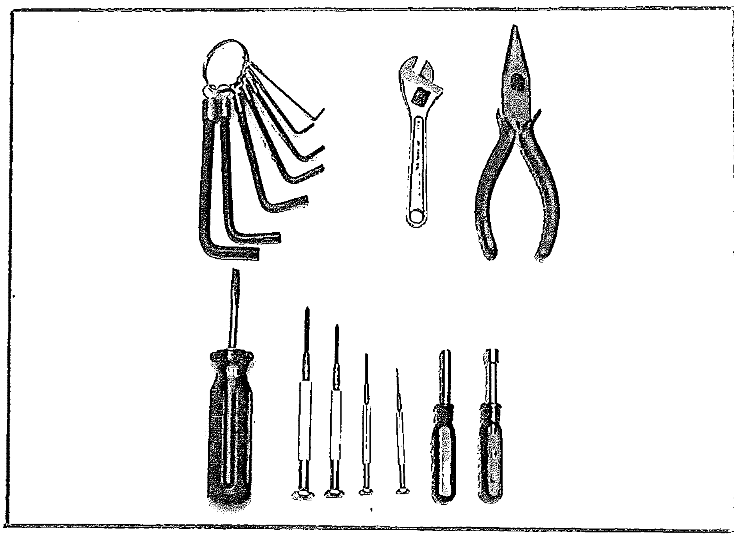
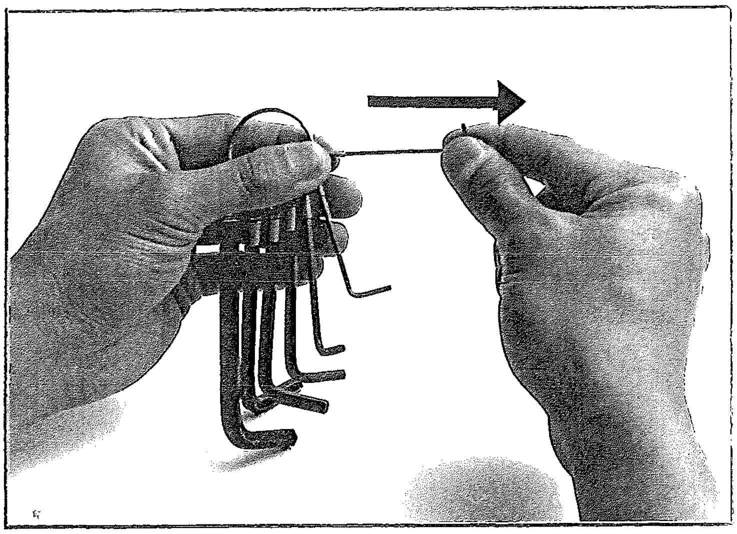
2.3) Removing the Allen key from its holder:

1) Select the Allen keys and locate the 1mm. Allen key.



2) With one hand, hold the spring-like holder.

3) With your other hand, pull the 1mm. Allen key from the spring-like holder.



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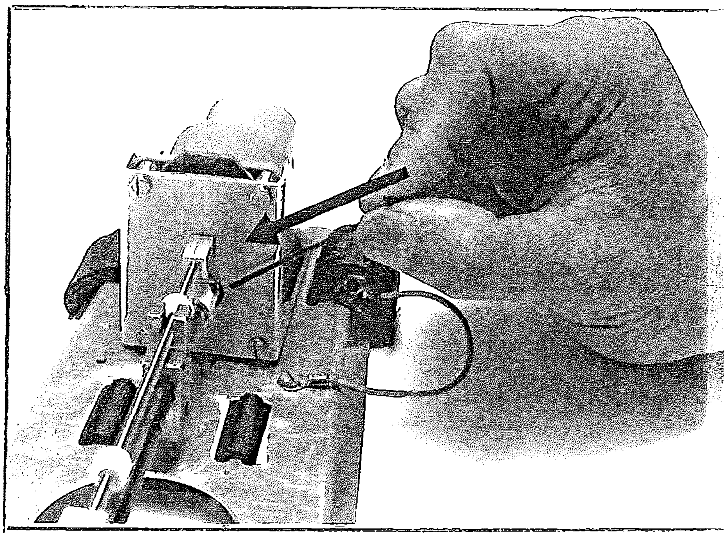
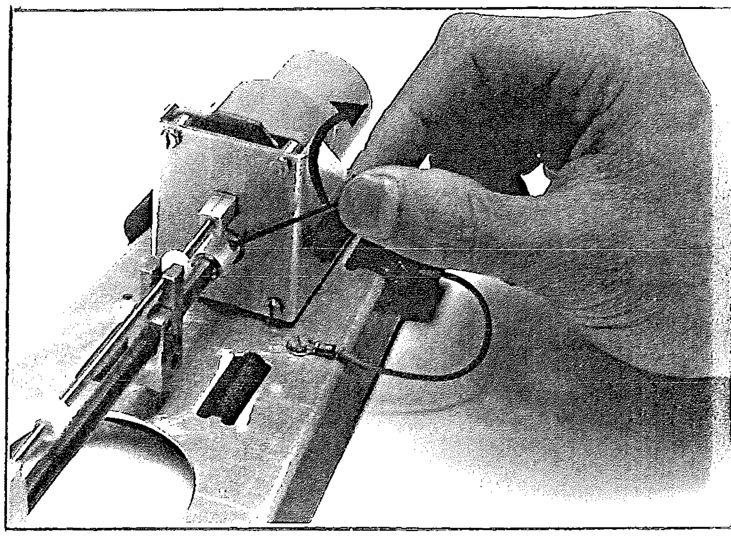
2.4) Tightening Allen Screw:

1) Slot the long-end of the Allen key into the Allen screw.



2) Tighten the Allen screw.



You have finished the cursor shaft assembly.

Proceed to the next step.

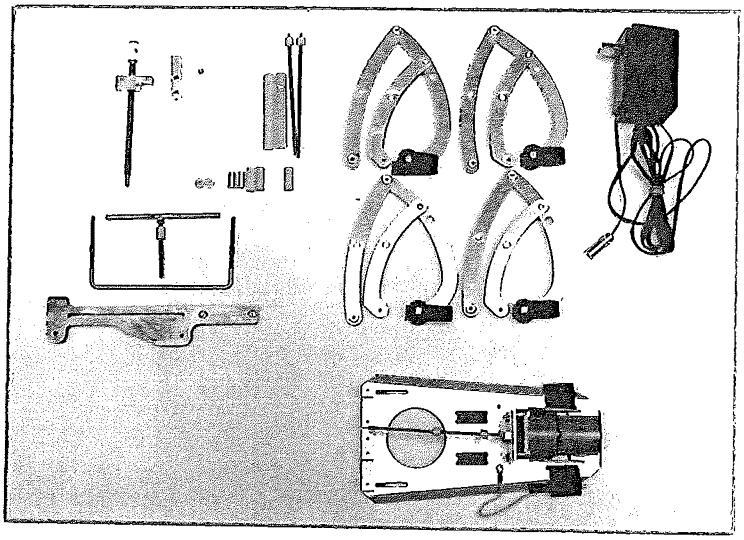
3.0) Hand Rod Assembly

The hand rod functions as a hand rest which supports the patient's hand while the hand and/or finger muscles are being exercised.

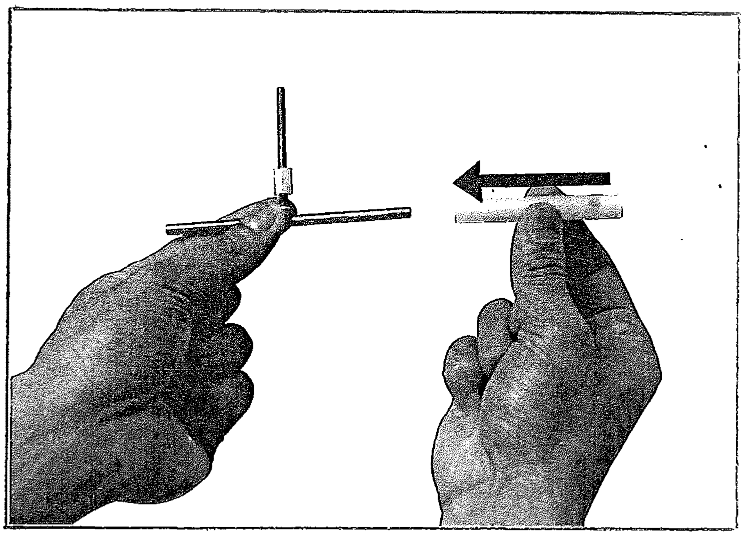
3.1) Hand rod assembly:

1) Select the T-bar.

2) Select the 2 plastic sleeves.



3) Slide the length of the 2 plastic sleeves onto the T-bar.



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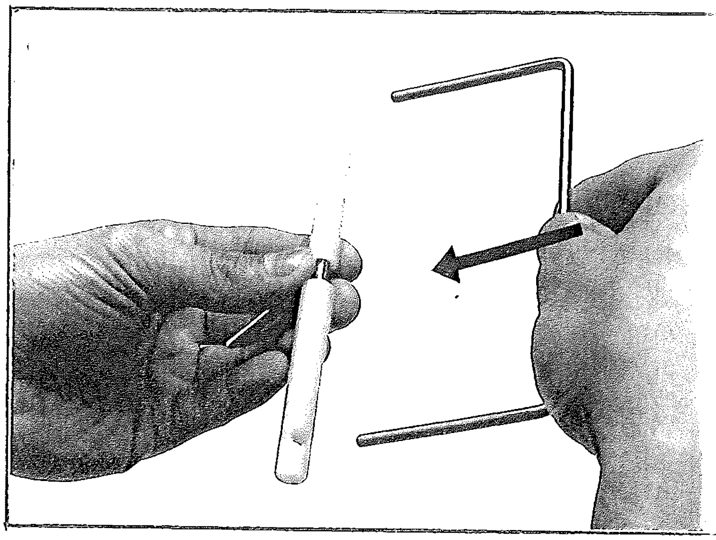
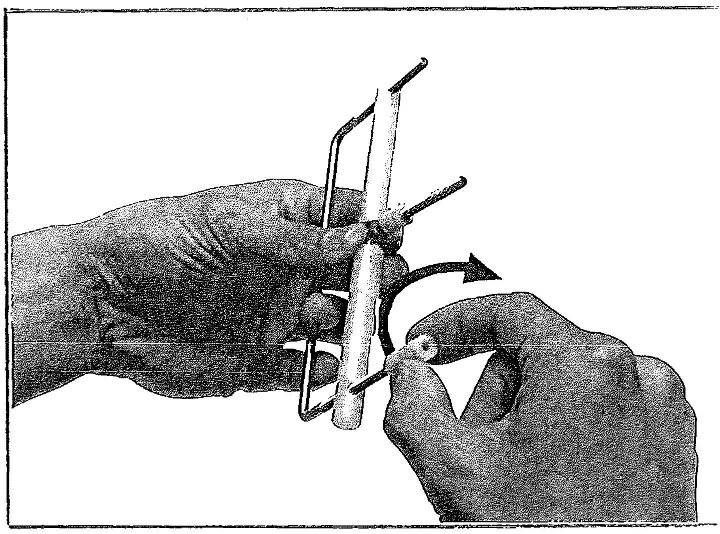
4) Hold the T-bar so that it represents the alphabetical letter 'T'.



5) Position the U-bar above the T-bar.

6) Slot both ends of the U-bar into the holes on the plastic sleeves.

7) Secure the U-bar onto the T-bar with a long plastic nut at each end.



8) Tighten both nuts until they stop.

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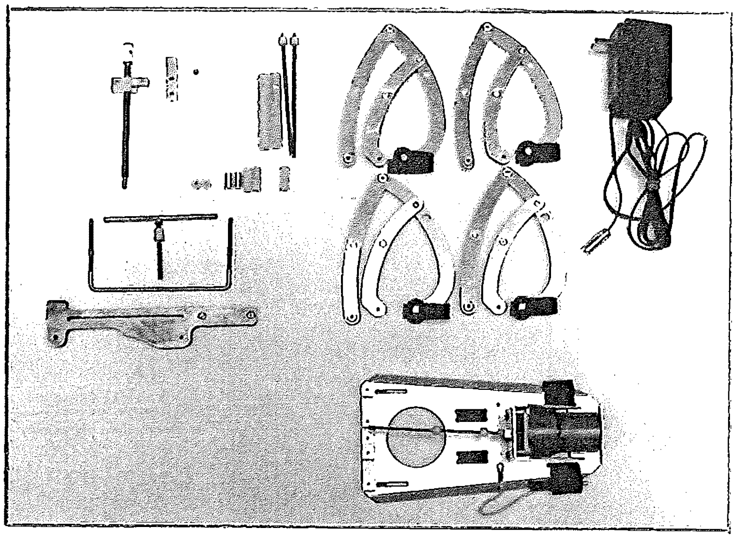
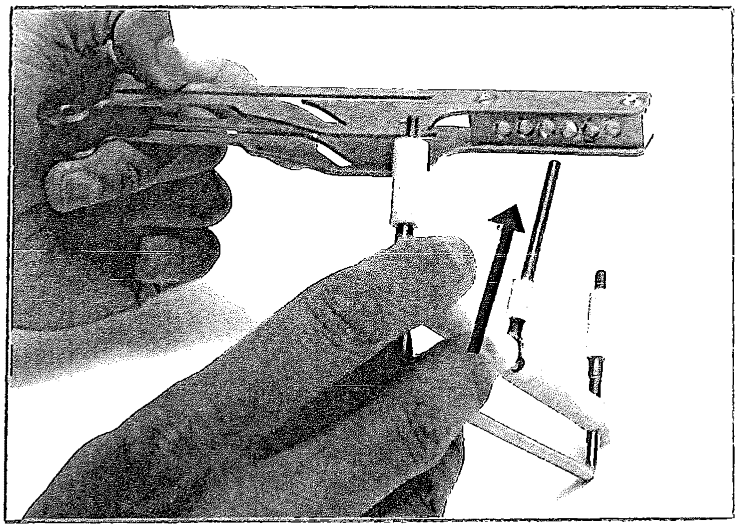
3.2) Fastening hand rod onto cursor casing:

1) Select the cursor casing.



2) With one hand, hold the cursor casing so that the straightest edge of the cursor casing is on top.



3) With your other hand, position the T-bar underneath the cursor casing.

4) Insert the T-bar of the hand rod into the 3rd hole from the front of the cursor casing.

(**Note:** The T-bar should be positioned at a 'cross-angle' with the cursor casing.)

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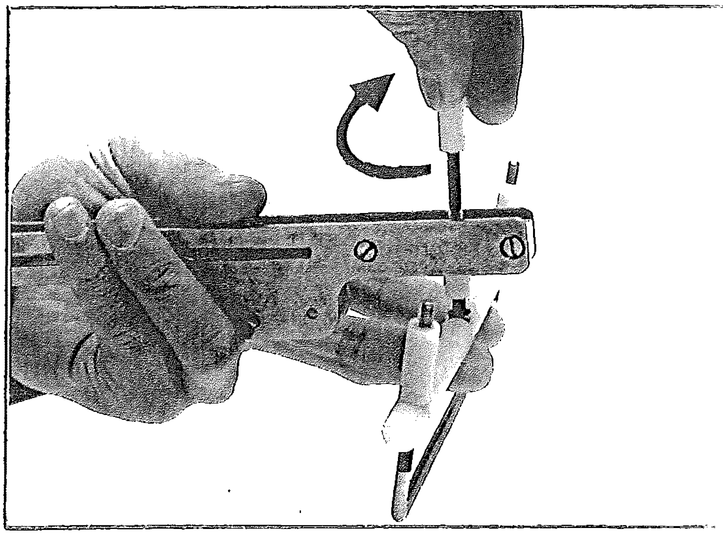
5) Fasten the T-bar in place with the remaining long plastic nut.

6) Tighten the nut until it stops.



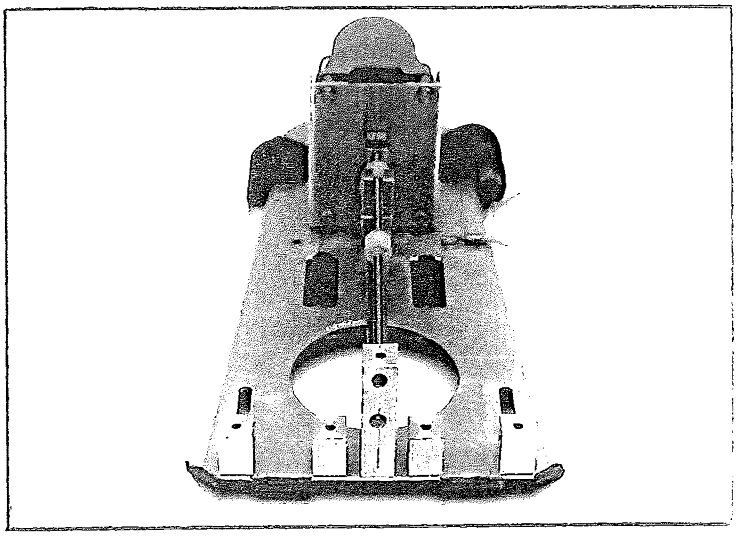
You have finished the hand rod assembly.

Proceed to the next step.

4.0) Cursor Casing Assembly

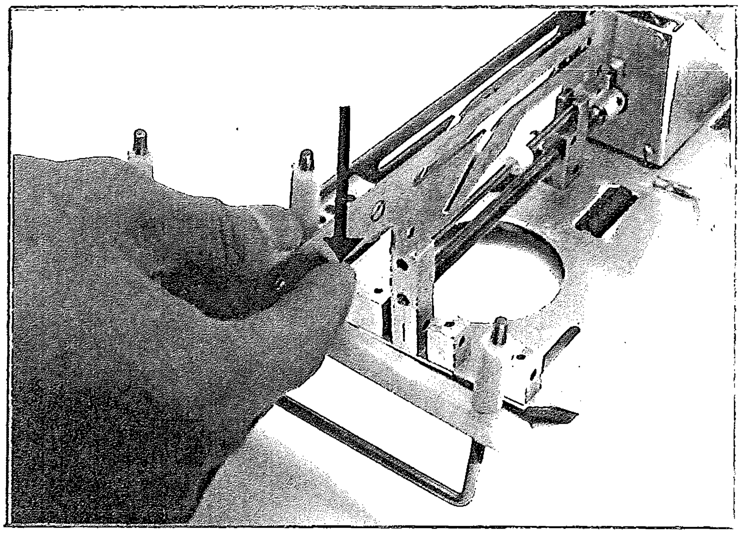
The cursor casing functions as a guide rail for the cursor which ensures the correct movement of the finger linkages.

1) Locate the black square of the aluminium block (connected to the switch rod).



2) Hold the cursor casing so that the straightest edge of the cursor casing is on top.

3) Slot the cursor casing onto the cursor-shaft-block and the cursor.



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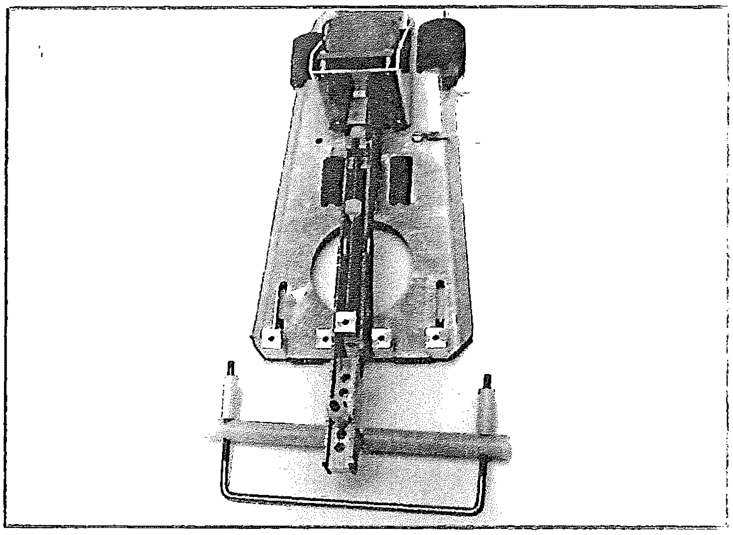
4) Align the back of the cursor casing so that it covers the black square of the aluminium block, leaving a gap between the cursor casing and the motor casing.



(**Note:** This will allow for easier assembly of the finger linkages.)

You have finished the cursor casing assembly.

Proceed to the next step.

5.0) Finger Linkage Assembly

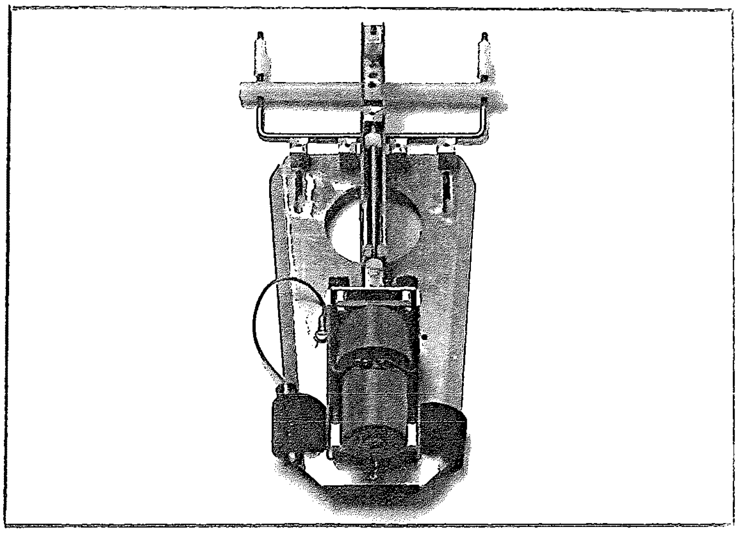
The finger linkages are attached to the CPM base unit in 2 places:

1) The linkage attachment blocks located at the front of the CPM unit base-plate.

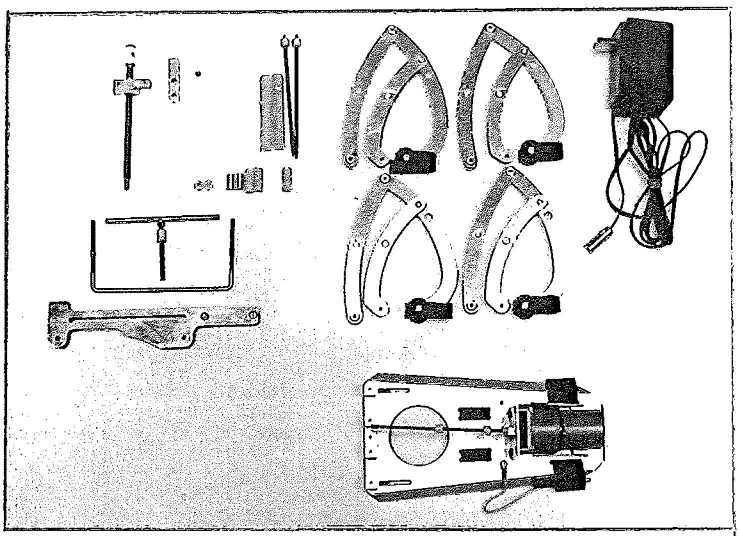
2) The cursor.

5.1) Fastening the (front) finger linkage attachment to the blocks:

1) Position the CPM base unit so that the back of the motor faces towards you.



2) Select one of the finger linkages.



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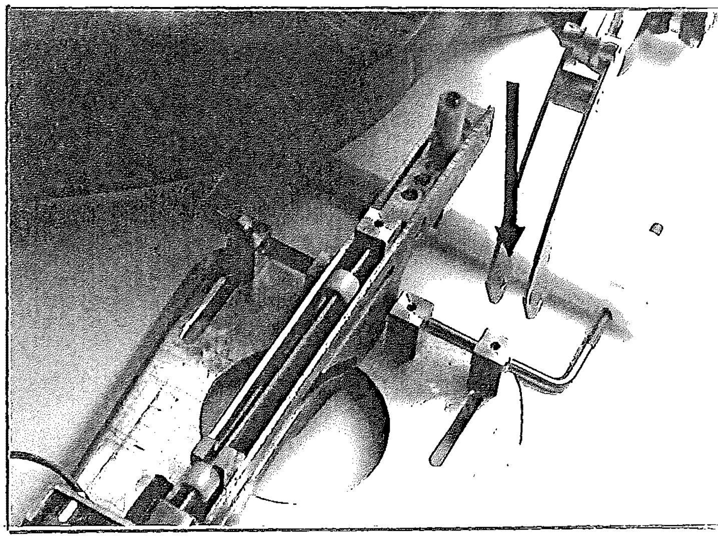
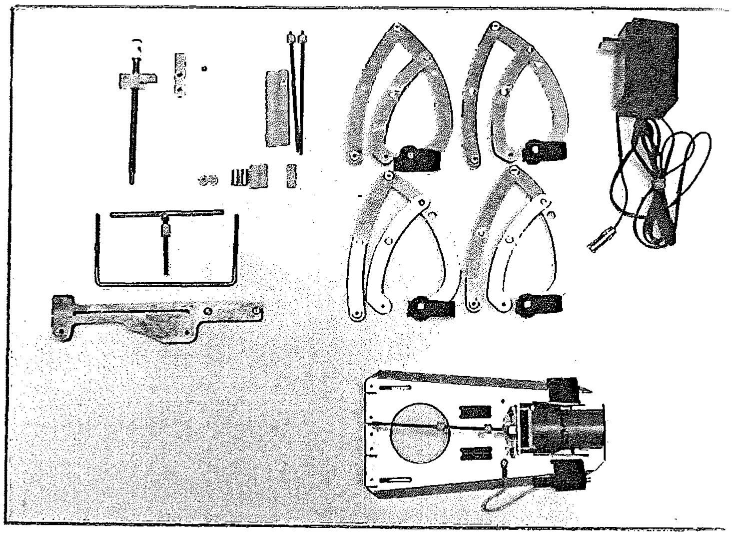
4) Slot the front finger linkage attachment onto the 1st attachment block,located at the right front of the CPM unit.



(**Note:** a) The velcro strip should be positioned in front of the hand rod.

b) The back linkage attachment should be positioned behind the attachment block.)

5) Select one of the bolt rods.



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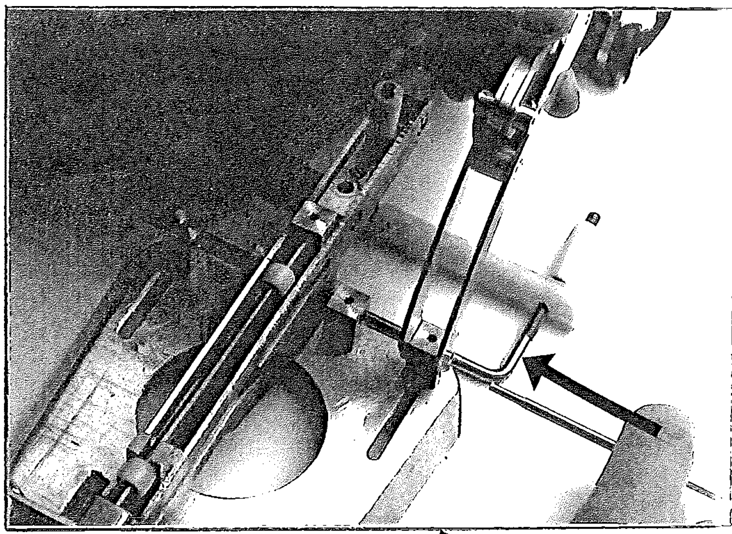
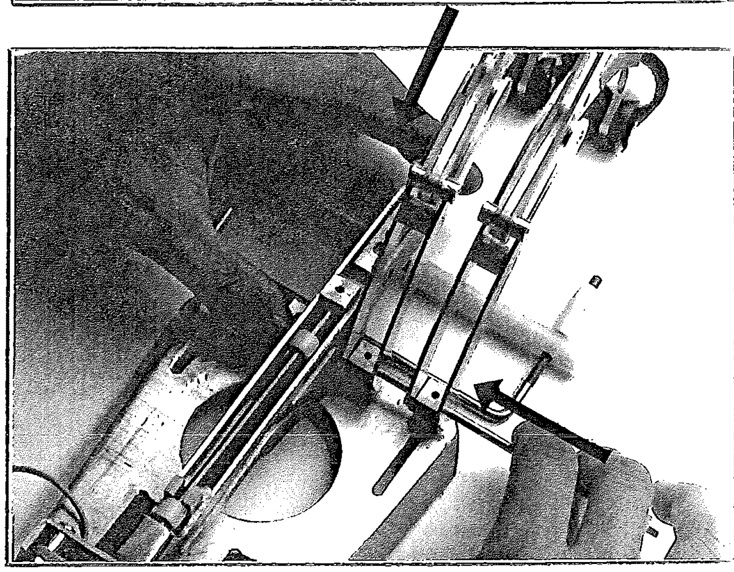
6) Insert the bolt-rod through the hole on the side of the front linkage until it protrudes slightly on the other side of the 1st linkage.

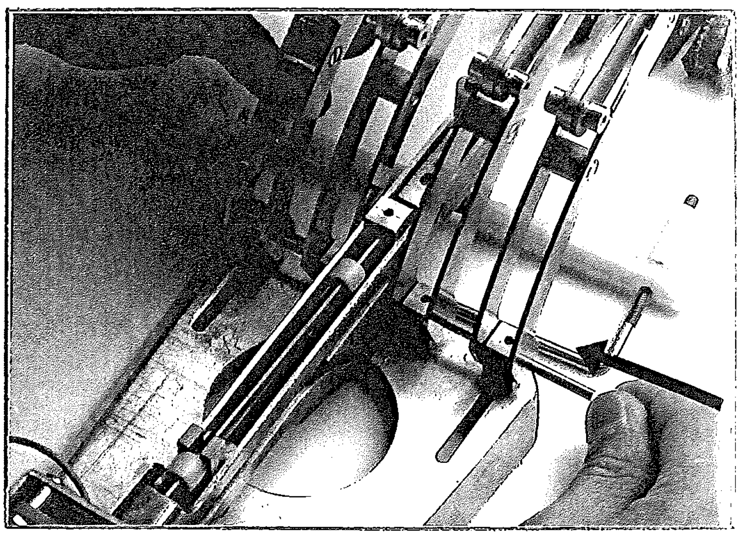


7) Slot a 2nd linkage onto the next block.

8) Push the cursor casing slowly towards the motor at the same time you are inserting the bolt-rod through the 2nd linkage.



9) Continue to fasten the remaining 3rd and 4th linkages.



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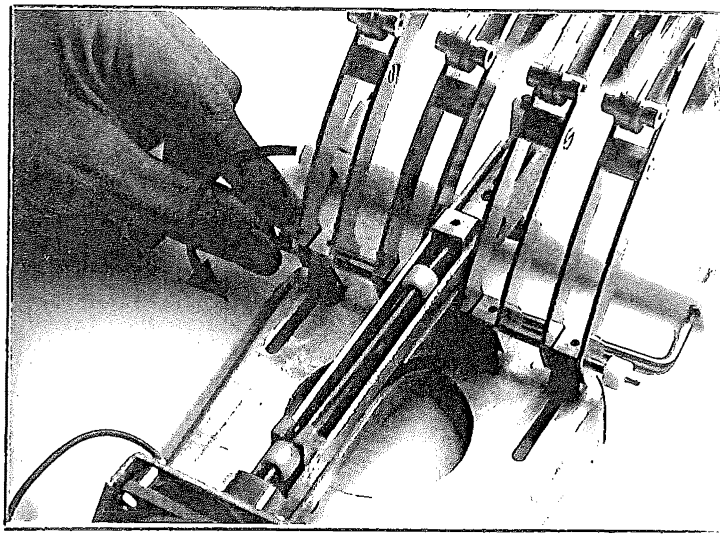
10) Fasten the bolt-rod with one of the plastic nuts.

11) Tighten the nut until it stops.



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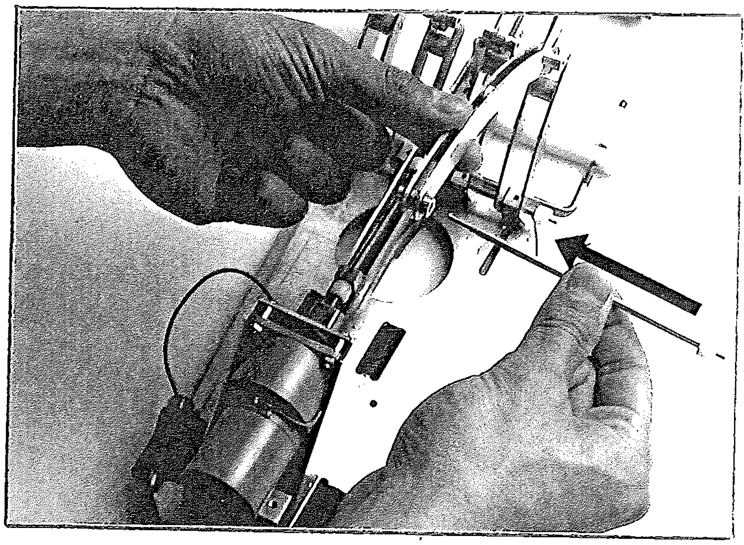
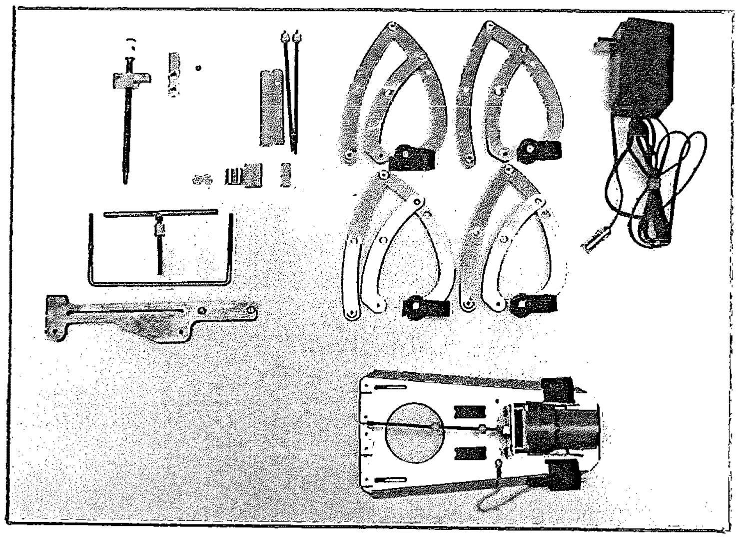
5.2) Fastening the (back) finger linkage attachment to the cursor:

(**Note:** Begin with the right-most finger linkage.)

1) Insert the bolt-rod through the hole at the back-end of the linkage.



2) Select one of the aluminium spacers.



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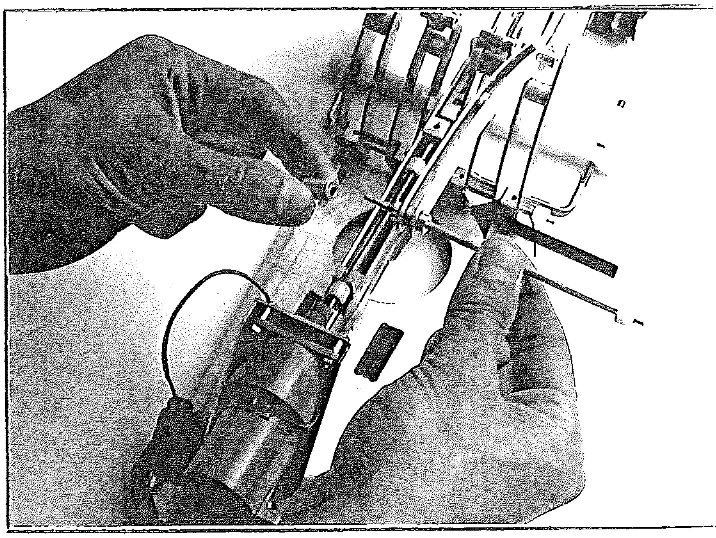
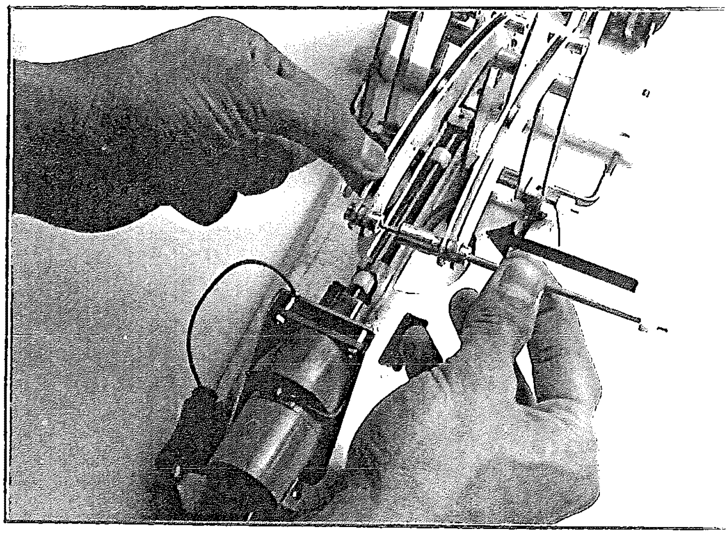
3) Insert the bolt-rod through the aluminium spacer.

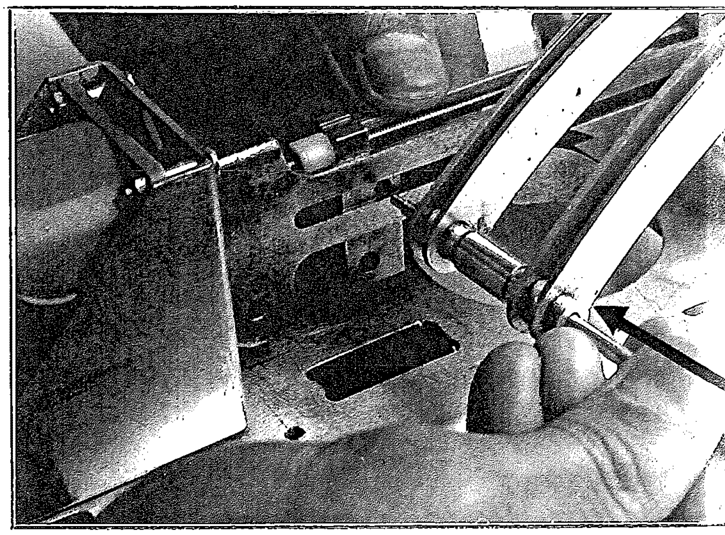


4) Insert the bolt-rod through the hole of the next linkage.



5) Lift the cursor casing slightly and hold it in a position where you can see a 2nd hole on the cursor.

6) Insert the bolt-rod through (both) the gap on the cursor casing and the 2nd hole on the cursor.



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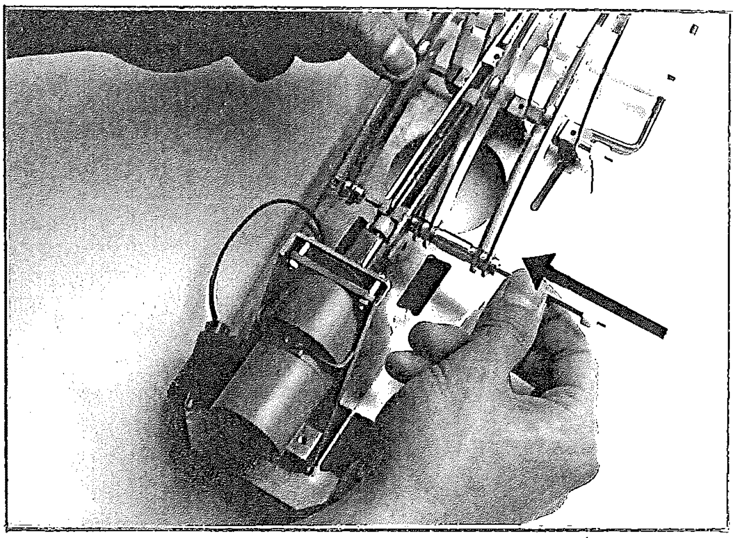
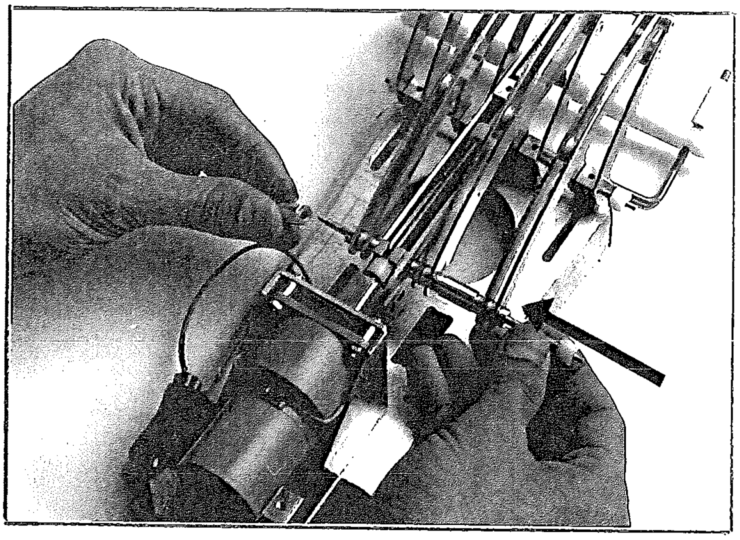
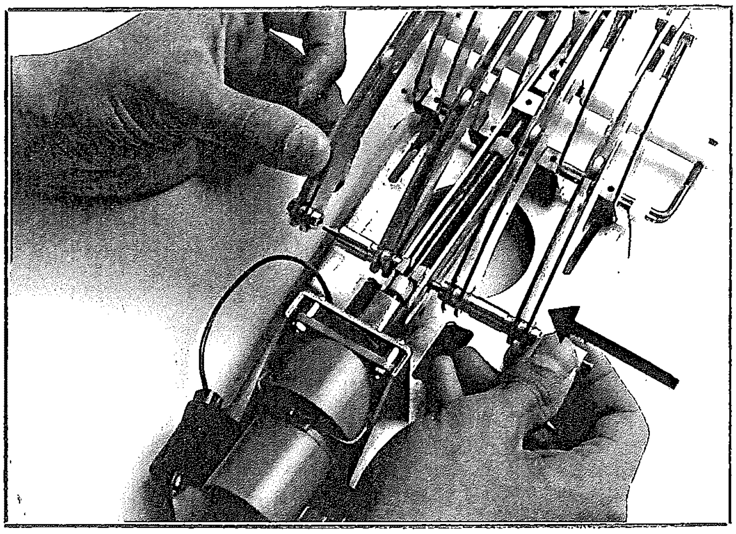
7) Insert the bolt-rod through the next linkage.



8) Insert the bolt-rod through the remaining aluminium spacer.



9) Insert the bolt-rod through the last linkage.



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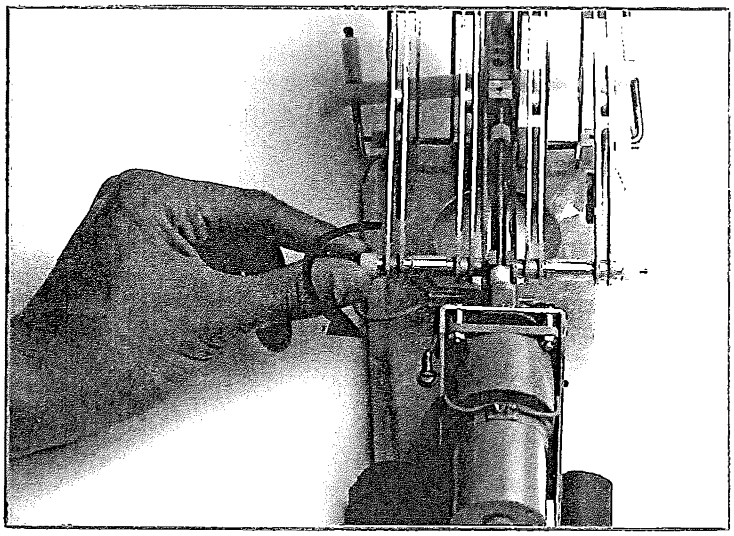
10) Fasten the bolt rod with the remaining plastic nut.

11) Tighten the nut until it stops.



Proceed to the next page.

You have completed the assembly procedure.

Please close the instruction manual.

Testing Procedures

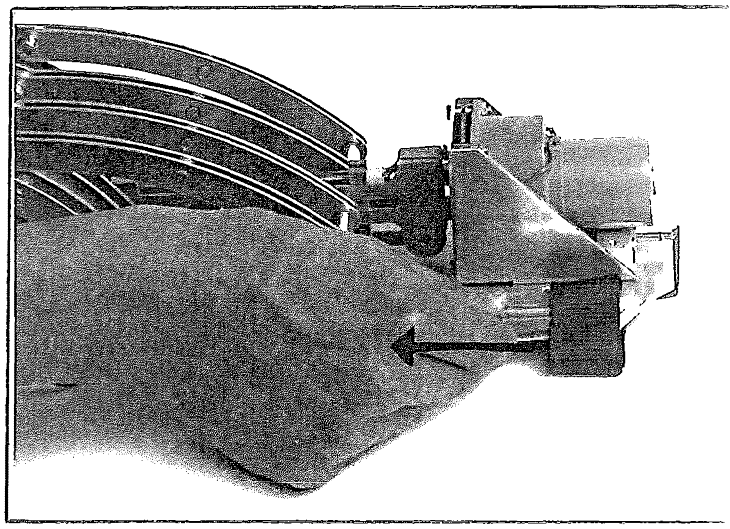
6.0) Testing Procedures

The following procedures allow you to operate and test the finger linkage movements of the CPM unit.

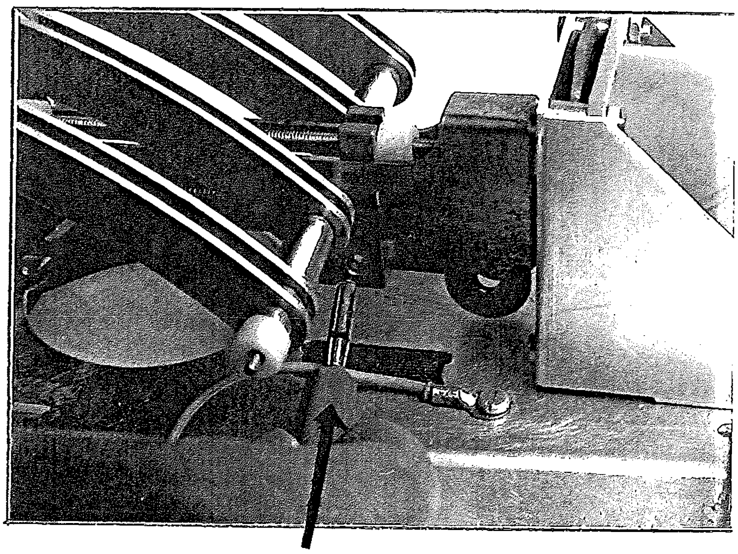
6.1) Inserting the plug into the cursor:

(**Note:** Ensure that the back of the motor unit is facing you).

1) Remove the plug from the velcro strap.



2) Insert the plug through the hole on the cursor up to the black line of the plug.



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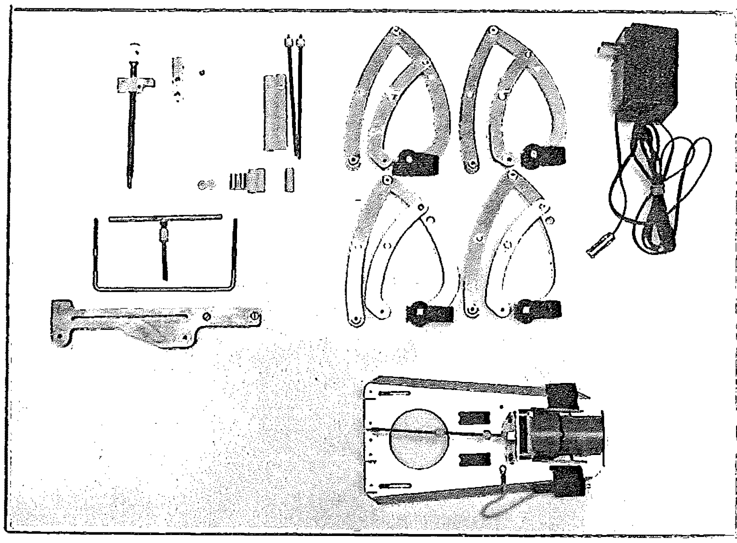
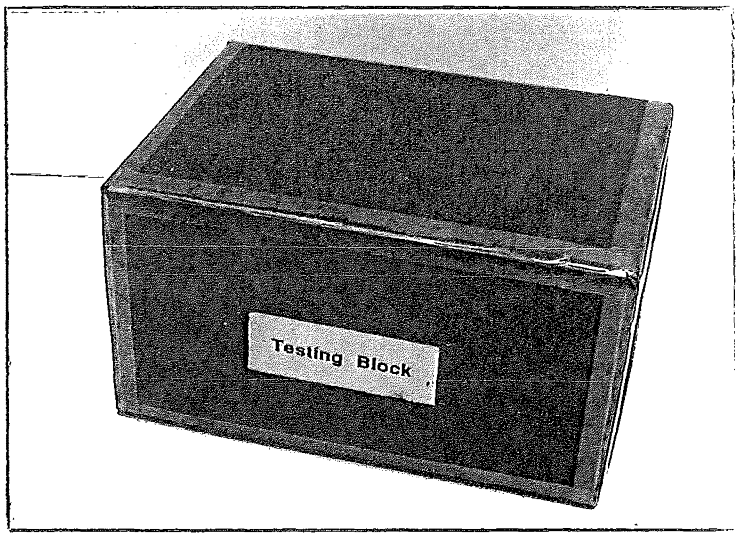
6.2) Testing cursor movement:

1) Select the adapter.



2) Position in front of you the box marked 'TESTING BLOCK'.



(**Note:** The label should be facing you.)

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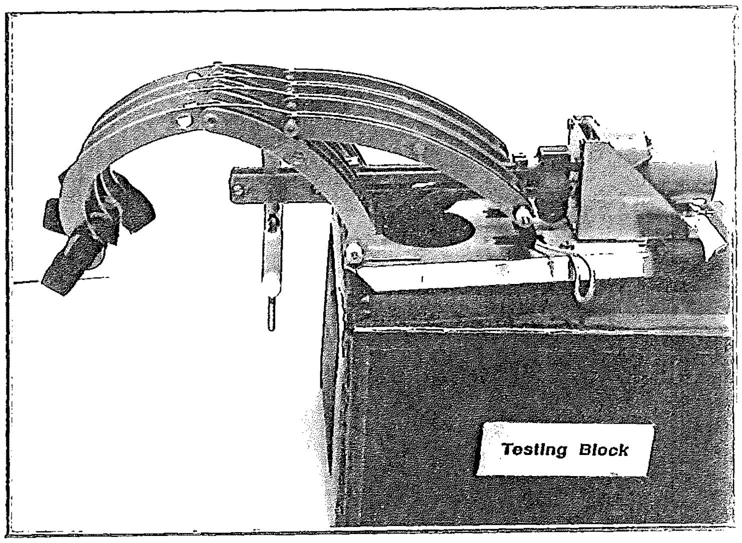
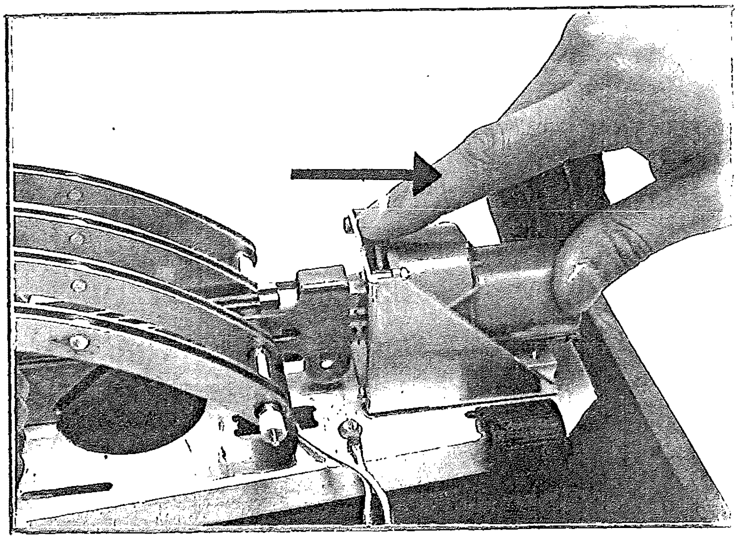
3) Place the CPM unit on top of the testing block and align the front edge of the CPM unit base-plate with the edge of the block.



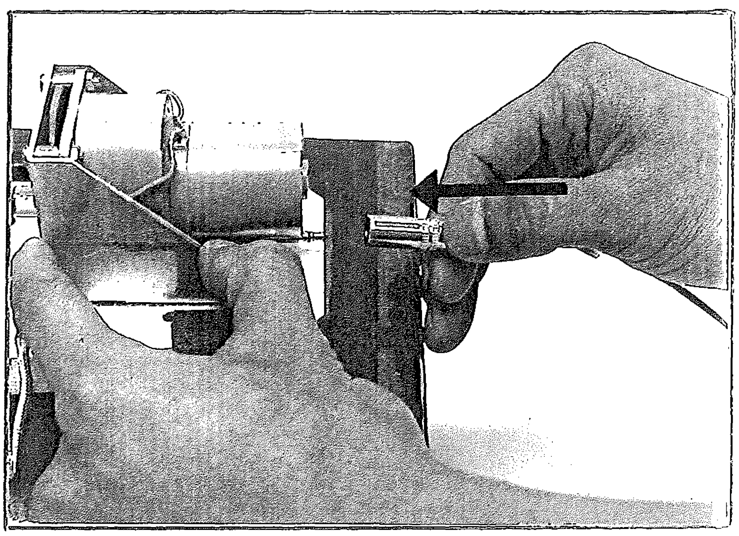
(**Note:** The hand rod should be hanging over the edge of the block.)

4) Pull back the direction switch located at the top of the motor unit until it 'clicks'.



5) With one hand, hold the CPM unit by its motor casing.

6) With your other hand, push the adapter socket into the adapter plug as far as you can (until it 'clicks').



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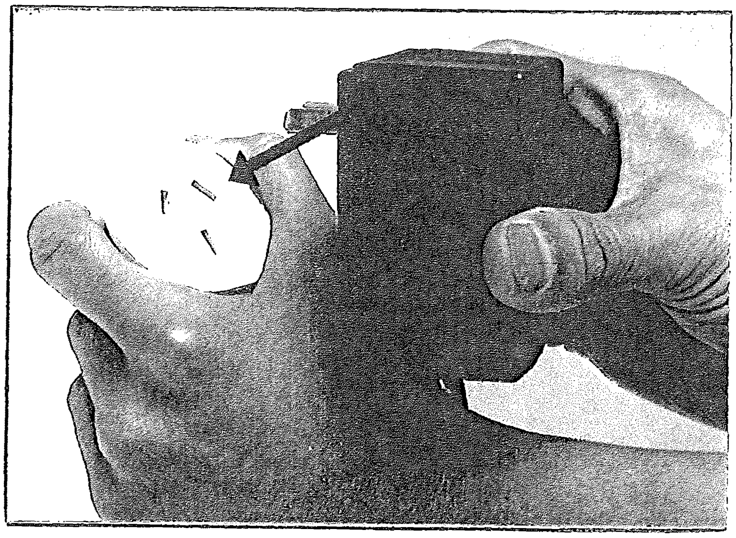
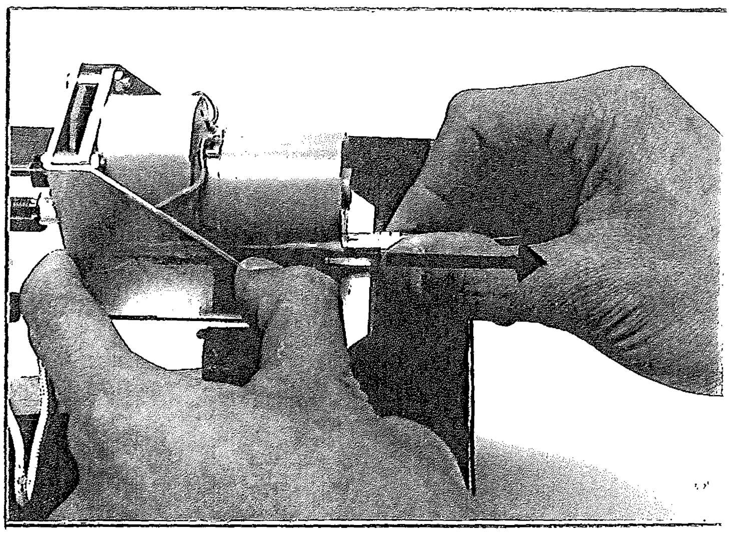
7) Plug the adapter into the extension cord (located on the top right-hand corner of the table.)



(Note: The CPM unit will make a 'roaring' sound as soon as the adapter is plugged into the extension cord.)

The cursor will move forward until it reaches the front (white) plastic nut on the switch rod. The cursor will automatically reverse the motor and move the cursor back towards its original position.

8) Disconnect the adapter socket when the cursor touches the plastic nut on the back end of the switch rod.

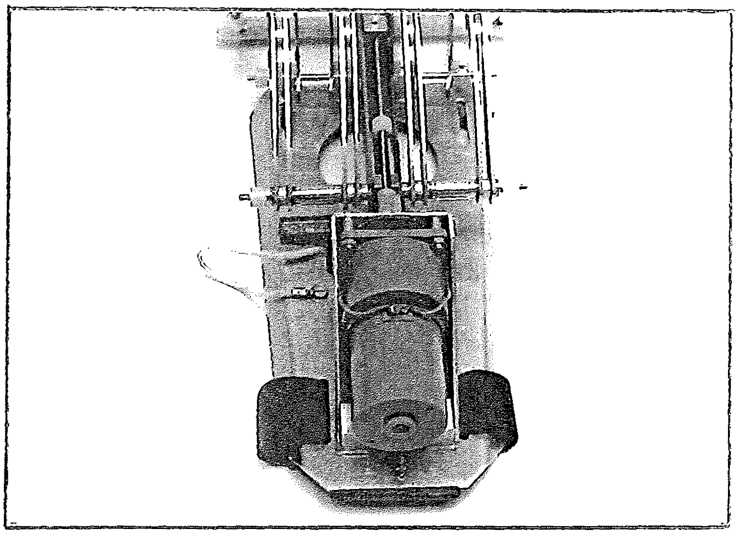


Proceed to the next step.

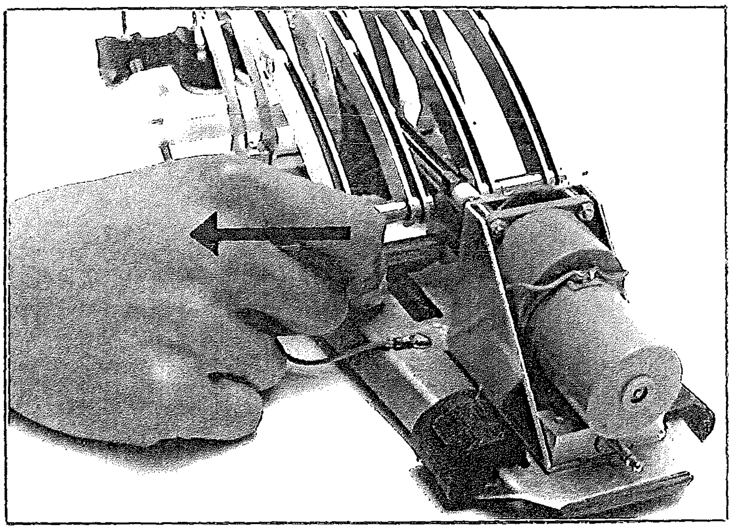
7.0) Test With Plug in Cursor Casing Position

7.1) Inserting plug into the cursor casing:

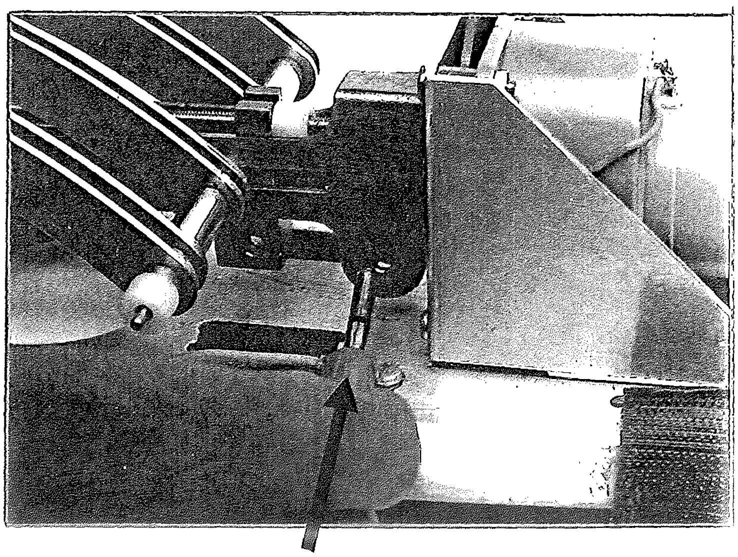
1) Place the CPM unit back on the table so that the back of the motor is facing you.



2) Remove the plug from the cursor.

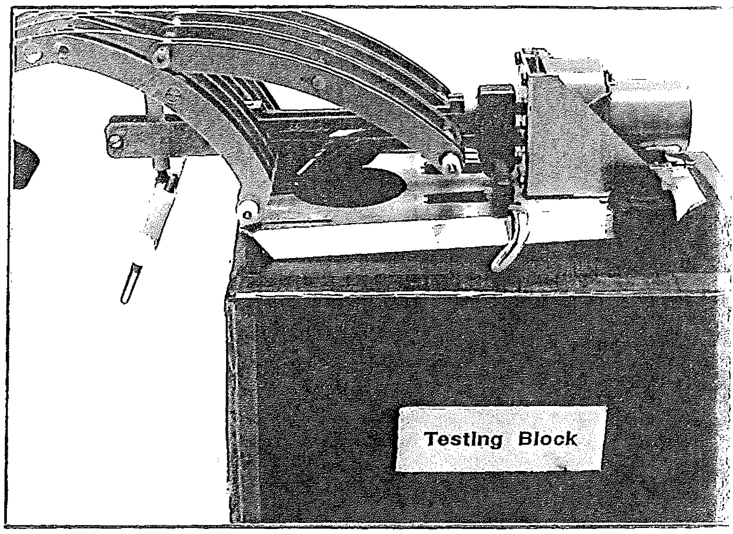


3) Insert the plug through the hole on the back of the cursor casing up to the black line of the plug.



7.2) Testing cursor movement:

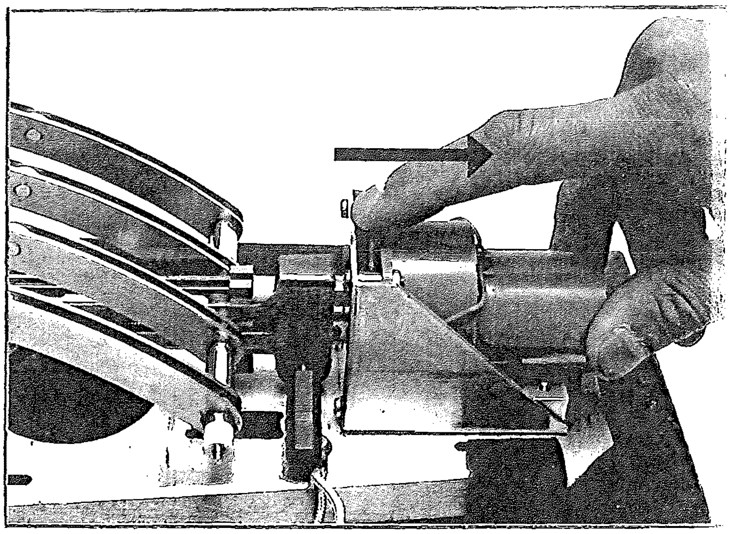
1) Position in front of you the box marked 'TESTING BLOCK'.



2) Place the CPM unit on top of the testing block and align the front edge of the CPM unit base-plate with the edge of the block.

(**Note:** The hand rod should be hanging over the edge of the block.)

3) Pull back the direction switch located at the top of the motor unit until it 'clicks'.



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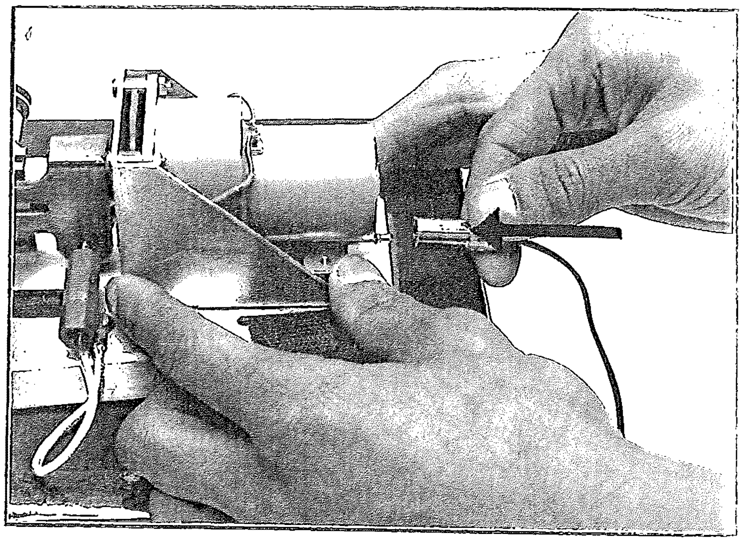
4) With one hand, hold the CPM unit by its motor casing.

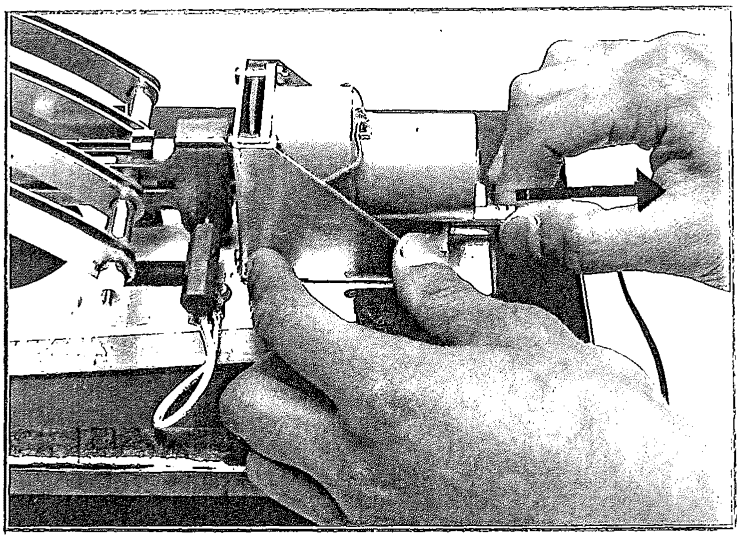
5) With your other hand, push the adapter socket into the adapter plug as far as you can (until it 'clicks').



(**Note:** The CPM unit will make a 'roaring' sound as soon as the adapter socket is pushed into the adapter plug.)

The cursor will move forward until it reaches the front (white) plastic nut on the switch rod. The cursor will automatically reverse the motor and move the cursor back towards its original position.

6) Disconnect the adapter socket when the cursor touches the plastic nut on the back end of the switch rod.



Proceed to the next page.

You have completed the testing procedures.

Please close the instruction manual.

Thank you for your participation.

Appendix 6.

Instruction manual Condition-8.

THE CPM UNIT:

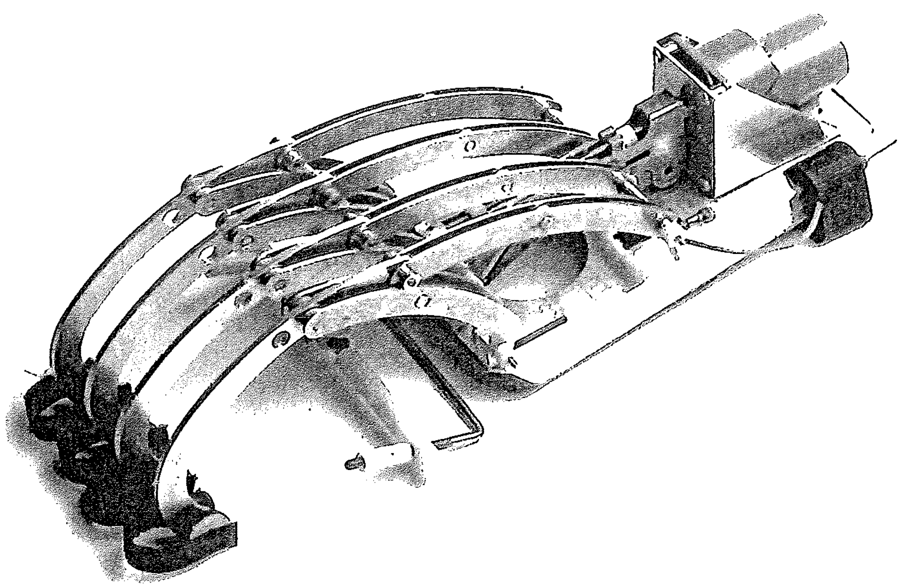
ASSEMBLY AND TESTING INSTRUCTIONS

The CPM Unit

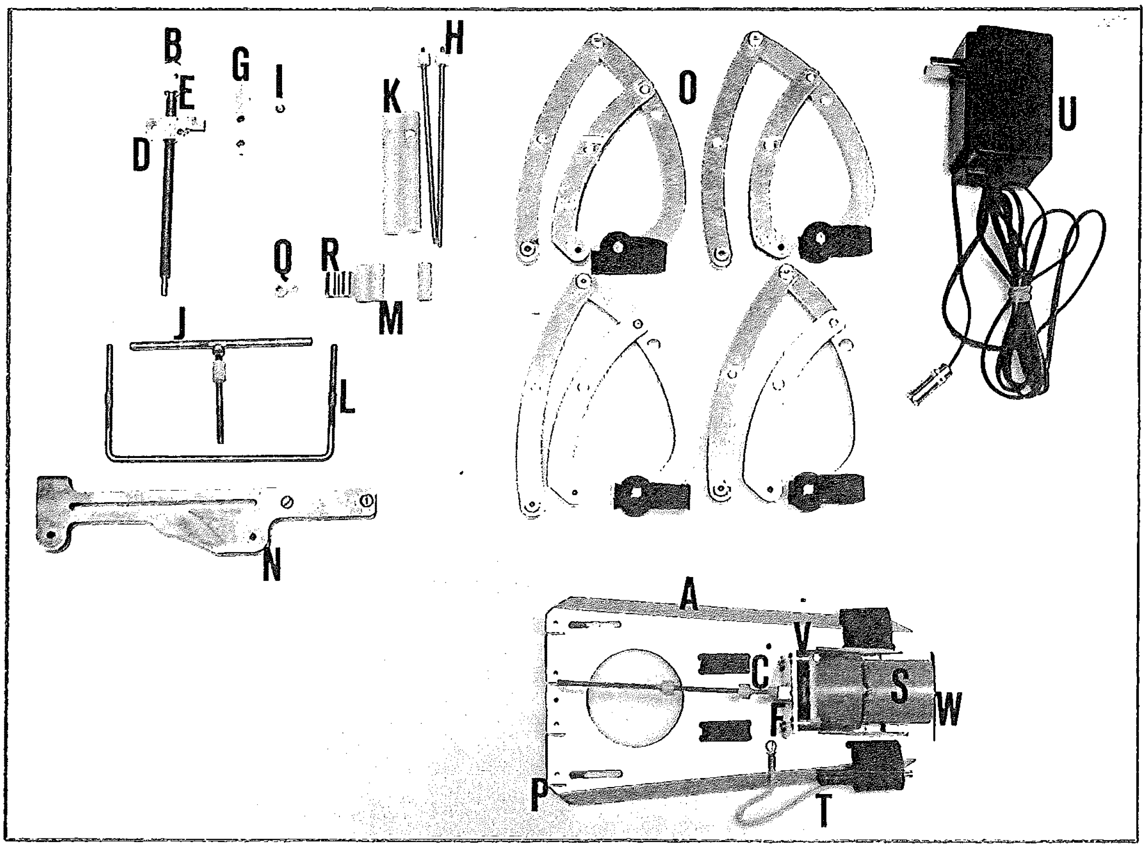
The portable continuous passive motion hand unit (CPM) is an orthopaedic hand exercise unit, designed to help the healing of the hand and/or finger muscles after injury. The lightweight design of the unit means the patient can take the unit home and supervise their own personal therapy for up to 24 hours.

The unit fits comfortably on top of the hand and wrist. It is secured with velcro binding for easy attachment to and release from the fingers and wrist.

A small motor operates the finger linkages of the CPM unit which helps the patient to exercise his/her hand without effort.



Names of CPM Parts



CONTENTS

1.0) Names of CPM Parts

The following names refer to the names of the CPM parts and their location on the CPM unit. The order of presentation corresponds with the order of the procedural steps.

A) **The CPM Base Unit:** The CPM base unit is the largest sub-assembled component made up of an aluminium base-plate, a motor unit, a red plug, and 4 linkage attachment blocks.

B) **The Cursor Shaft:** The cursor shaft is the longest metal rod with a brass block threaded onto it. The cursor shaft is attached to the motor shaft.

C) **The Switch Rod:** The switch rod is the brass rod with 2 short plastic nuts threaded onto it. The switch rod is attached to the motor unit.

D) **The Cursor:** The cursor is the brass block with 2 holes and a groove. The cursor is threaded onto the cursor shaft.

E) **The Allen Screw:** The Allen screw is the screw threaded into the white portion of the cursor shaft.

F) **The Motor Shaft:** The motor shaft is the small metal rod protruding from the motor unit.

G) **The Cursor-Shaft-Block:** The cursor-shaft-block is the long rectangular, aluminium block with holes on it. The cursor-shaft-block is fastened onto the CPM unit base-plate.

H) **The Bolt Rod:** The bolt rod is the long brass rod with a short plastic nut threaded onto it. The bolt rod secures the finger linkages onto the CPM unit.

I) **The screw:** The screw is the smallest un-assembled CPM component. The screw secures the cursor-shaft-block onto the CPM unit base-plate.

Proceed to the next page.

J) **The T-Bar:** The T-bar is the metal component which represents the alphabetical letter 'T', a short plastic nut is threaded onto it. The T-bar is a sub-part of the hand rod unit fastened onto the cursor casing.

K) **The Plastic Sleeves:** The plastic sleeves are the longest plastic component of the CPM parts. Each plastic sleeve is partially hollow with a hole on one end. The plastic sleeves are a sub-part of the hand rod unit slotted onto the T-bar.

L) **The U-Bar:** The U-bar is the metal component which represents a very wide alphabetical letter 'U'. The U-bar is a sub-part of the hand rod unit and is fastened to the T-bar.

M) **The Long Plastic Nut:** The long plastic nut is the longest nut of the CPM parts. It is a sub-part of the hand rod unit which secures the U-bar to the T-bar.

N) **The Cursor Casing:** The cursor casing is the largest metal component of the CPM parts. The cursor casing is an aluminium block with 6 holes fixed between the metal at the front-end, with gaps in the mid-section and one hole at the back-end of the metal part. The cursor casing encases the cursor and the cursor-shaft-block.

O) **The Finger Linkages:** The finger linkages are the 3-pronged aluminium objects with a black velcro strip fastened at the front-end. The finger linkages are attached to the CPM base unit in 2 places: 1) the 4 linkage attachment blocks, 2) the cursor.

P) **The Attachment Blocks:** The attachment blocks are the 4 short aluminium blocks secured onto the front-end of the CPM unit base-plate.

Q) **The Plastic Nut:** The plastic nut is the shortest plastic component of the CPM parts. The nut secures the bolt rods attaching the finger linkages to the attachment blocks and the cursor.

R) **The Aluminium Spacer:** The aluminium spacer is the hollow, pipe-like aluminium component of the CPM parts. The aluminium spacer is slotted onto the bolt rod between the back finger linkage attachments.

Proceed to the next page.

S) **The Motor Unit:** The motor unit is the sub-assembled component secured to the back-end of the CPM unit base-plate.

T) **The Plug:** The (red) plug is attached to the black velcro strap located at the back-end of the CPM base unit.

U) **The Adapter:** The adapter is the black 'cubical' object with a silver socket attached to the black cord.

V) **The Direction Switch:** The direction switch is the brown PC board located on the top of the motor unit.

W) **The Adapter Plug:** The adapter plug is the silver metal rod that protrudes from the back end of the motor unit.

Proceed to the next page.

Assembly and Testing Procedure Instructions

All the parts and tools you will need to assemble and operate the CPM unit are in front of you.

1) Perform the task as accurately and as fast as you can.

2) Please follow the procedures and notes in a step-by-step manner

3) Please close the instruction manual.

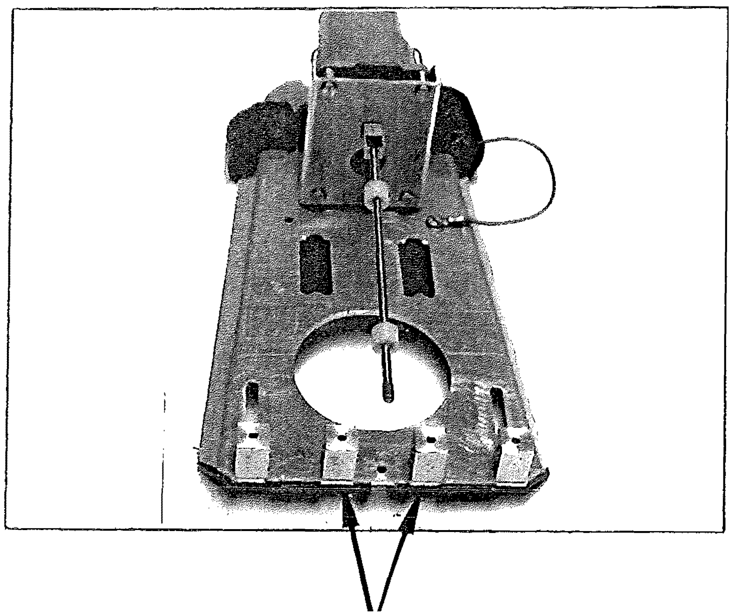
Assembly Procedures

2.0) Cursor Shaft Assembly

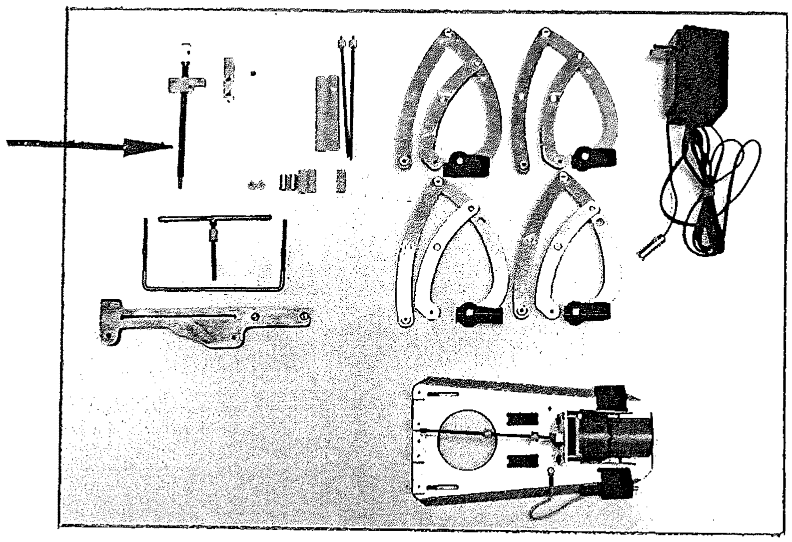
The cursor shaft is the metal shaft which is threaded through the cursor. When the motor is operating, the cursor allows for forward and backward motion of the finger linkages.

2.1) Positioning the cursor shaft into the motor shaft:

1) Position the CPM base unit so that the 4 linkage attachment blocks are facing you.



2) Select the cursor shaft.



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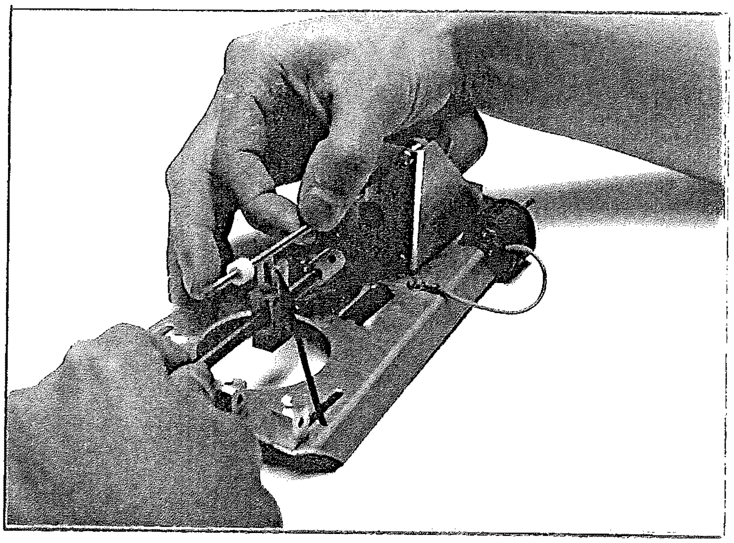
3) With one hand, lift the switch rod.

4) With your other hand, position the cursor shaft below the switch rod.

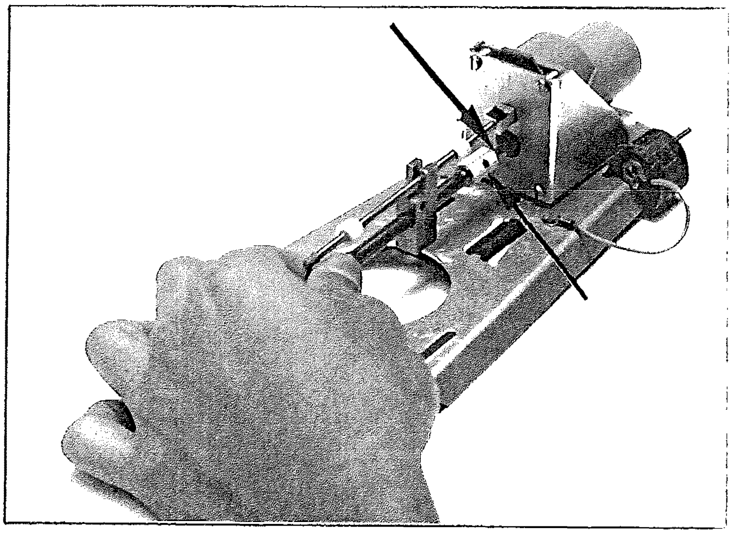
5) Place the switch rod in the groove of the cursor.



(**Note:** The cursor should be positioned between the 2 plastic nuts.)

6) Turn the cursor shaft so that the Allen screw is aligned with the flat side of the motor shaft.

7) Insert the cursor shaft into the motor shaft as far as you can.



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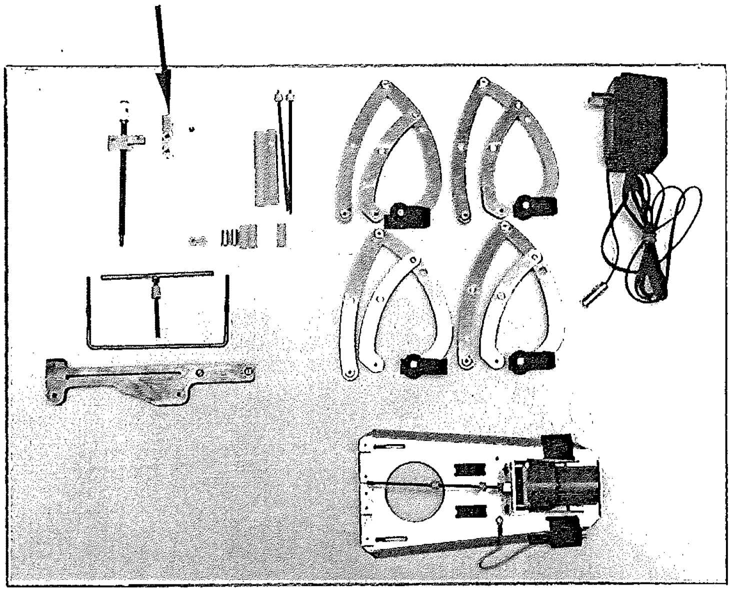
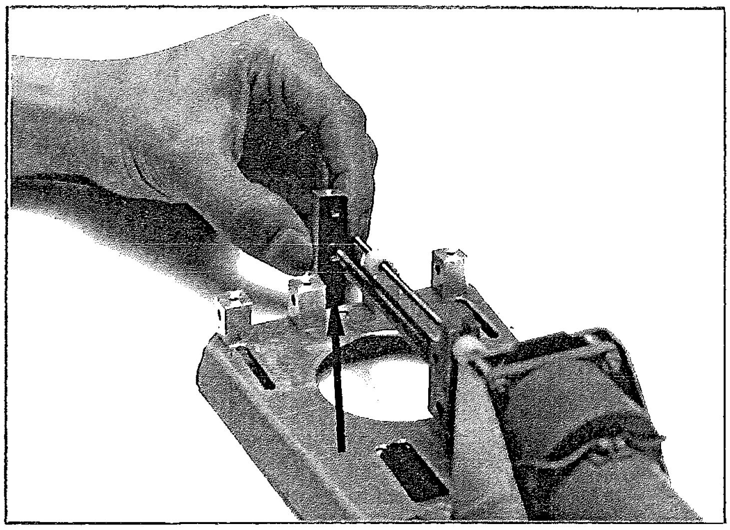
2.2) Mounting the cursor-shaft-block onto the CPM base unit:

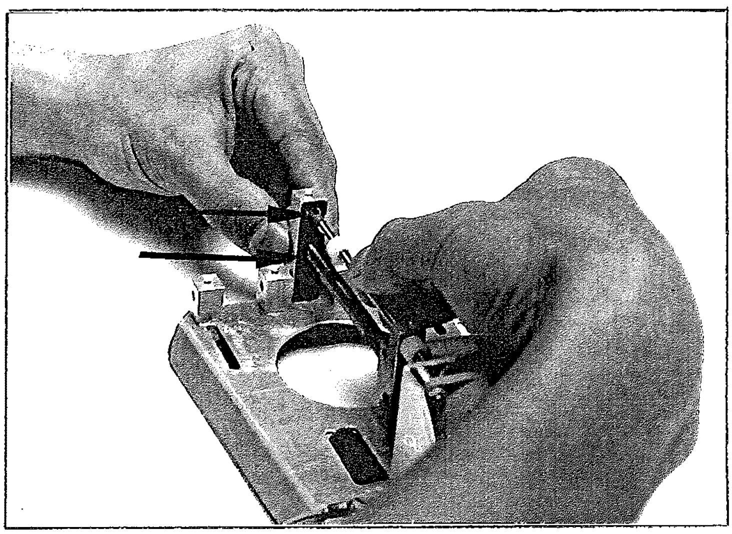
1) Select the cursor-shaft-block.



2) Hold the cursor-shaft-block so that the black side is facing the motor unit.



3) At the same time, slot the hole located in the middle of the cursor-shaft-block into the cursor shaft and the top hole into the switch rod.



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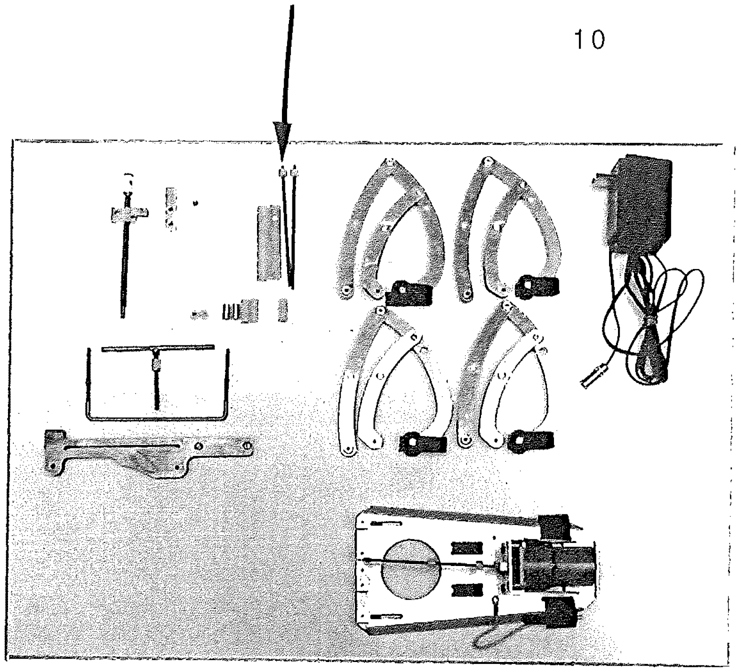
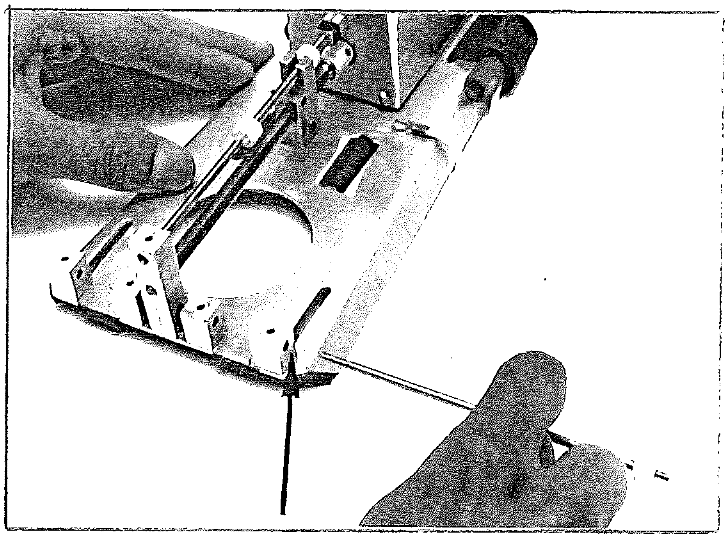
4) Select one of the bolt rods.



5) Starting from the right-most attachment block, insert the bolt rod through the side holes of the linkage attachment block.



(**Note:** The bolt rod should slide through the 4 attachment blocks and the cursor-shaft-block.)

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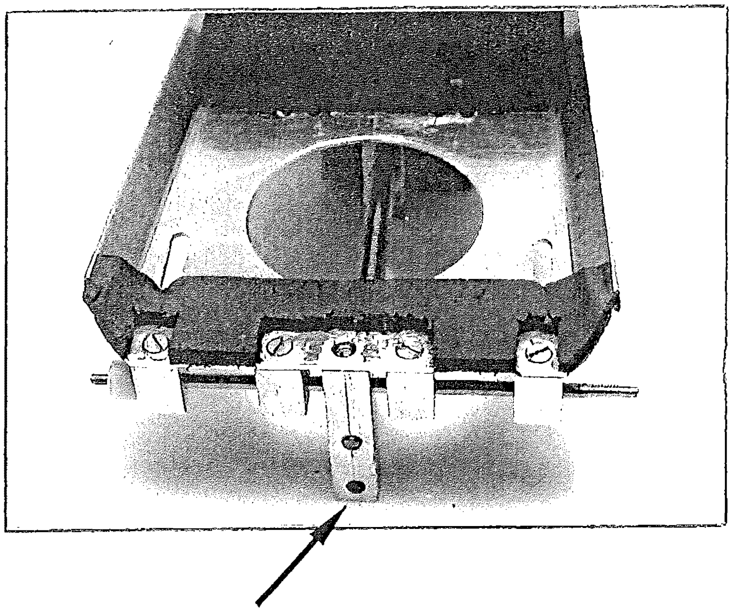
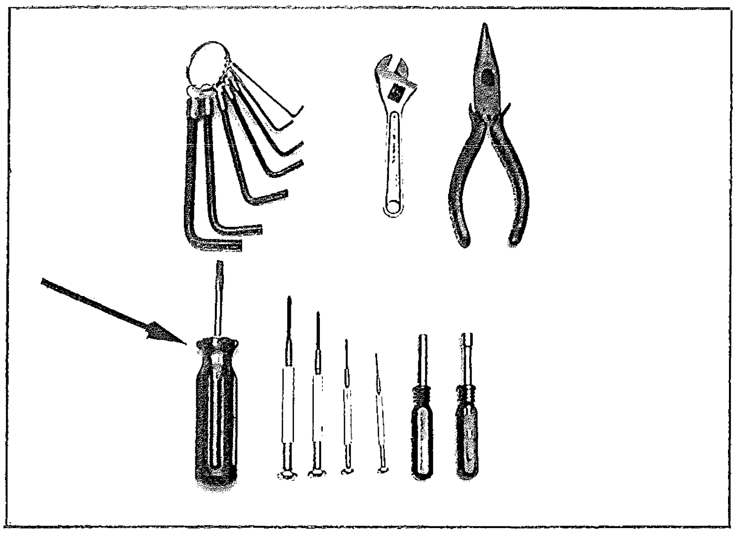
6) Turn the CPM unit over and rest the unit on the table.

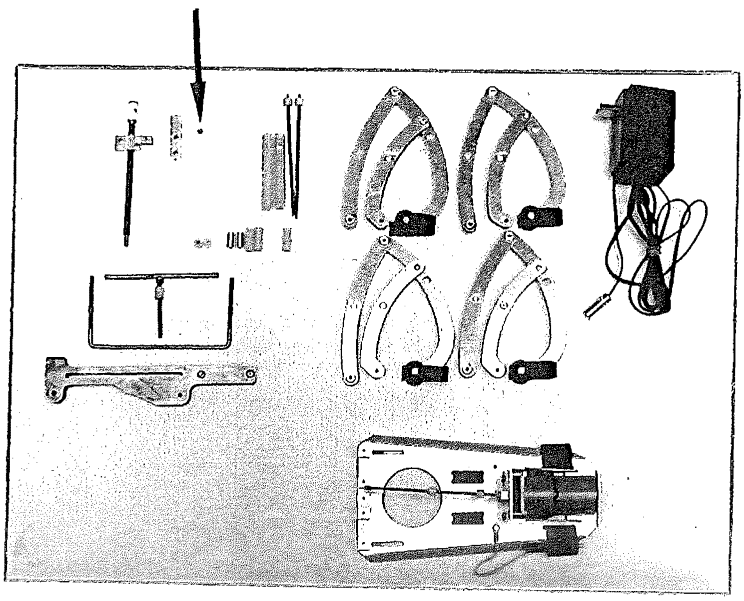


(**Note:** The cursor-shaft-block should be positioned upright, touching the table.)

7) Select a standard screwdriver.



8) Select the screw.



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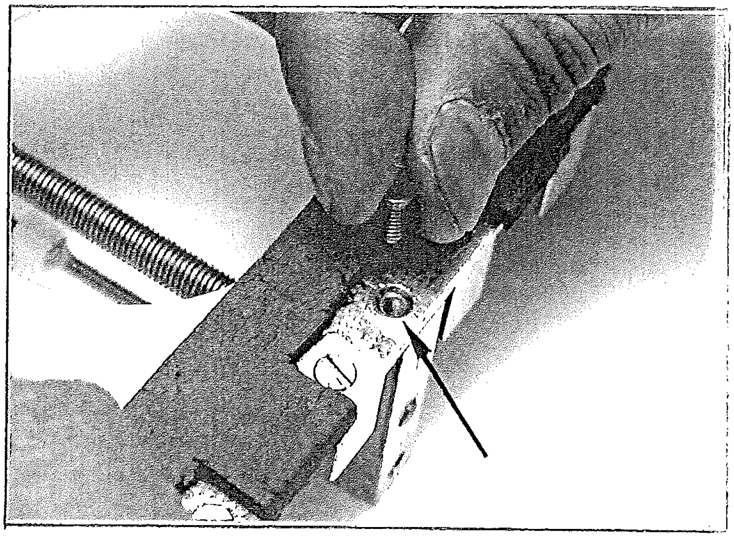
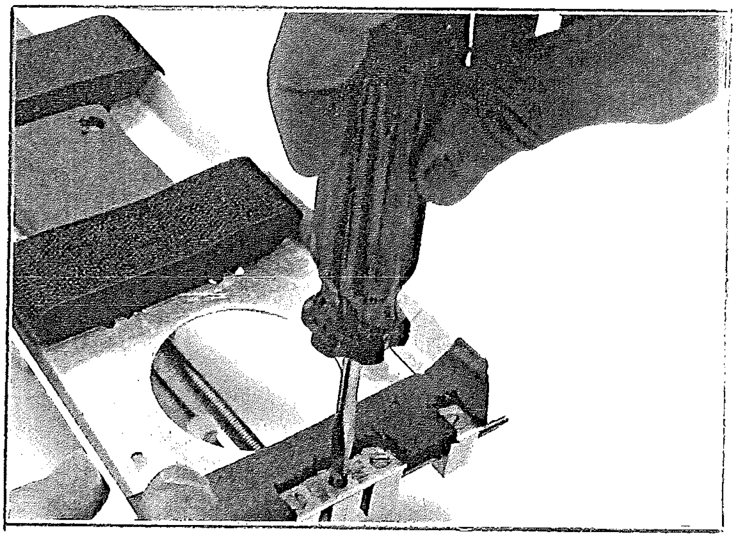
9) Hold the CPM unit firmly and ensure that the cursor-shaft-block is touching the table.

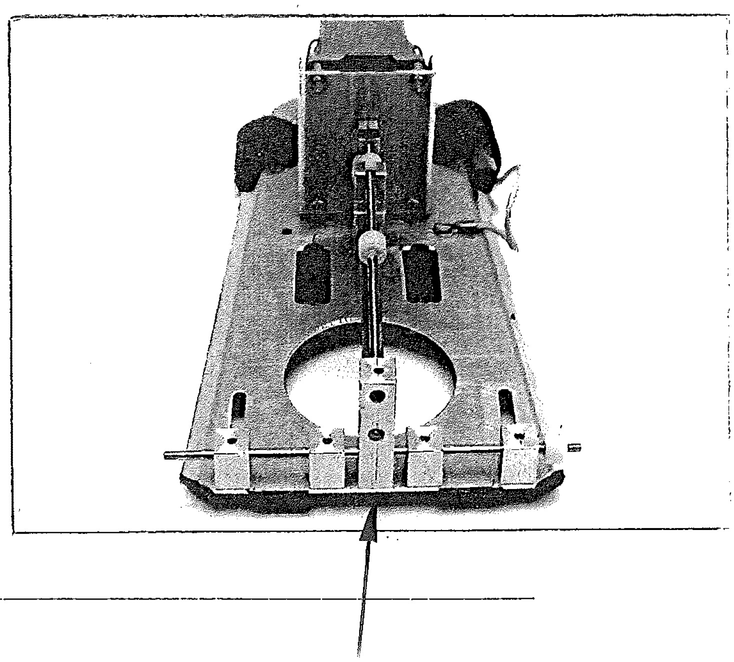
10) With the screw, secure the cursor-shaft-block to the CPM unit base-plate.



11) Using the screwdriver, tighten the screw.



12) Turn the unit back over and position the CPM base unit so that the 4 attachment blocks are facing you.



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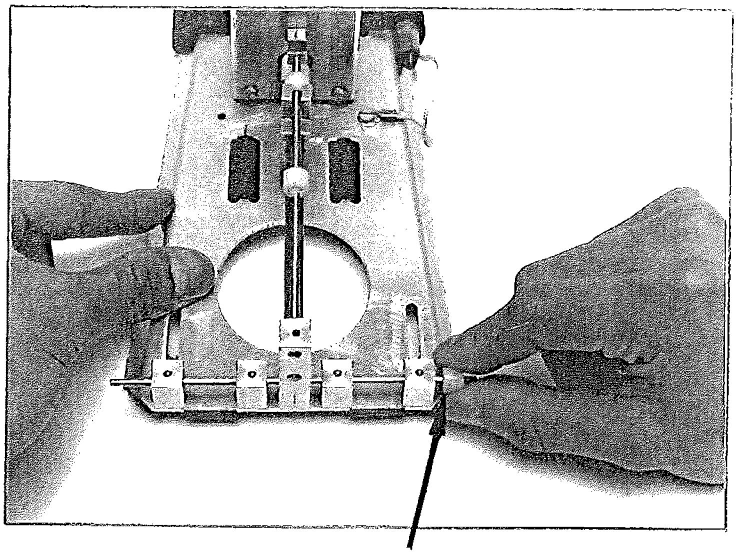
13) Remove the bolt rod from the attachment blocks.



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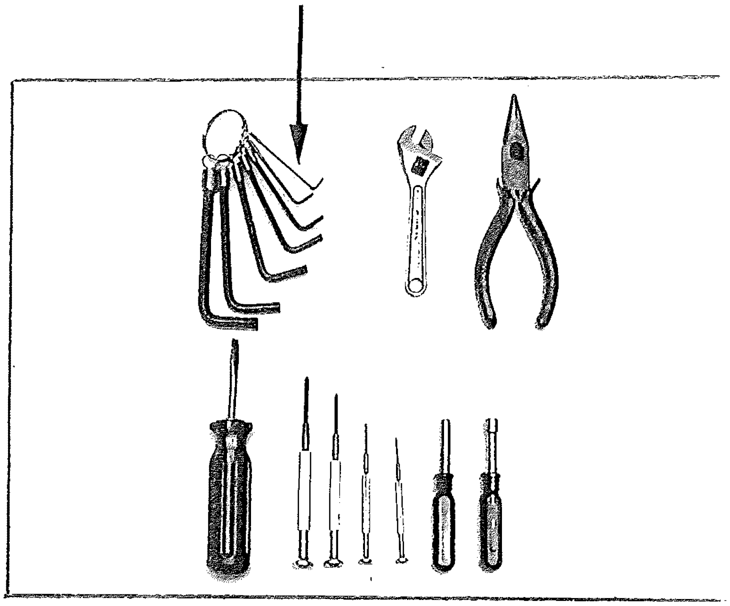
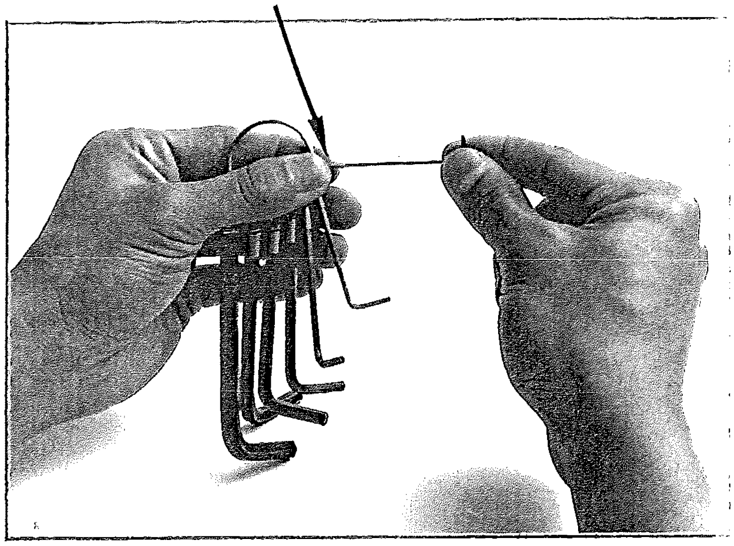
2.3) Removing the Allen key from its holder:

1) Select the Allen keys and locate the 1mm. Allen key.



2) With one hand, hold the spring-like holder.

3) With your other hand, pull the 1mm. Allen key from the spring-like holder.



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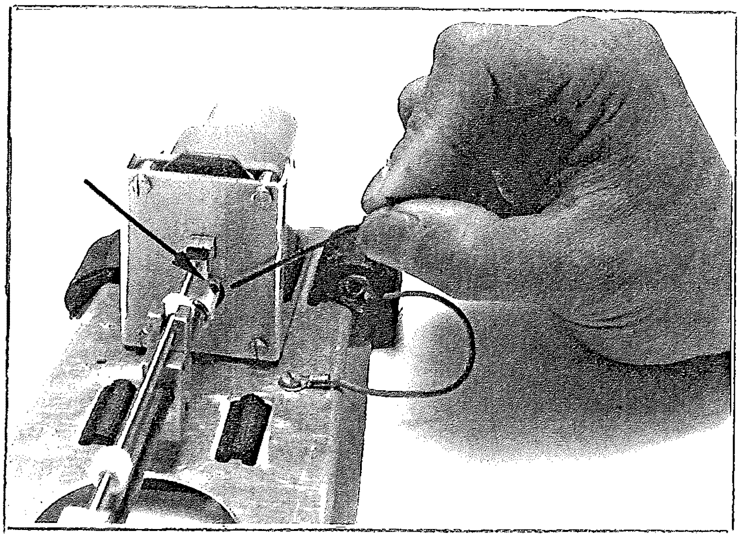
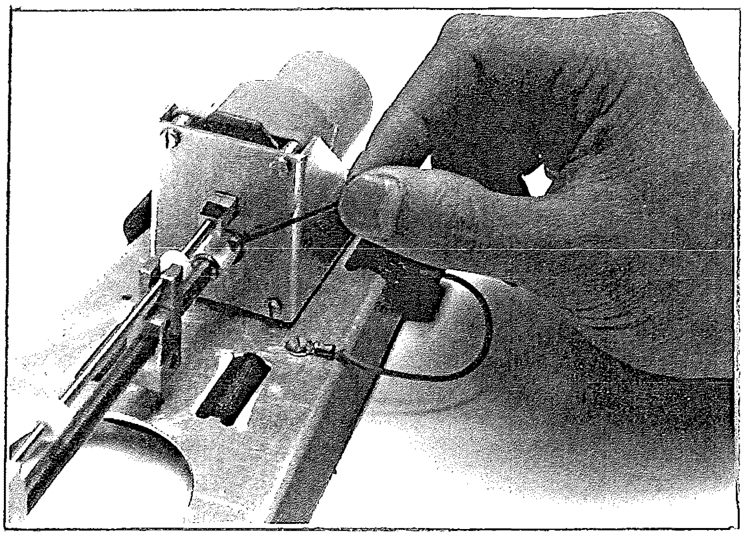
2.4) Tightening Allen Screw:

1) Slot the long-end of the Allen key into the Allen screw.



2) Tighten the Allen screw.



You have finished the cursor shaft assembly.

Proceed to the next step.

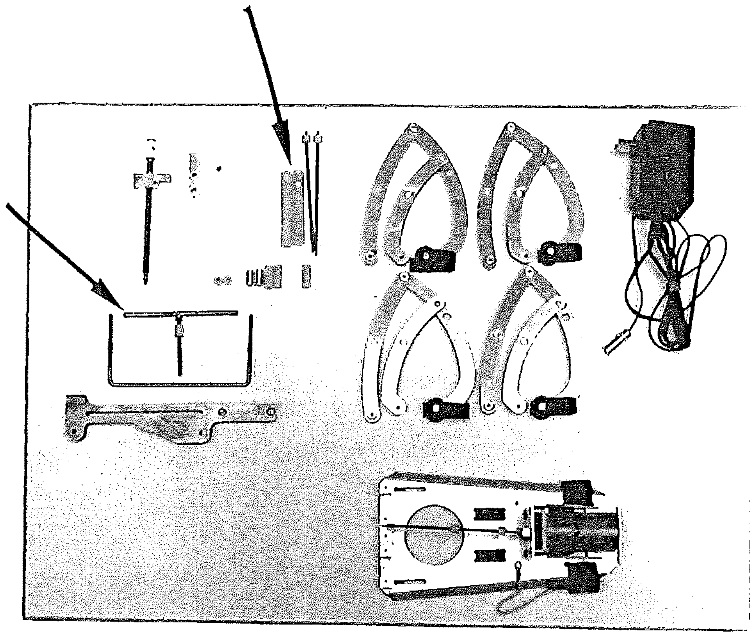
3.0) Hand Rod Assembly

The hand rod functions as a hand rest which supports the patient's hand while the hand and/or finger muscles are being exercised.

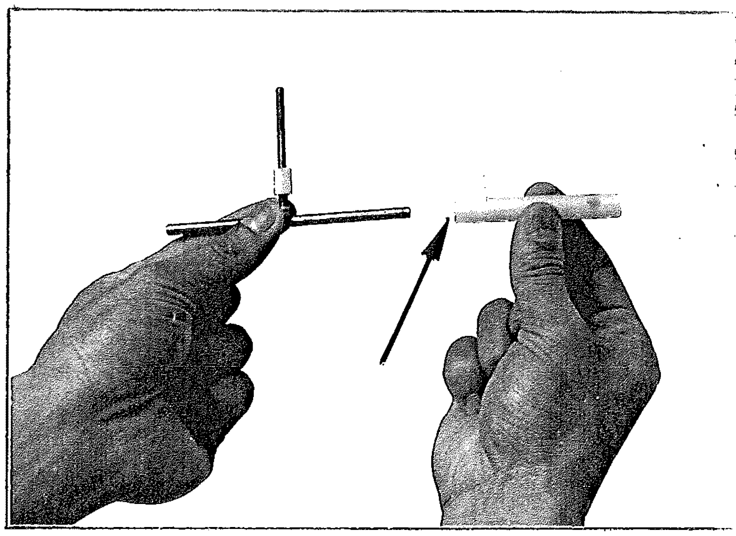
3.1) Hand rod assembly:

1) Select the T-bar.

2) Select the 2 plastic sleeves.



3) Slide the length of the 2 plastic sleeves onto the T-bar.



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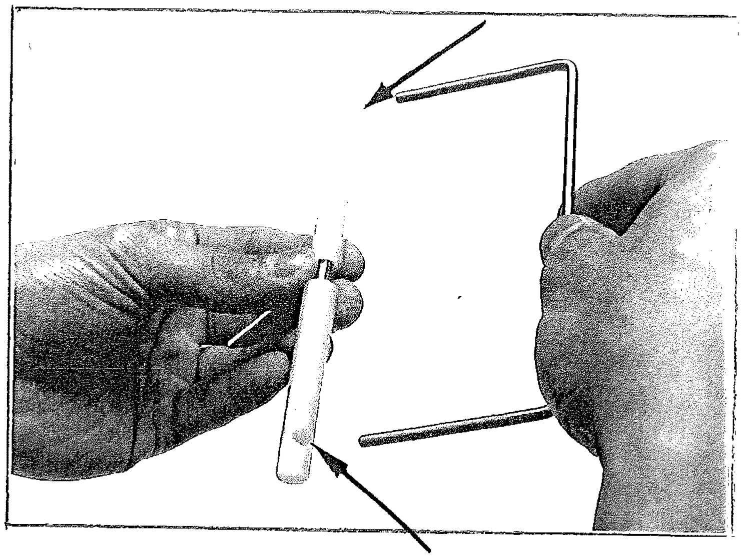
4) Hold the T-bar so that it represents the alphabetical letter 'T'.

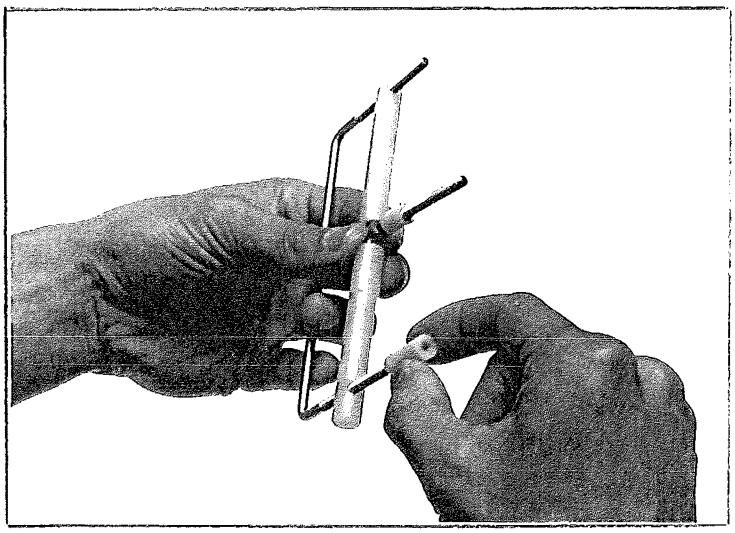
5) Position the U-bar above the T-bar.

6) Slot both ends of the U-bar into the holes on the plastic sleeves.



7) Secure the U-bar onto the T-bar with a long plastic nut at each end.

8) Tighten both nuts until they stop.



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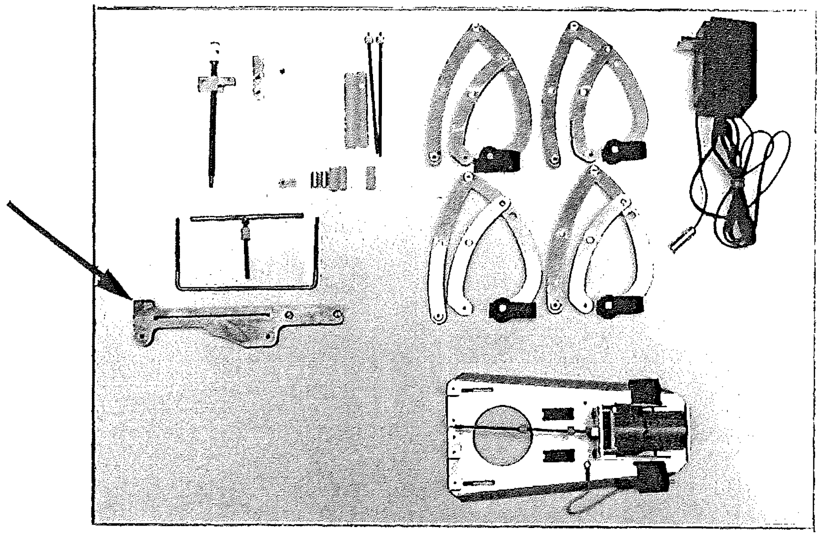
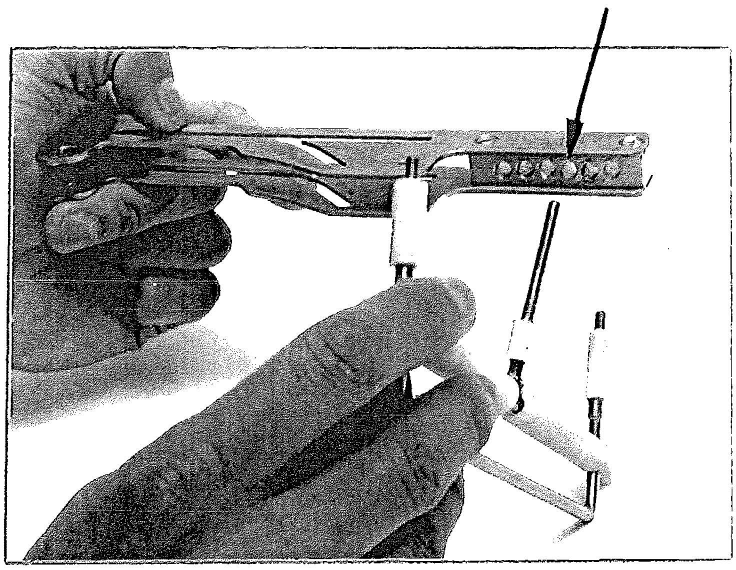
3.2) Fastening hand rod onto cursor casing:

1) Select the cursor casing.





2) With one hand, hold the cursor casing so that the straightest edge of the cursor casing is on top.

3) With your other hand, position the T-bar underneath the cursor casing.

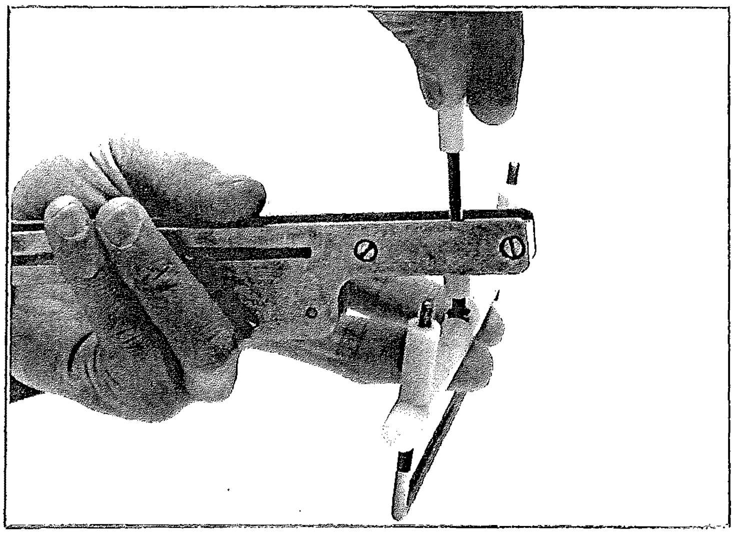
4) Insert the T-bar of the hand rod into the 3rd hole from the front of the cursor casing.

(**Note:** The T-bar should be positioned at a 'cross-angle' with the cursor casing.)

Proceed to the next page.

5) Fasten the T-bar in place with the remaining long plastic nut.

6) Tighten the nut until it stops.



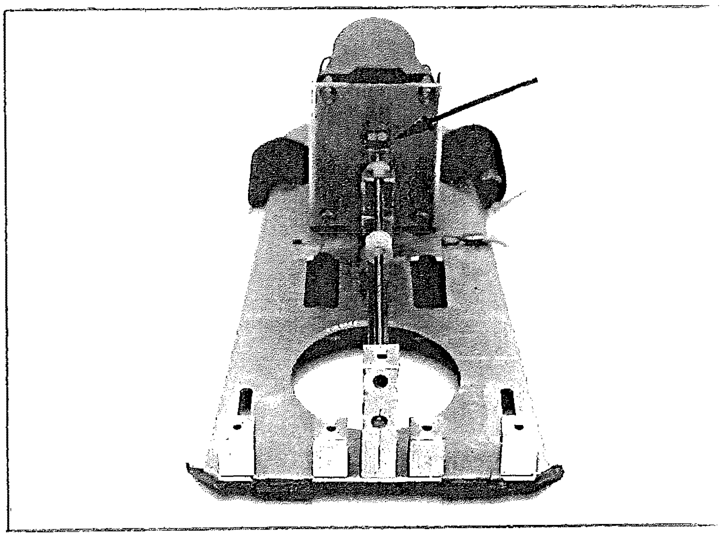
You have finished the hand rod assembly.

Proceed to the next step.

4.0) Cursor Casing Assembly

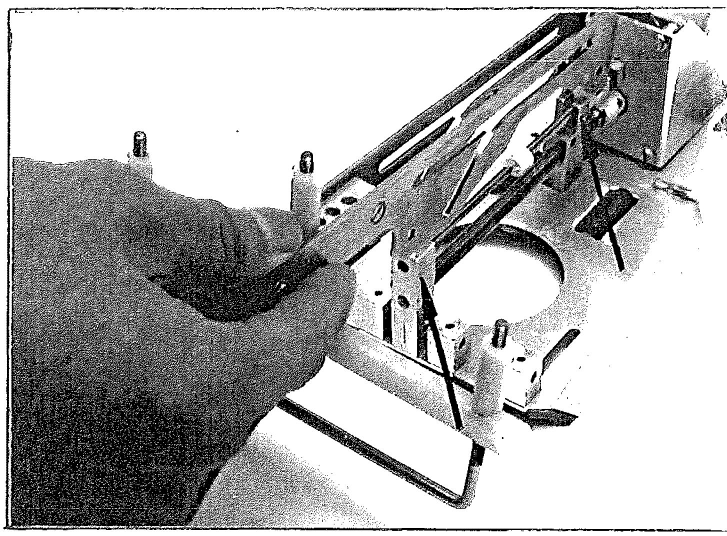
The cursor casing functions as a guide rail for the cursor which ensures the correct movement of the finger linkages.

1) Locate the black square of the aluminium block (connected to the switch rod).



2) Hold the cursor casing so that the straightest edge of the cursor casing is on top.

3) Slot the cursor casing onto the cursor-shaft-block and the cursor.



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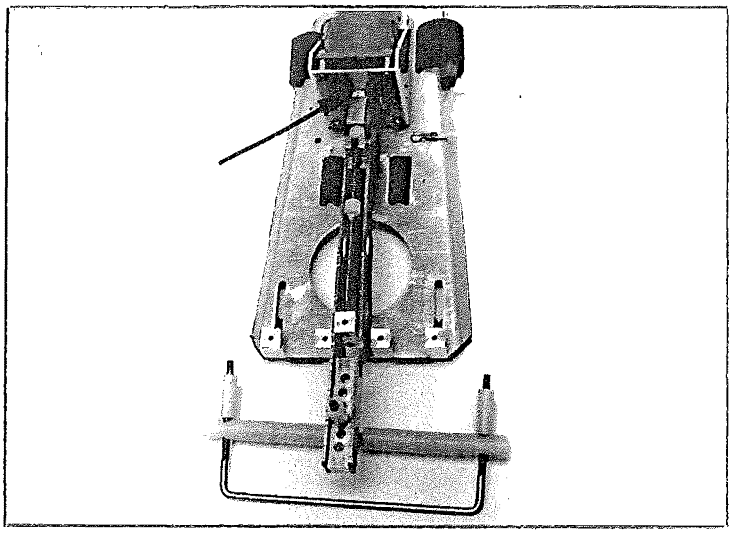
4) Align the back of the cursor casing so that it covers the black square of the aluminium block, leaving a gap between the cursor casing and the motor casing.



(**Note:** This will allow for easier assembly of the finger linkages.)

You have finished the cursor casing assembly.

Proceed to the next step.

5.0) Finger Linkage Assembly

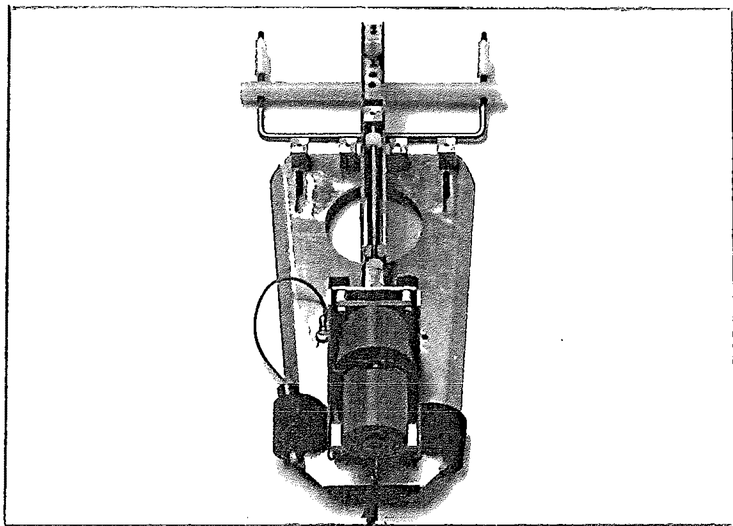
The finger linkages are attached to the CPM base unit in 2 places:

1) The linkage attachment blocks located at the front of the CPM unit base-plate.

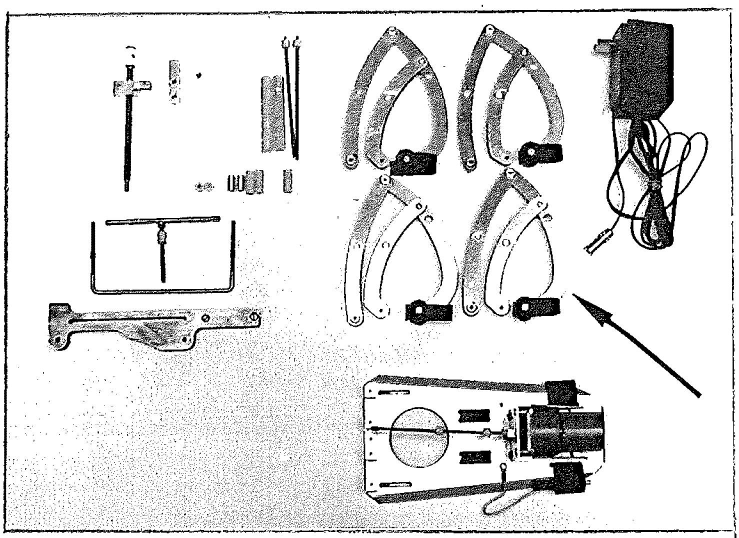
2) The cursor.

5.1) Fastening the (front) finger linkage attachment to the blocks:

1) Position the CPM base unit so that the back of the motor faces towards you.



2) Select one of the finger linkages.



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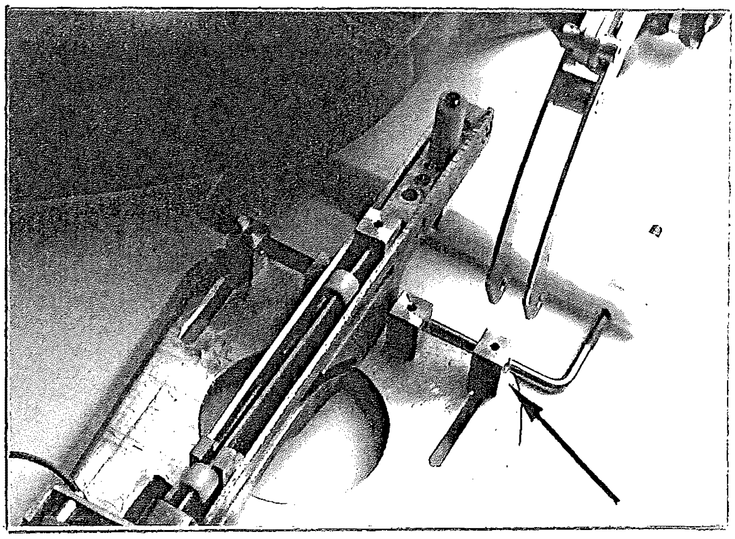
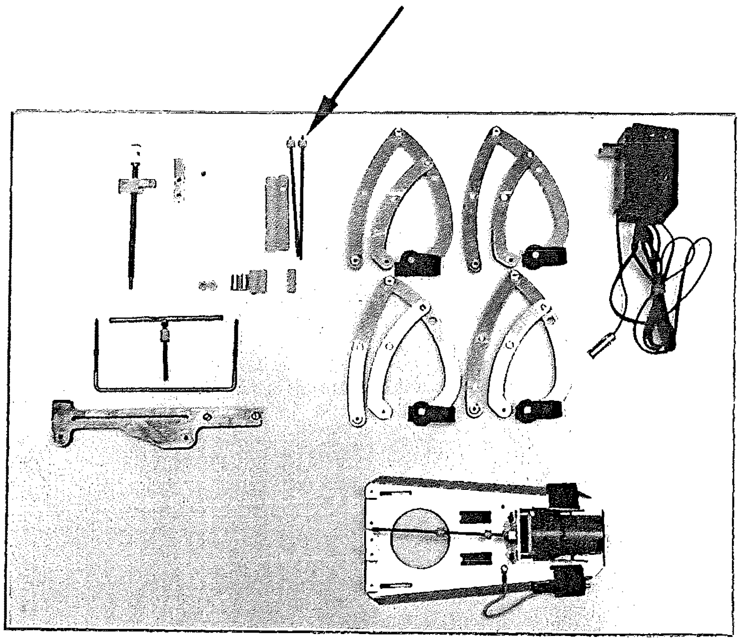
4) Slot the front finger linkage attachment onto the 1st attachment block,located at the right front of the CPM unit.



(**Note:** a) The velcro strip should be positioned in front of the hand rod.

b) The back linkage attachment should be positioned behind the attachment block.)

5) Select one of the bolt rods.



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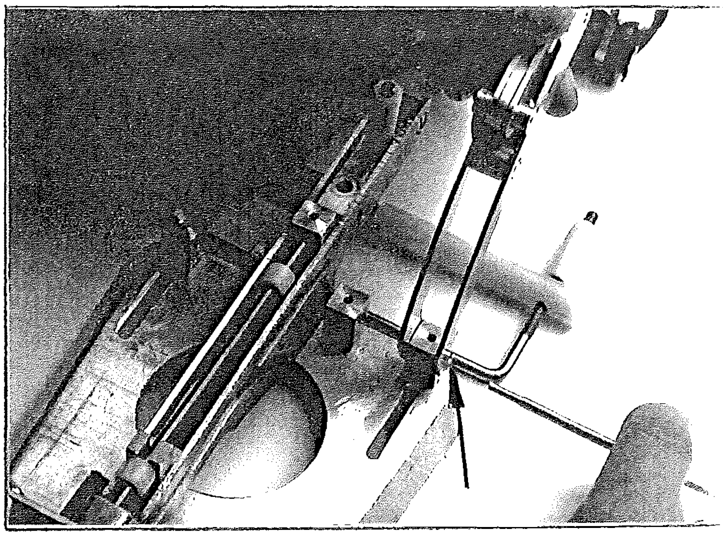
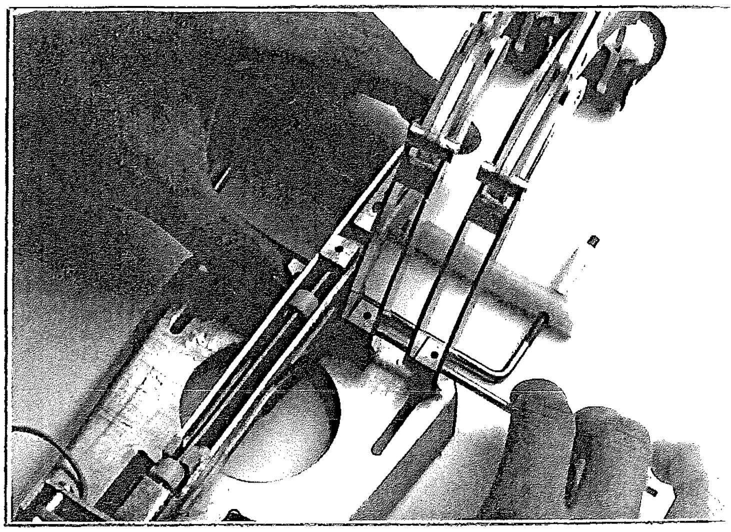
6) Insert the bolt-rod through the hole on the side of the front linkage until it protrudes slightly on the other side of the 1st linkage.

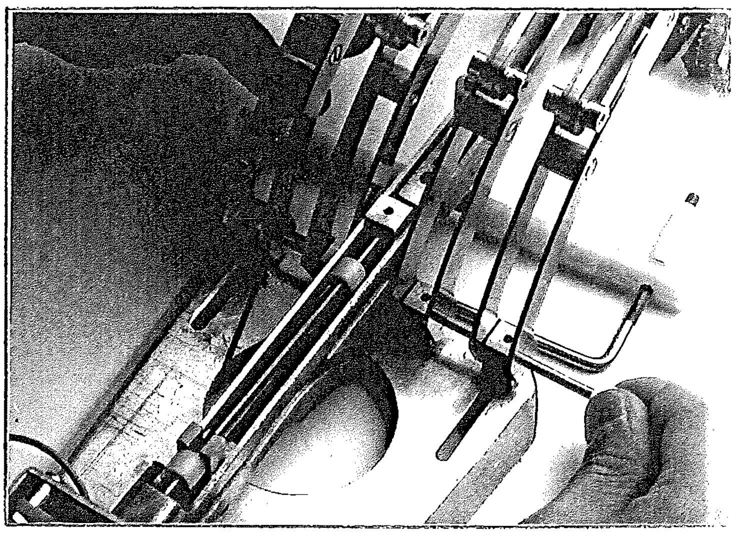


7) Slot a 2nd linkage onto the next block.

8) Push the cursor casing slowly towards the motor at the same time you are inserting the bolt-rod through the 2nd linkage.



9) Continue to fasten the remaining 3rd and 4th linkages.



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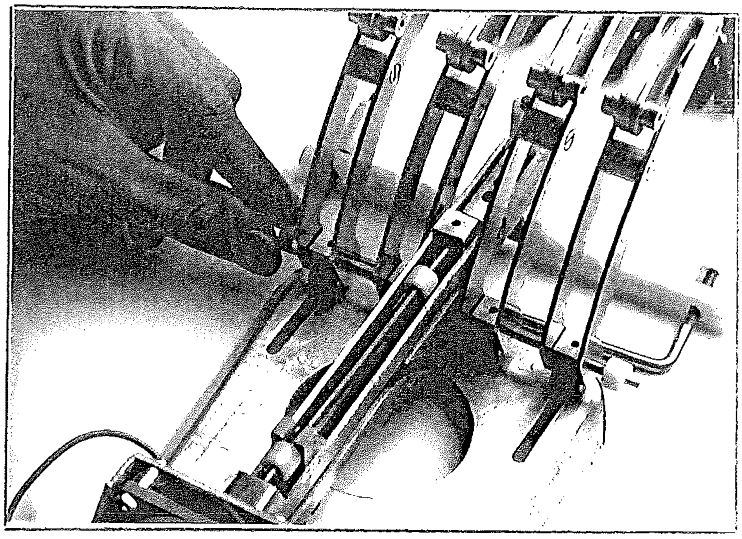
10) Fasten the bolt-rod with one of the plastic nuts.

11) Tighten the nut until it stops.



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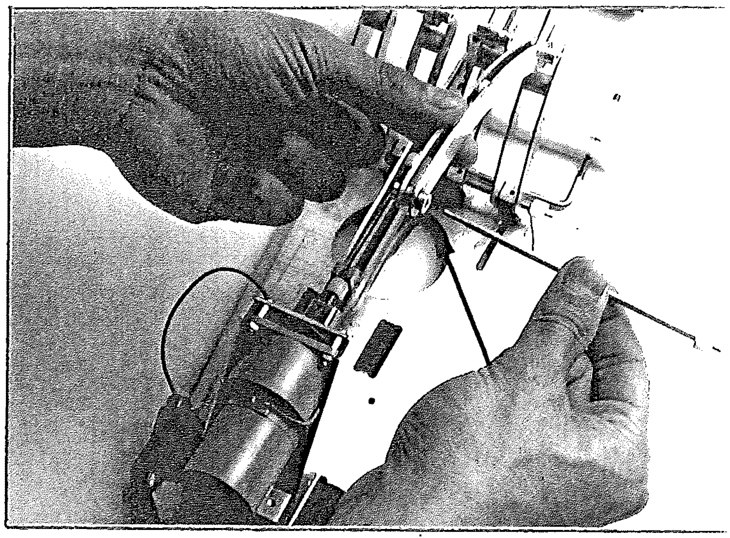
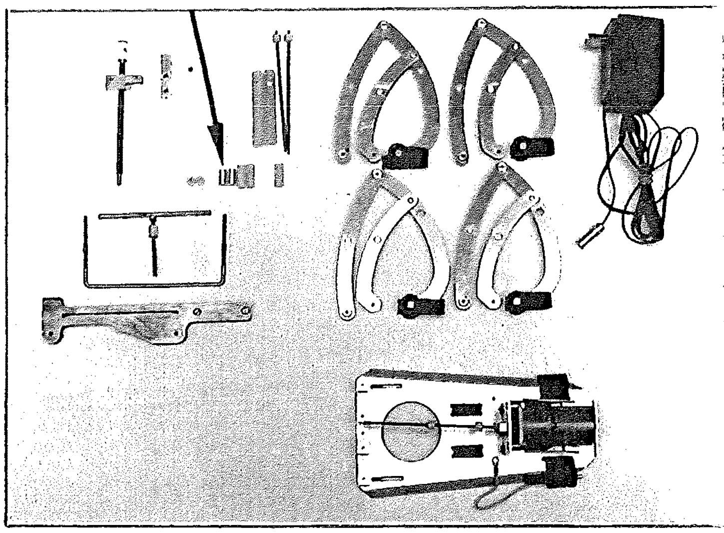
5.2) Fastening the (back) finger linkage attachment to the cursor:

(**Note:** Begin with the right-most finger linkage.)

1) Insert the bolt-rod through the hole at the back-end of the linkage.



2) Select one of the aluminium spacers.



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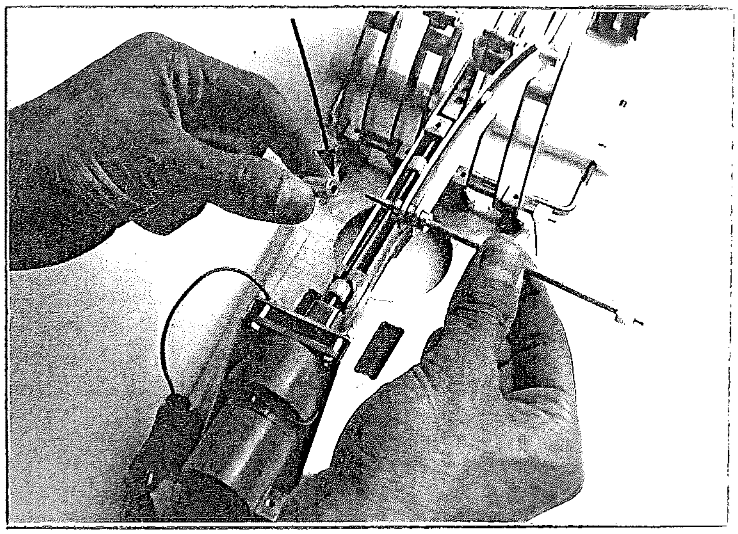
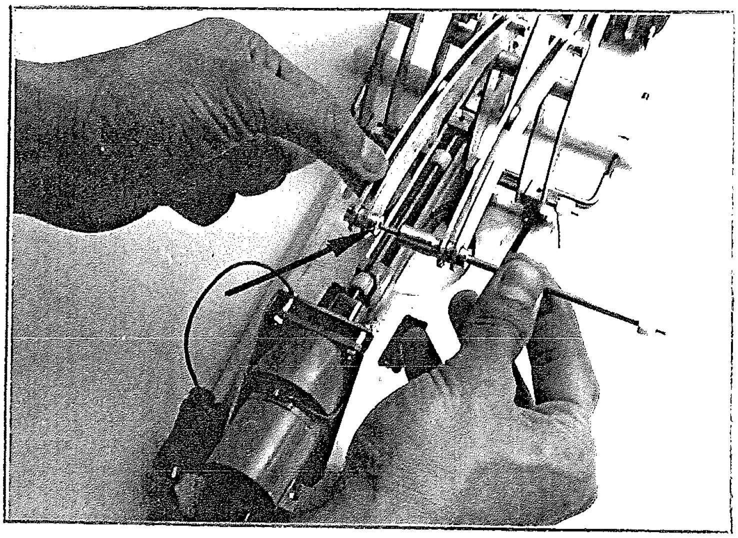
3) Insert the bolt-rod through the aluminium spacer.

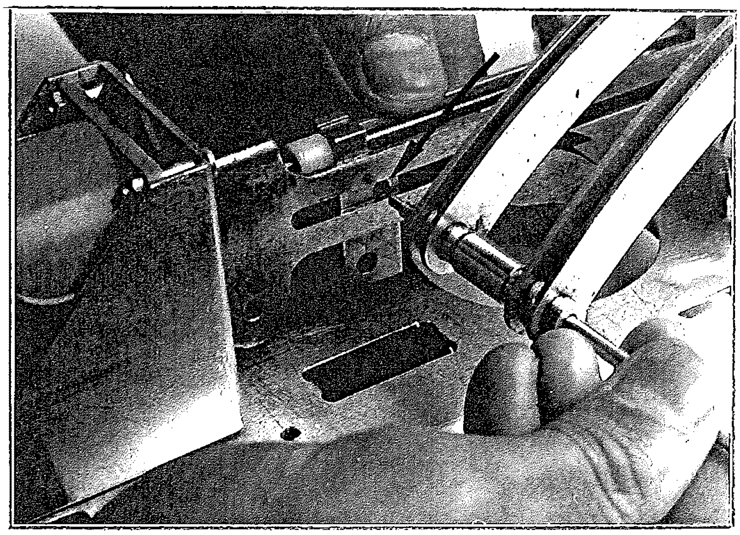


4) Insert the bolt-rod through the hole of the next linkage.



5) Lift the cursor casing slightly and hold it in a position where you can see a 2nd hole on the cursor.

6) Insert the bolt-rod through (both) the gap on the cursor casing and the 2nd hole on the cursor.



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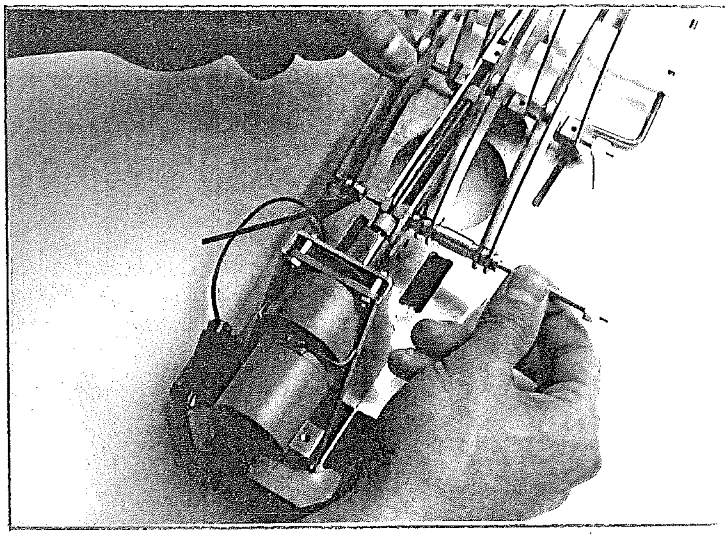
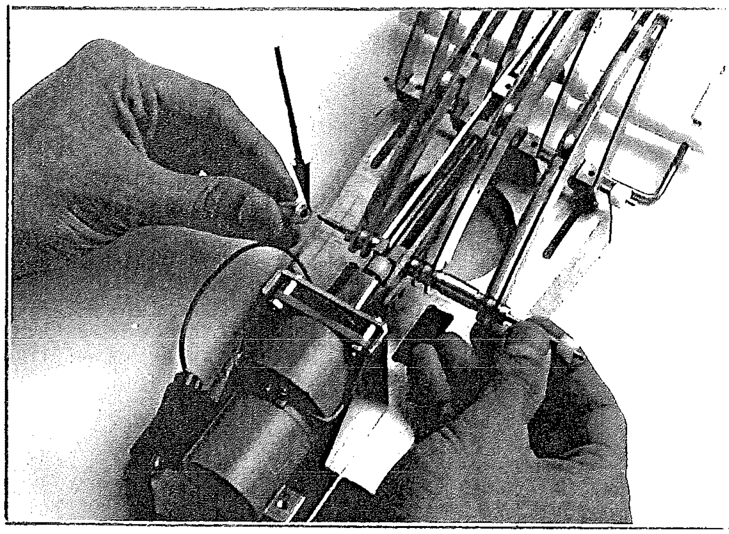
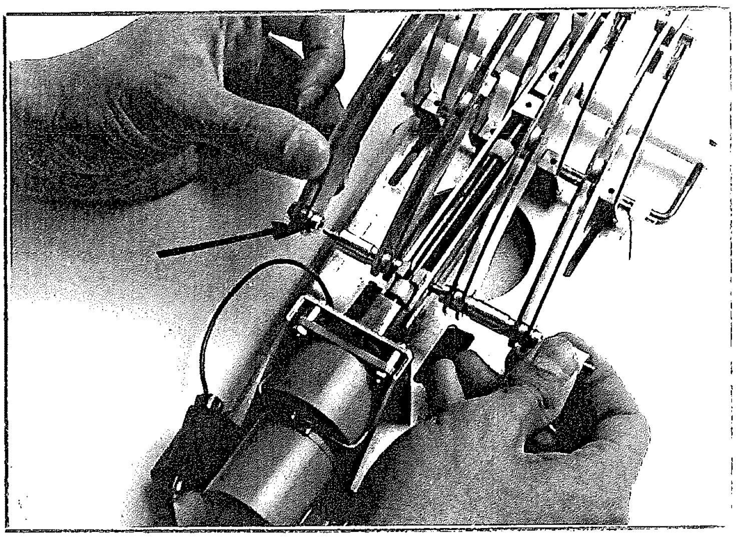
7) Insert the bolt-rod through the next linkage.



8) Insert the bolt-rod through the remaining aluminium spacer.



9) Insert the bolt-rod through the last linkage.



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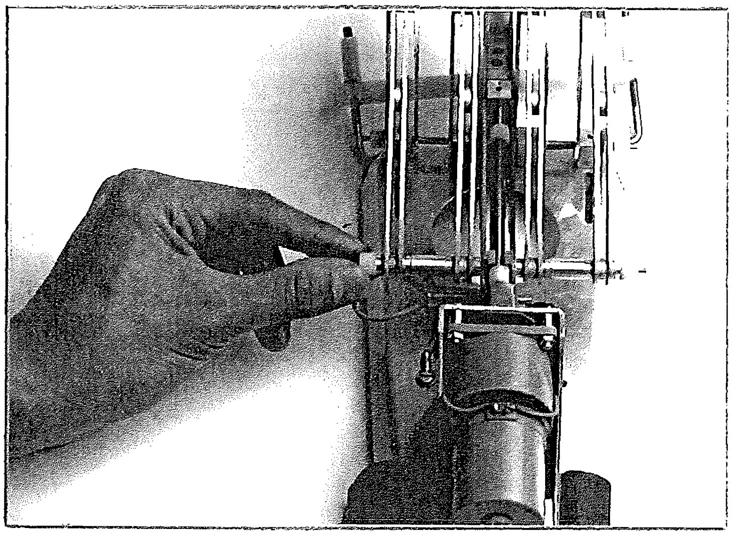
10) Fasten the bolt rod with the remaining plastic nut.

11) Tighten the nut until it stops.



Proceed to the next page.

You have completed the assembly procedure.

Please close the instruction manual.

Testing Procedures

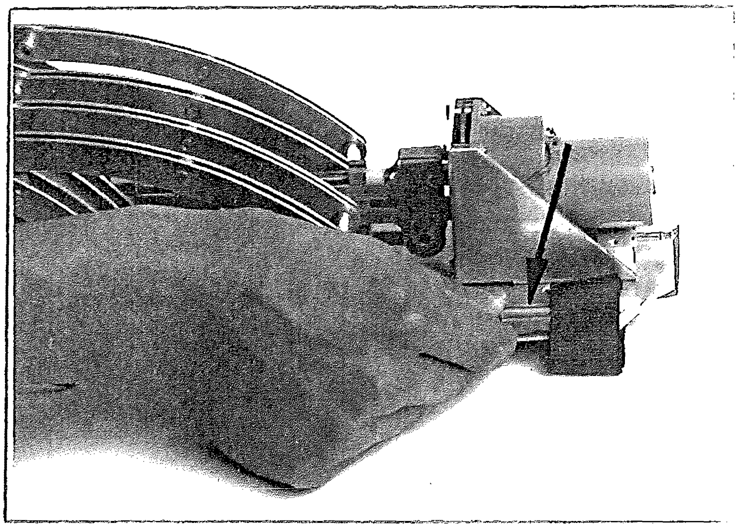
6.0) Testing Procedures

The following procedures allow you to operate and test the finger linkage movements of the CPM unit.

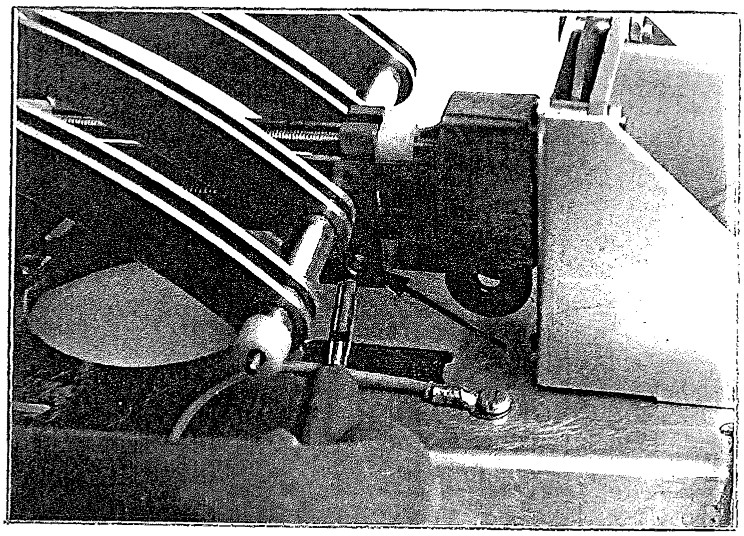
6.1) Inserting the plug into the cursor:

(**Note:** Ensure that the back of the motor unit is facing you).

1) Remove the plug from the velcro strap.



2) Insert the plug through the hole on the cursor up to the black line of the plug.



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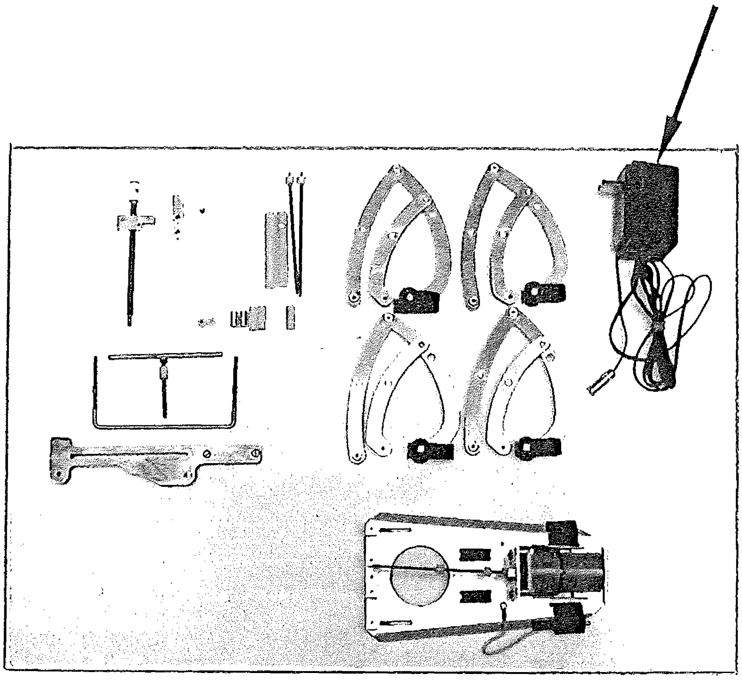
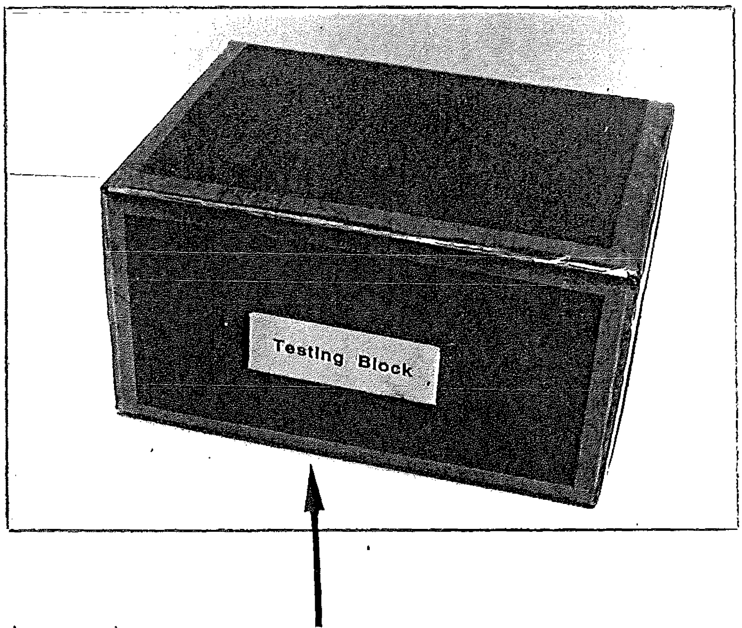
6.2) Testing cursor movement:

1) Select the adapter.



2) Position in front of you the box marked 'TESTING BLOCK'.



(Note: The label should be facing you.)

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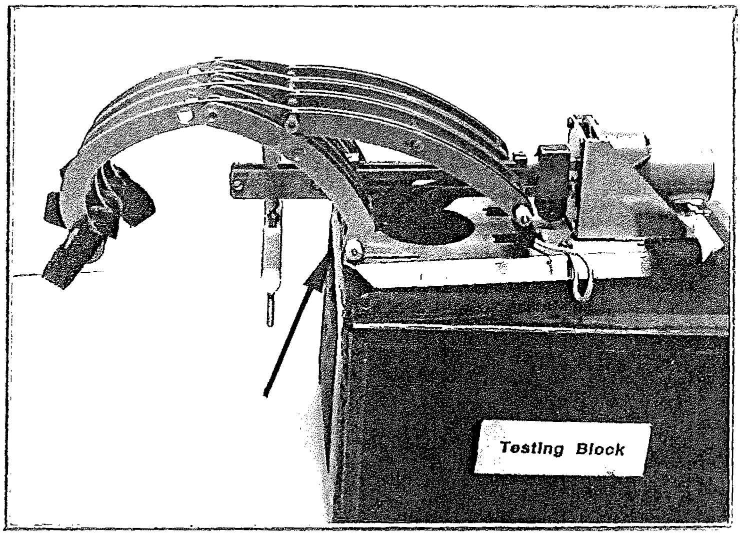
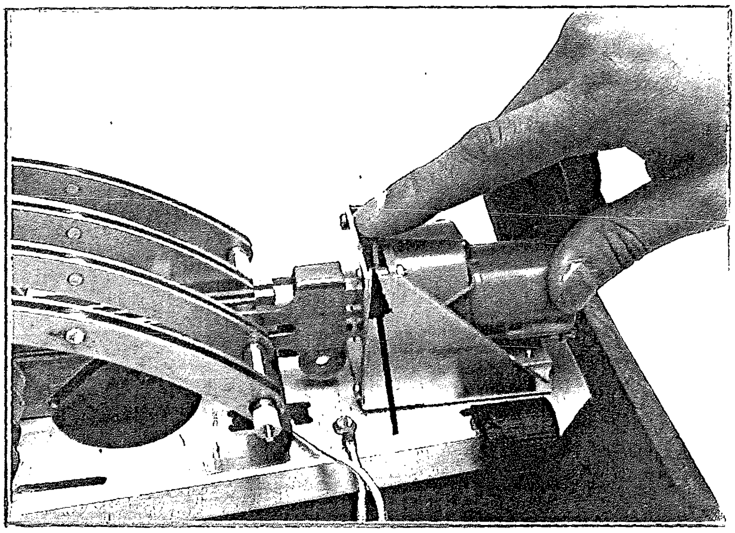
3) Place the CPM unit on top of the testing block and align the front edge of the CPM unit base-plate with the edge of the block.



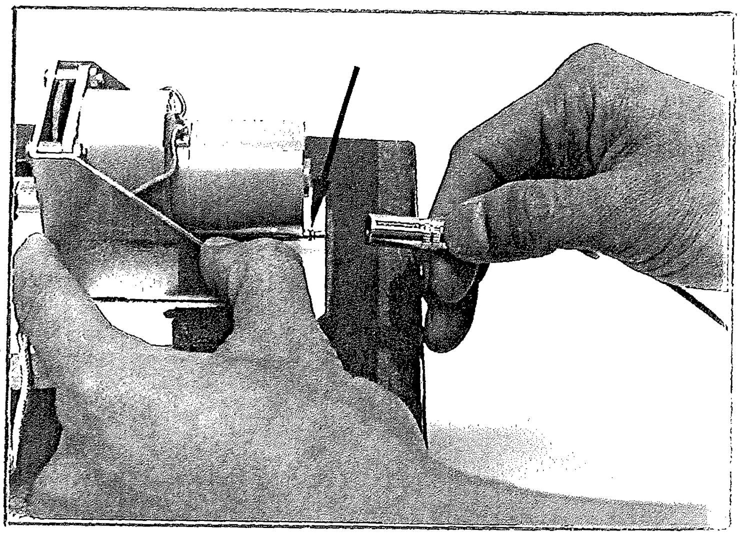
(**Note:** The hand rod should be hanging over the edge of the block.)

4) Pull back the direction switch located at the top of the motor unit until it 'clicks'.



5) With one hand, hold the CPM unit by its motor casing.

6) With your other hand, push the adapter socket into the adapter plug as far as you can (until it 'clicks').



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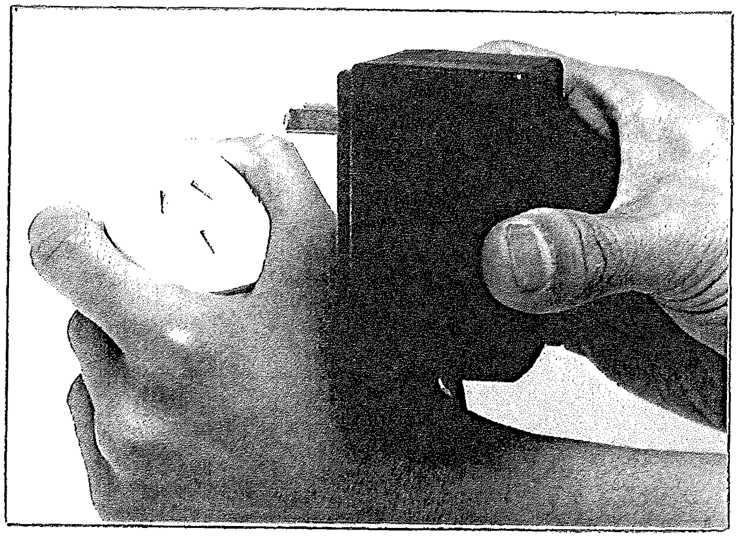
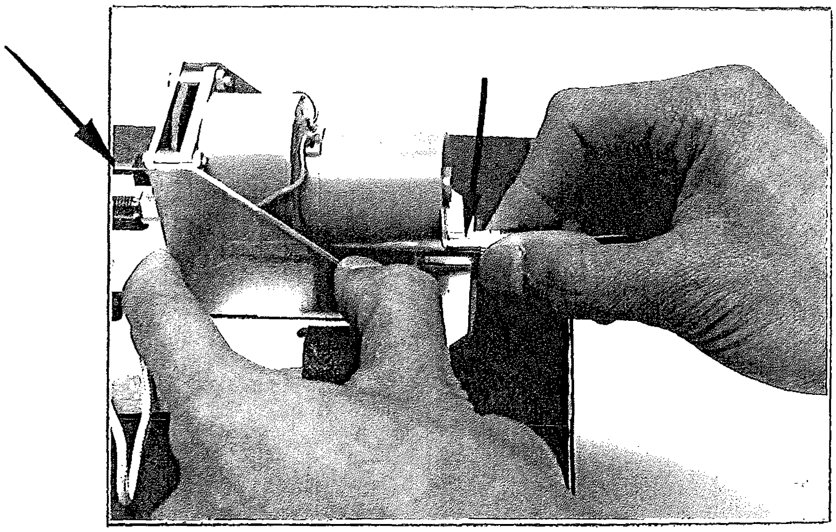
7) Plug the adapter into the extension cord (located on the top right-hand corner of the table.)



(**Note:** The CPM unit will make a 'roaring' sound as soon as the adapter is plugged into the extension cord.)

The cursor will move forward until it reaches the front (white) plastic nut on the switch rod. The cursor will automatically reverse the motor and move the cursor back towards its original position.

8) Disconnect the adapter socket when the cursor touches the plastic nut on the back end of the switch rod.

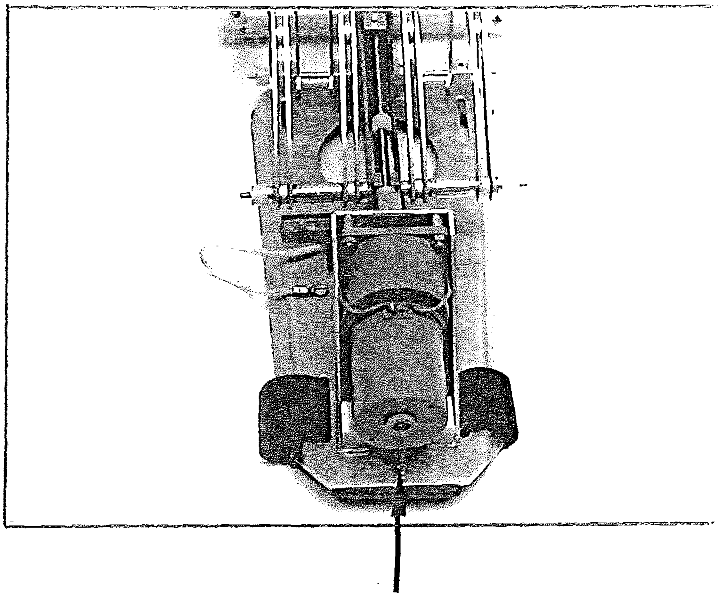


Proceed to the next step.

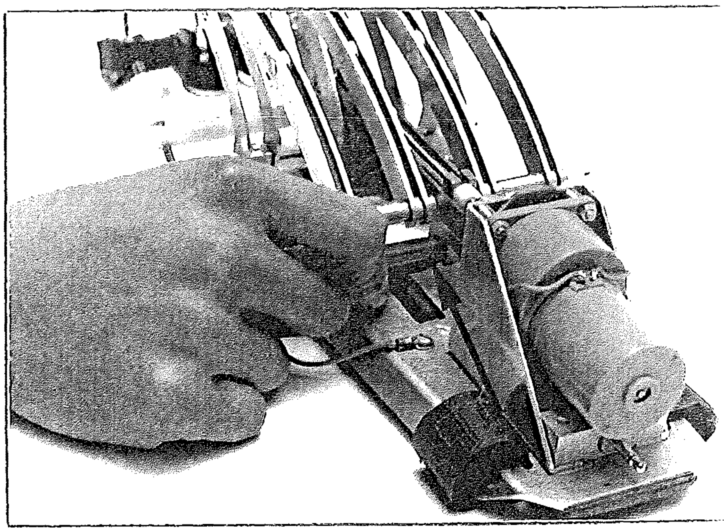
7.0) Test With Plug in Cursor Casing Position

7.1) Inserting plug into the cursor casing:

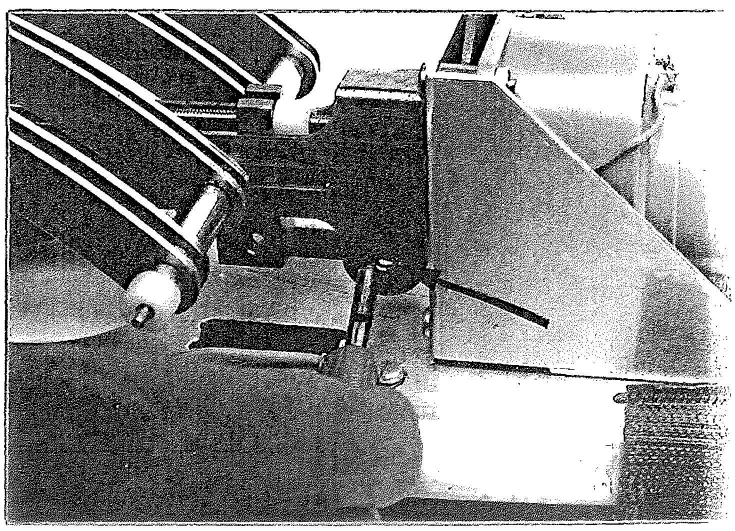
1) Place the CPM unit back on the table so that the back of the motor is facing you.



2) Remove the plug from the cursor.



3) Insert the plug through the hole on the back of the cursor casing up to the black line of the plug.



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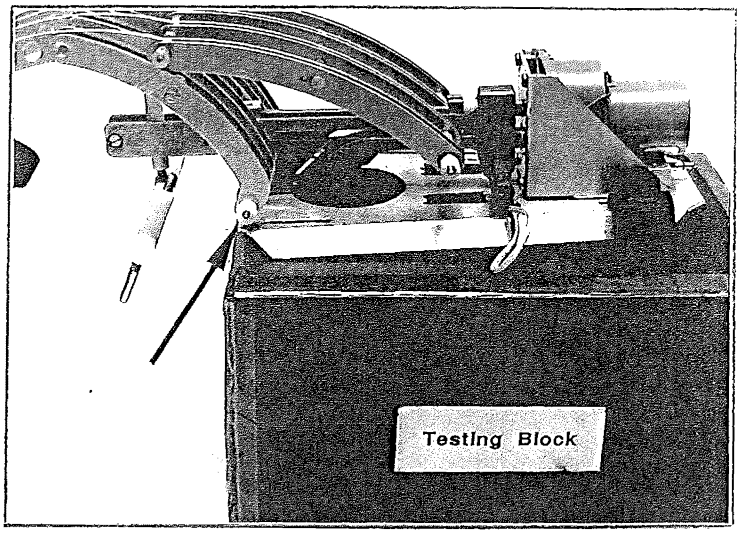
7.2) Testing cursor movement:

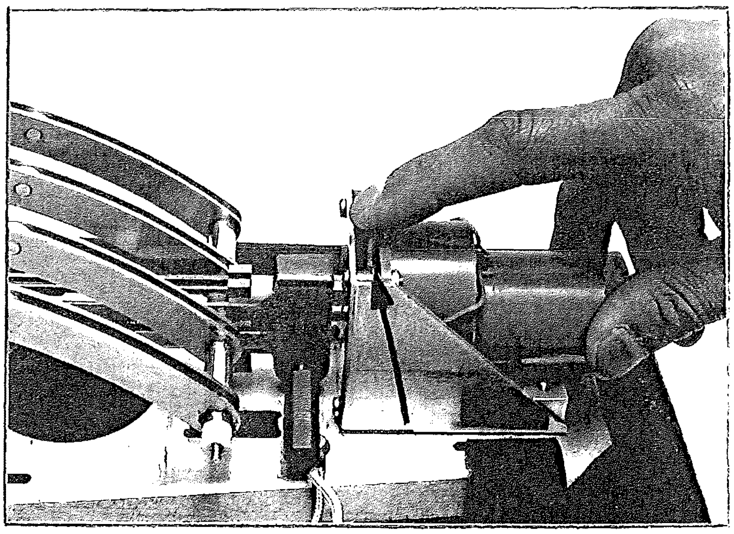
1) Position in front of you the box marked 'TESTING BLOCK'.

2) Place the CPM unit on top of the testing block and align the front edge of the CPM unit base-plate with the edge of the block.



(**Note:** The hand rod should be hanging over the edge of the block.)

3) Pull back the direction switch located at the top of the motor unit until it 'clicks'.



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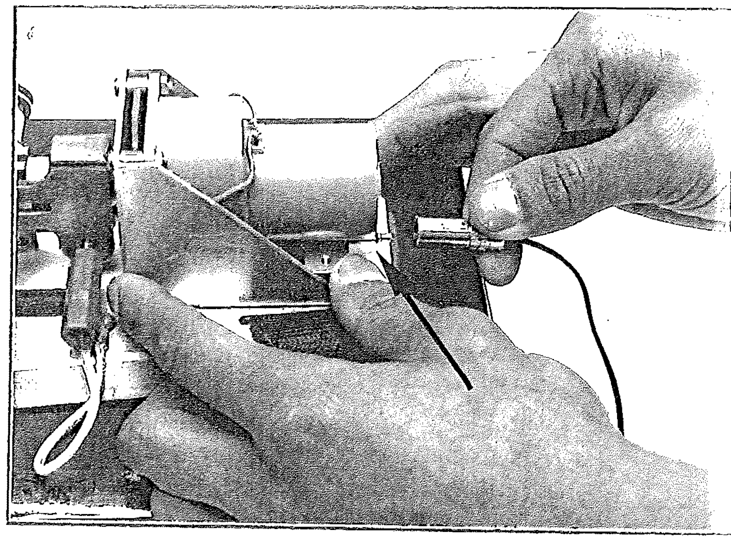
4) With one hand, hold the CPM unit by its motor casing.

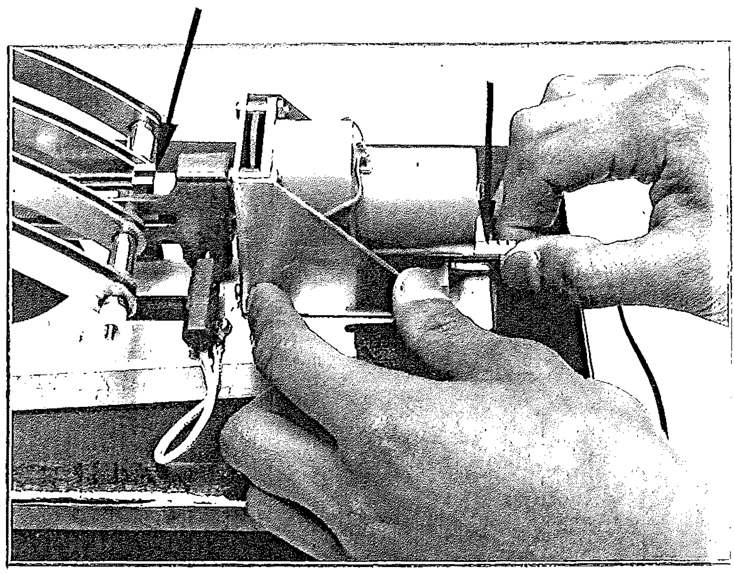
5) With your other hand, push the adapter socket into the adapter plug as far as you can (until it 'clicks').



(**Note:** The CPM unit will make a 'roaring' sound as soon as the adapter socket is pushed into the adapter plug.)

The cursor will move forward until it reaches the front (white) plastic nut on the switch rod. The cursor will automatically reverse the motor and move the cursor back towards its original position.

6) Disconnect the adapter socket when the cursor touches the plastic nut on the back end of the switch rod.



Proceed to the next page.

You have completed the testing procedures.

Please close the instruction manual.

Thank you for your participation.

Appendix 7.

Instruction manual Condition-9.

THE CPM UNIT:

ASSEMBLY AND TESTING INSTRUCTIONS

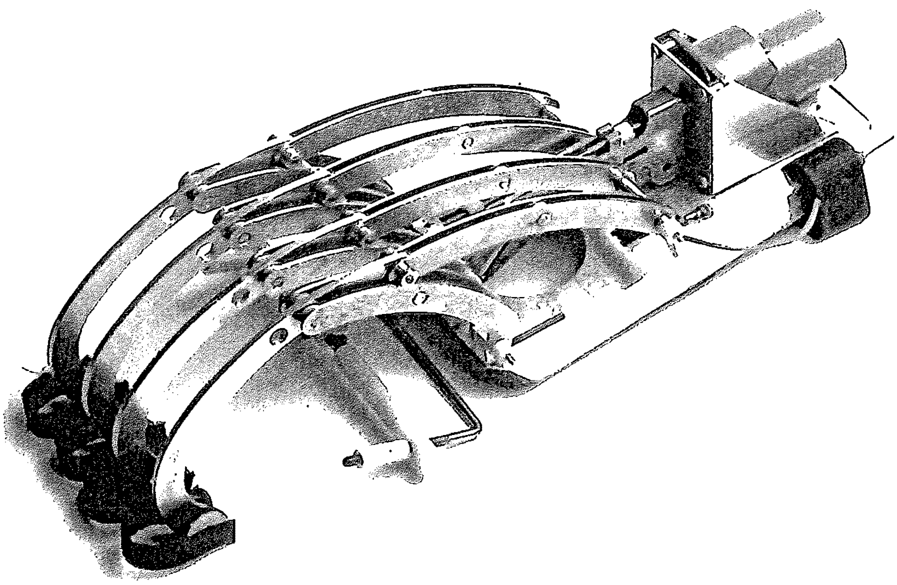
CONTENTS

The CPM Unit

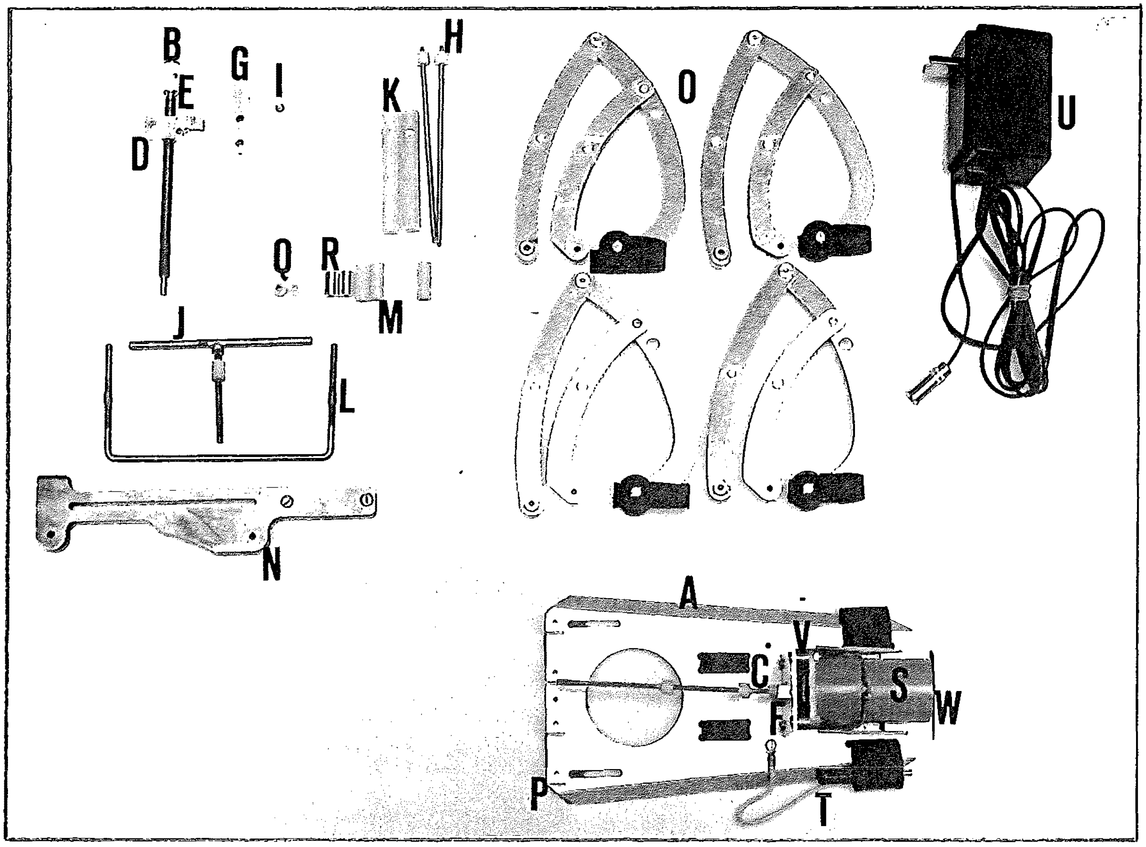
The portable continuous passive motion hand unit (CPM) is an orthopaedic hand exercise unit, designed to help the healing of the hand and/or finger muscles after injury. The lightweight design of the unit means the patient can take the unit home and supervise their own personal therapy for up to 24 hours.

The unit fits comfortably on top of the hand and wrist. It is secured with velcro binding for easy attachment to and release from the fingers and wrist.

A small motor operates the finger linkages of the CPM unit which helps the patient to exercise his/her hand without effort.



Names of CPM Parts



1.0) Names of CPM Parts

The following names refer to the names of the CPM parts and their location on the CPM unit. The order of presentation corresponds with the order of the procedural steps.

A) **The CPM Base Unit:** The CPM base unit is the largest sub-assembled component made up of an aluminium base-plate, a motor unit, a red plug, and 4 linkage attachment blocks.

B) **The Cursor Shaft:** The cursor shaft is the longest metal rod with a brass block threaded onto it. The cursor shaft is attached to the motor shaft.

C) **The Switch Rod:** The switch rod is the brass rod with 2 short plastic nuts threaded onto it. The switch rod is attached to the motor unit.

D) **The Cursor:** The cursor is the brass block with 2 holes and a groove. The cursor is threaded onto the cursor shaft.

E) **The Allen Screw:** The Allen screw is the screw threaded into the white portion of the cursor shaft.

F) **The Motor Shaft:** The motor shaft is the small metal rod protruding from the motor unit.

G) **The Cursor-Shaft-Block:** The cursor-shaft-block is the long rectangular, aluminium block with holes on it. The cursor-shaft-block is fastened onto the CPM unit base-plate.

H) **The Bolt Rod:** The bolt rod is the long brass rod with a short plastic nut threaded onto it. The bolt rod secures the finger linkages onto the CPM unit.

I) **The screw:** The screw is the smallest un-assembled CPM component. The screw secures the cursor-shaft-block onto the CPM unit base-plate.

Proceed to the next page.

J) **The T-Bar:** The T-bar is the metal component which represents the alphabetical letter 'T', a short plastic nut is threaded onto it. The T-bar is a sub-part of the hand rod unit fastened onto the cursor casing.

K) **The Plastic Sleeves:** The plastic sleeves are the longest plastic component of the CPM parts. Each plastic sleeve is partially hollow with a hole on one end. The plastic sleeves are a sub-part of the hand rod unit slotted onto the T-bar.

L) **The U-Bar:** The U-bar is the metal component which represents a very wide alphabetical letter 'U'. The U-bar is a sub-part of the hand rod unit and is fastened to the T-bar.

M) **The Long Plastic Nut:** The long plastic nut is the longest nut of the CPM parts. It is a sub-part of the hand rod unit which secures the U-bar to the T-bar.

N) **The Cursor Casing:** The cursor casing is the largest metal component of the CPM parts. The cursor casing is an aluminium block with 6 holes fixed between the metal at the front-end, with gaps in the mid-section and one hole at the back-end of the metal part. The cursor casing encases the cursor and the cursor-shaft-block.

O) **The Finger Linkages:** The finger linkages are the 3-pronged aluminium objects with a black velcro strip fastened at the front-end. The finger linkages are attached to the CPM base unit in 2 places: 1) the 4 linkage attachment blocks, 2) the cursor.

P) **The Attachment Blocks:** The attachment blocks are the 4 short aluminium blocks secured onto the front-end of the CPM unit base-plate.

Q) **The Plastic Nut:** The plastic nut is the shortest plastic component of the CPM parts. The nut secures the bolt rods attaching the finger linkages to the attachment blocks and the cursor.

R) **The Aluminium Spacer:** The aluminium spacer is the hollow, pipe-like aluminium component of the CPM parts. The aluminium spacer is slotted onto the bolt rod between the back finger linkage attachments.

Proceed to the next page.

S) **The Motor Unit:** The motor unit is the sub-assembled component secured to the back-end of the CPM unit base-plate.

T) **The Plug:** The (red) plug is attached to the black velcro strap located at the back-end of the CPM base unit.

U) **The Adapter:** The adapter is the black 'cubical' object with a silver socket attached to the black cord.

V) **The Direction Switch:** The direction switch is the brown PC board located on the top of the motor unit.

W) **The Adapter Plug:** The adapter plug is the silver metal rod that protrudes from the back end of the motor unit.

Proceed to the next page.

Assembly and Testing Procedure Instructions

All the parts and tools you will need to assemble and operate the CPM unit are in front of you.

1) Perform the task as accurately and as fast as you can.

2) Please follow the procedures and notes in a step-by-step manner

3) Please close the instruction manual.

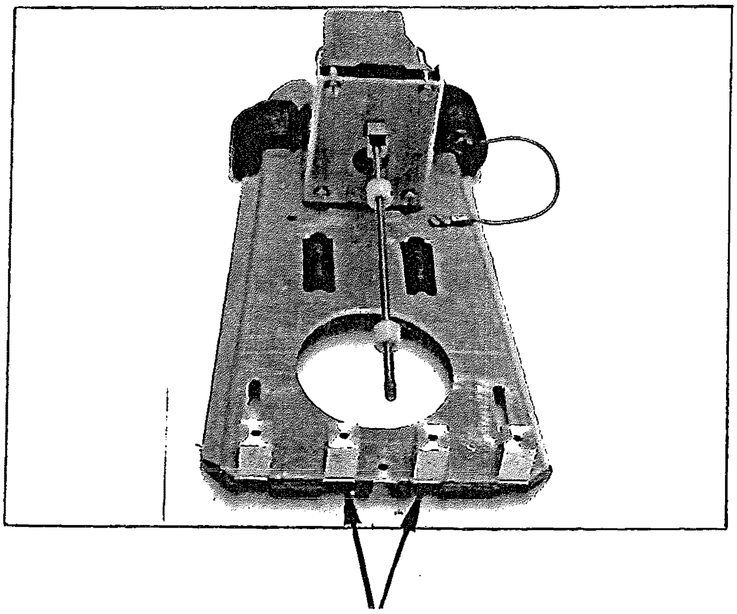
Assembly Procedures

2.0) Cursor Shaft Assembly

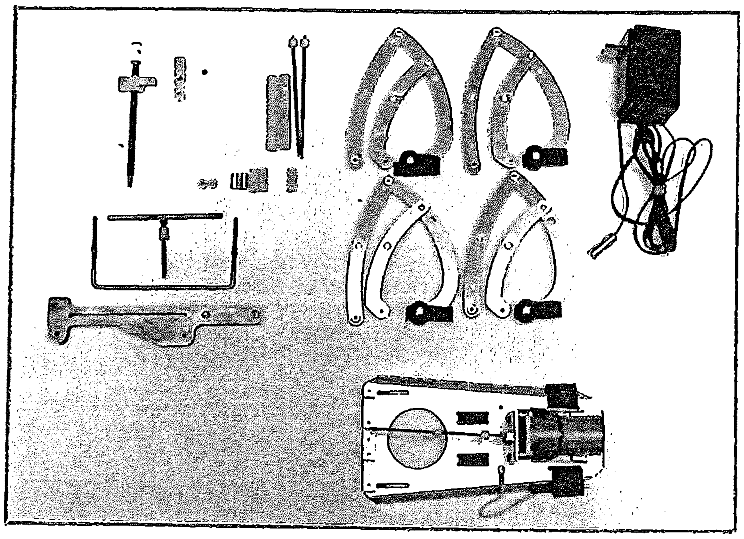
The cursor shaft is the metal shaft which is threaded through the cursor. When the motor is operating, the cursor allows for forward and backward motion of the finger linkages.

2.1) Positioning the cursor shaft into the motor shaft:

1) Position the CPM base unit so that the 4 linkage attachment blocks are facing you.



2) Select the cursor shaft.



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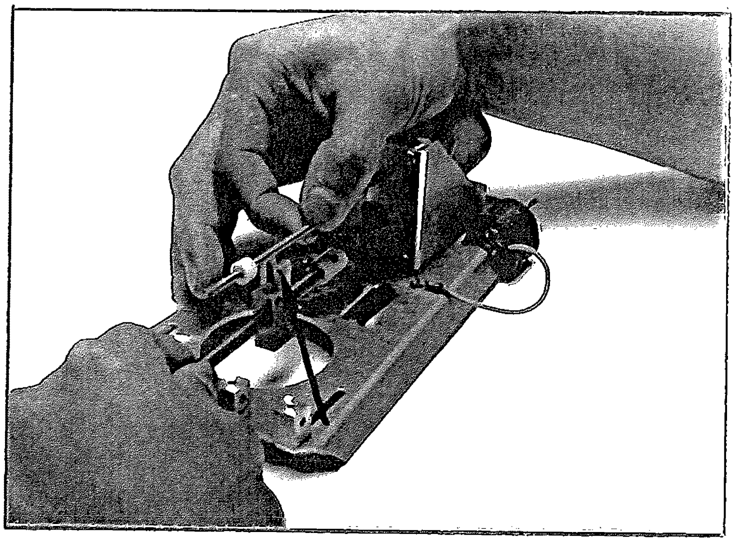
3) With one hand, lift the switch rod.

4) With your other hand, position the cursor shaft below the switch rod.

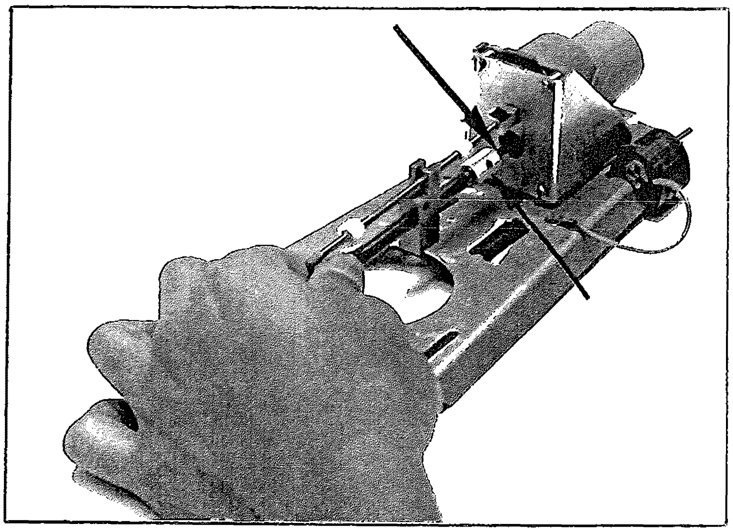
5) Place the switch rod in the groove of the cursor.



(**Note:** The cursor should be positioned between the 2 plastic nuts.)

6) Turn the cursor shaft so that the Allen screw is aligned with the flat side of the motor shaft.

7) Insert the cursor shaft into the motor shaft as far as you can.



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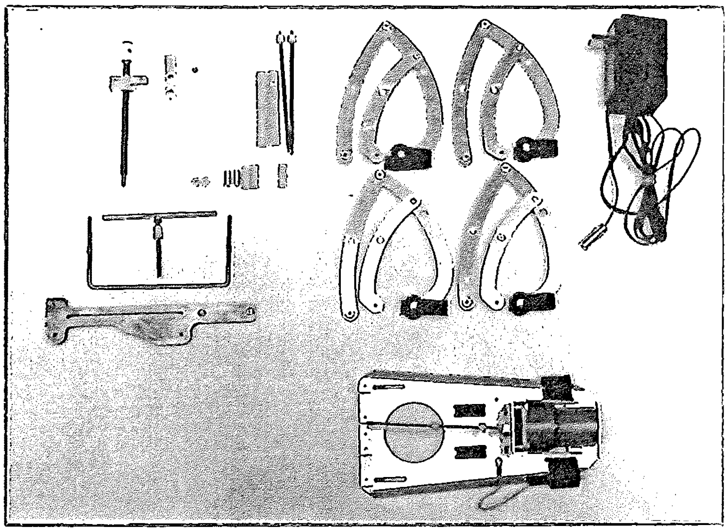
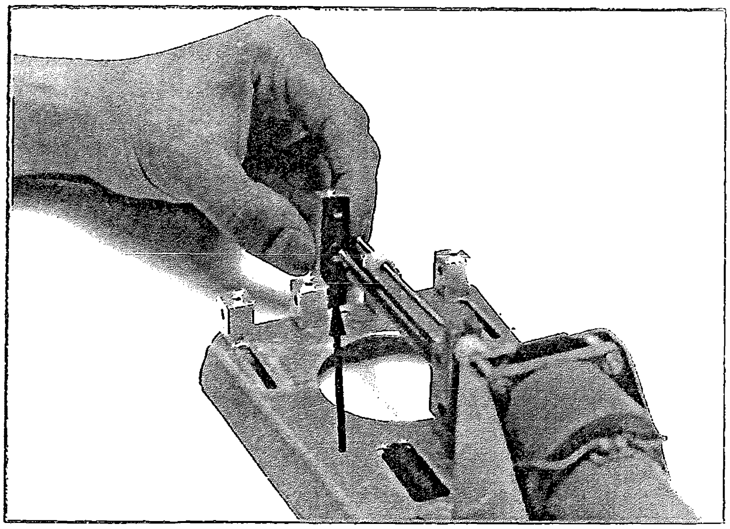
2.2) Mounting the cursor-shaft-block onto the CPM base unit:

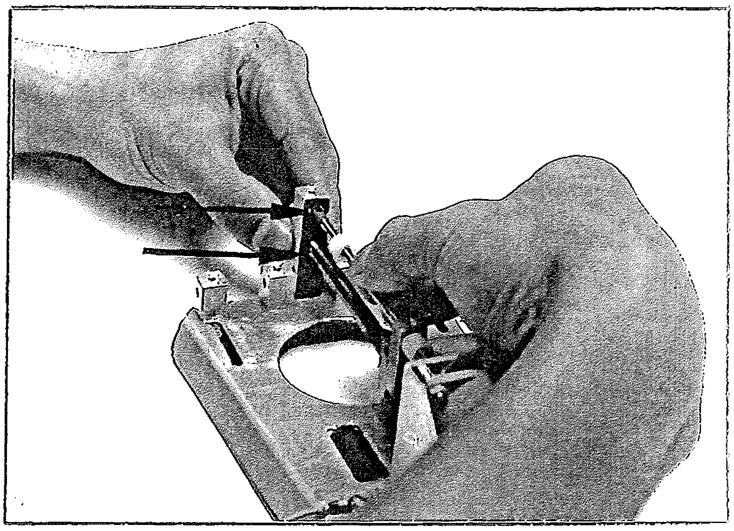
1) Select the cursor-shaft-block.



2) Hold the cursor-shaft-block so that the black side is facing the motor unit.



3) At the same time, slot the hole located in the middle of the cursor-shaft-block into the cursor shaft and the top hole into the switch rod.



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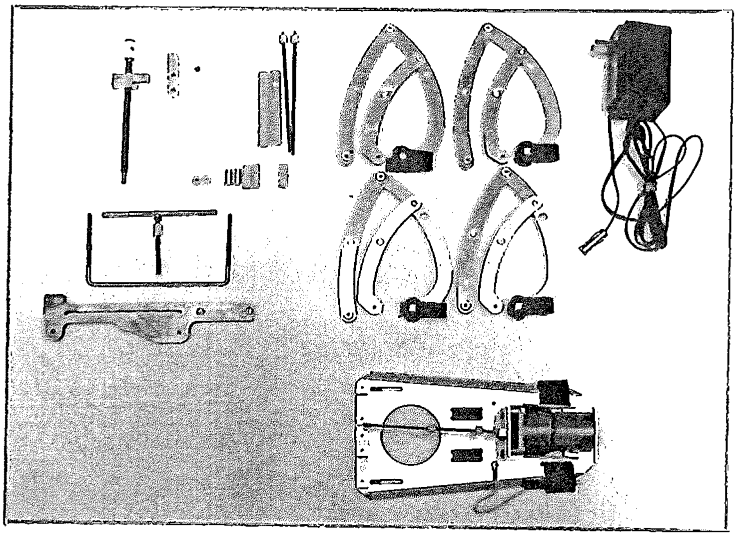
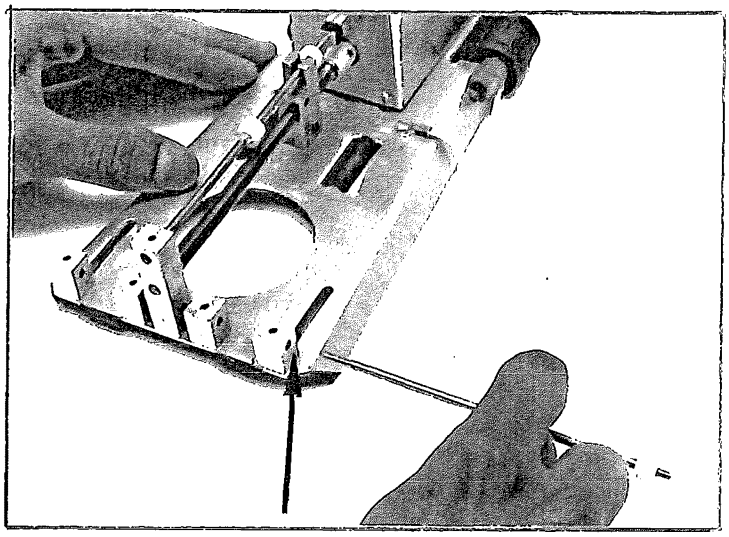
4) Select one of the bolt rods.



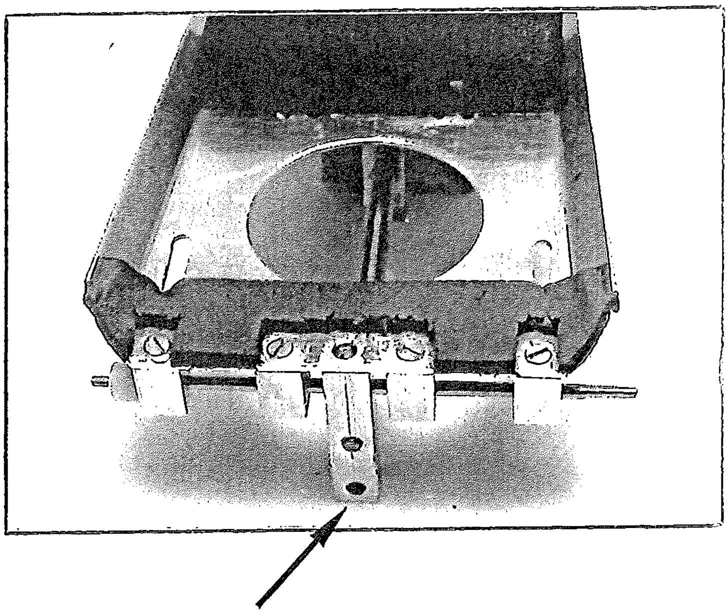
5) Starting from the right-most attachment block, insert the bolt rod through the side holes of the linkage attachment block.



(**Note:** The bolt rod should slide through the 4 attachment blocks and the cursor-shaft-block.)

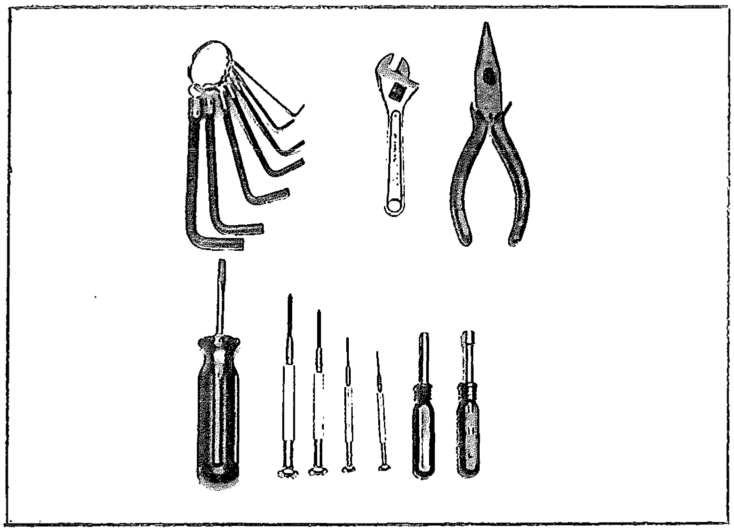
Proceed to the next page.

6) Turn the CPM unit over and rest the unit on the table.

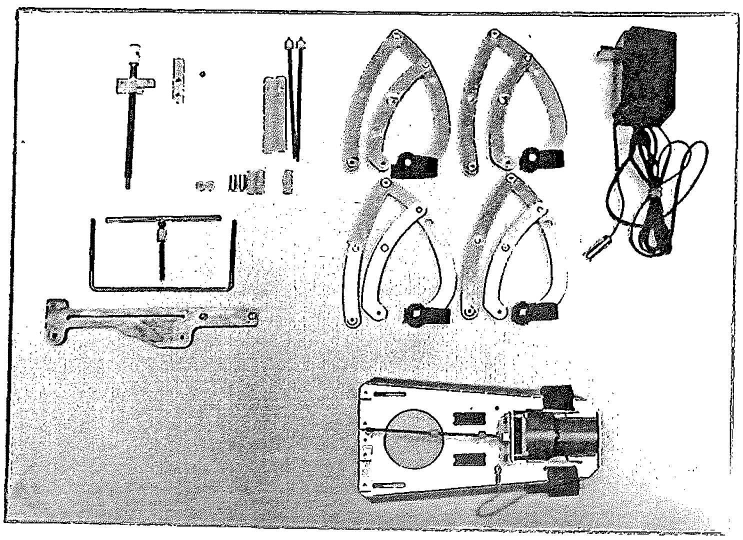


(Note: The cursor-shaft-block should be positioned upright, touching the table.)

7) Select a standard screwdriver.



8) Select the screw.



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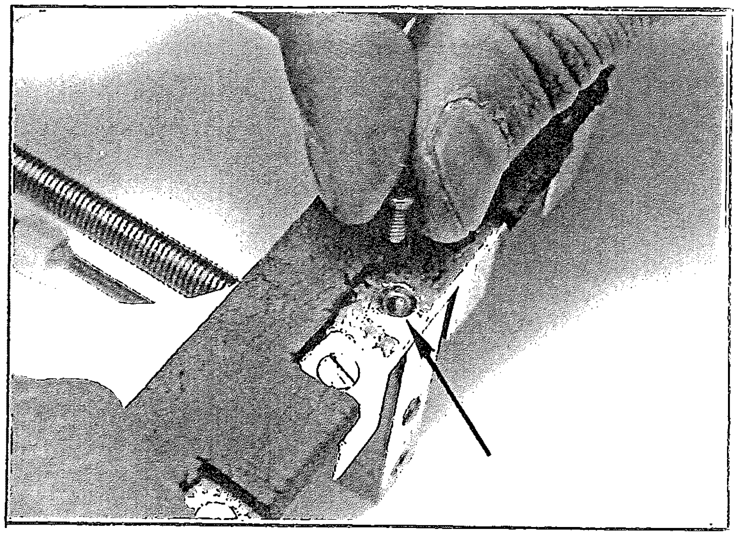
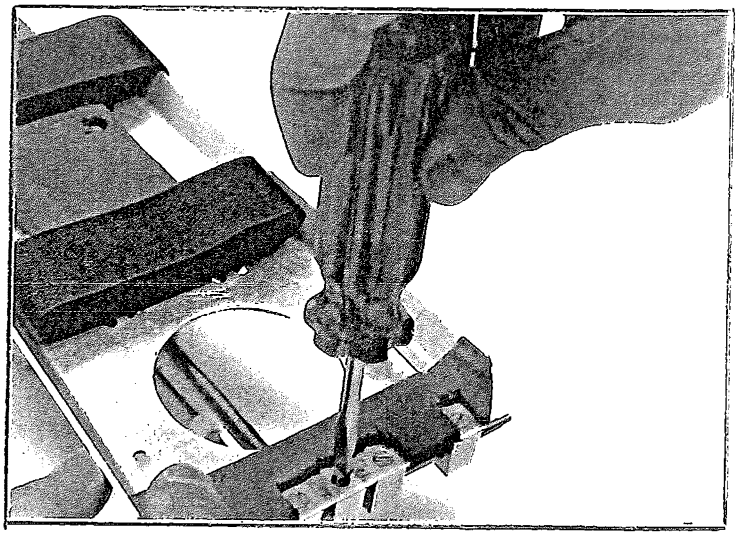
9) Hold the CPM unit firmly and ensure that the cursor-shaft-block is touching the table.

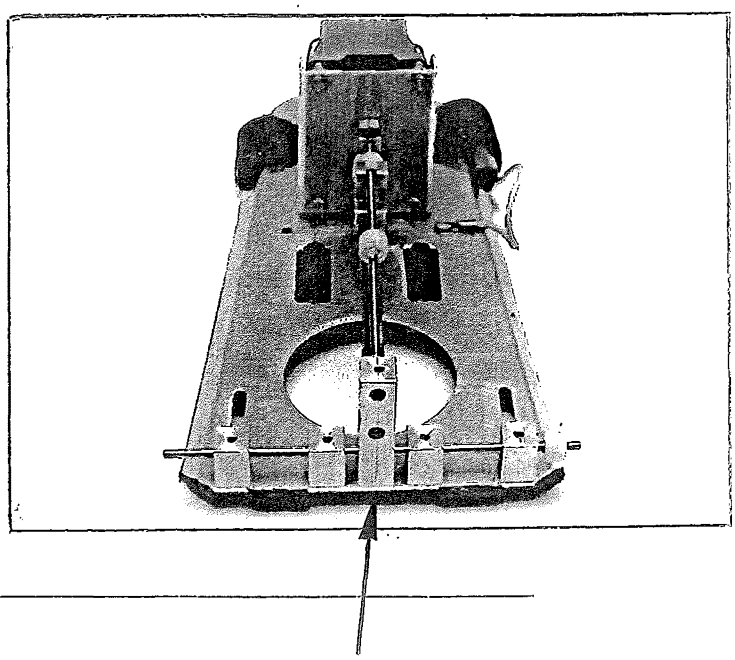


10) With the screw, secure the cursor-shaft-block to the CPM unit base-plate.

11) Using the screwdriver, tighten the screw.



12) Turn the unit back over and position the CPM base unit so that the 4 attachment blocks are facing you.



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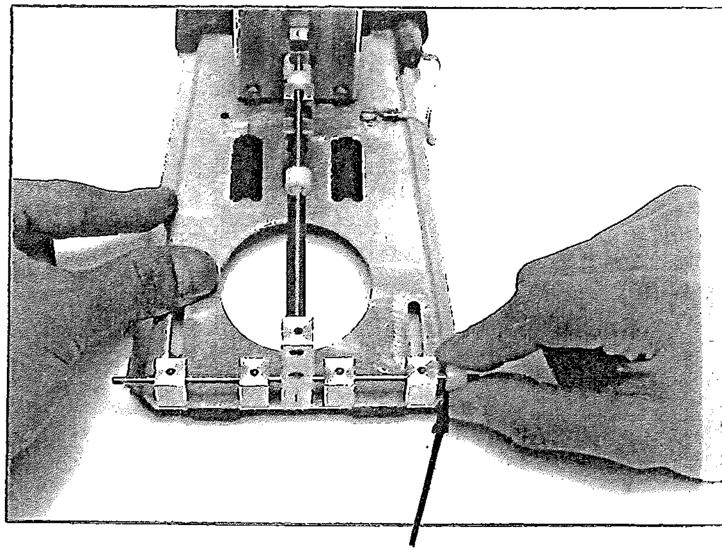
13) Remove the bolt rod from the attachment blocks.



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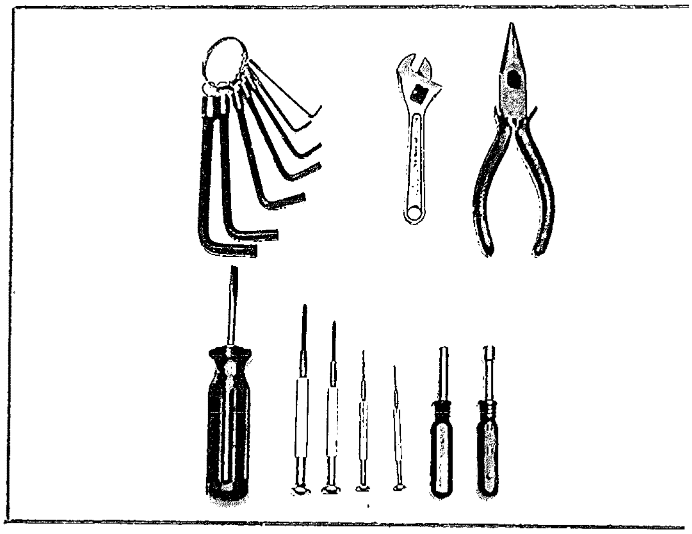
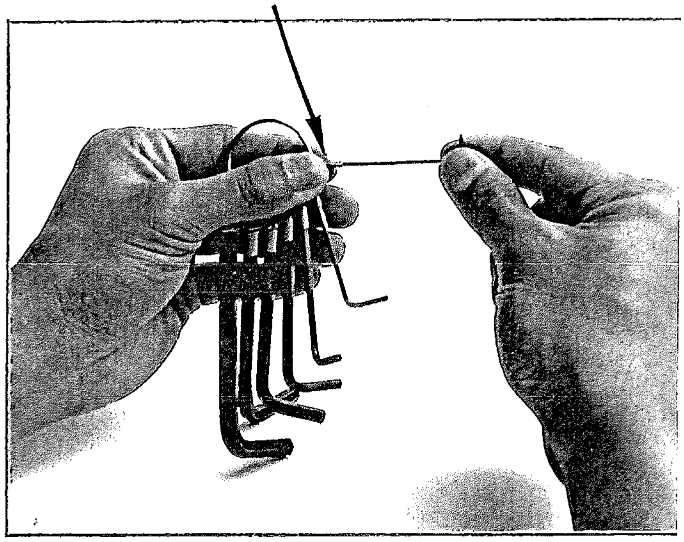
2.3) Removing the Allen key from its holder:

1) Select the Allen keys and locate the 1mm. Allen key.



2) With one hand, hold the spring-like holder.

3) With your other hand, pull the 1mm. Allen key from the spring-like holder.



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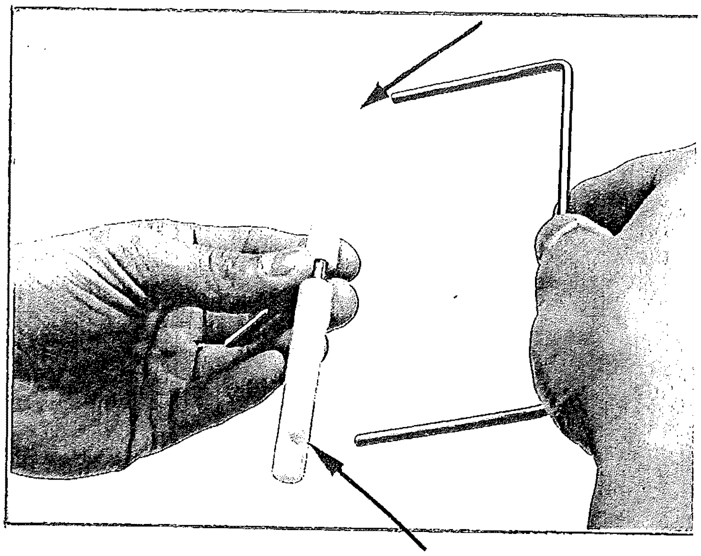
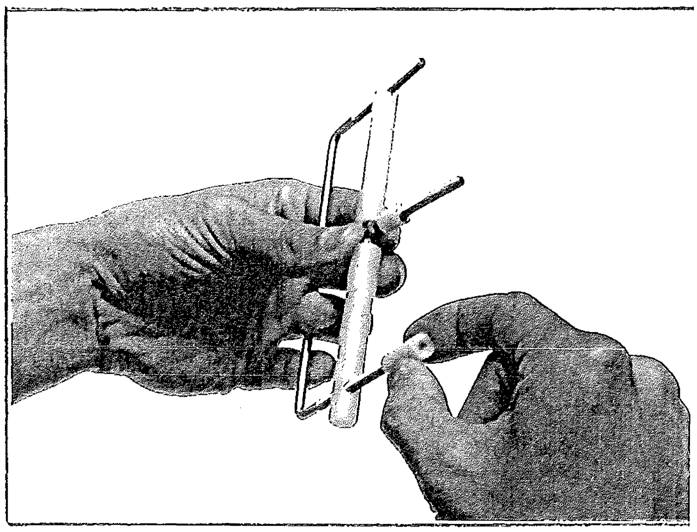


4) Hold the T-bar so that it represents the alphabetical letter 'T'.

5) Position the U-bar above the T-bar.

6) Slot both ends of the U-bar into the holes on the plastic sleeves.



7) Secure the U-bar onto the T-bar with a long plastic nut at each end.

8) Tighten both nuts until they stop.

Proceed to the next page.

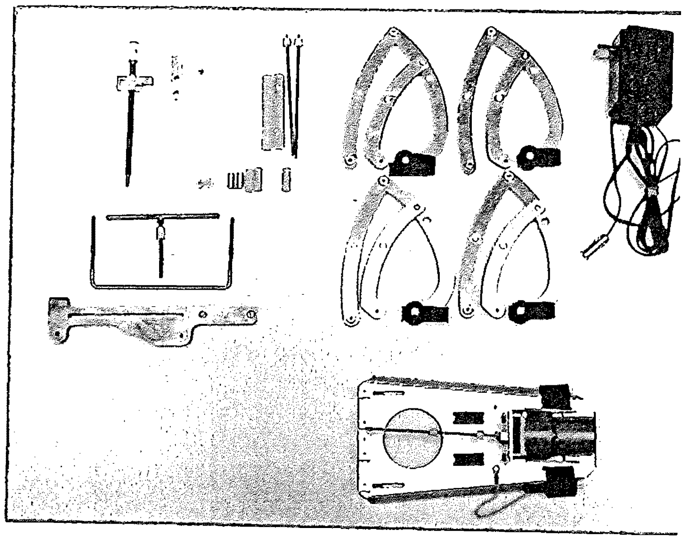
3.0) Hand Rod Assembly

The hand rod functions as a hand rest which supports the patient's hand while the hand and/or finger muscles are being exercised.

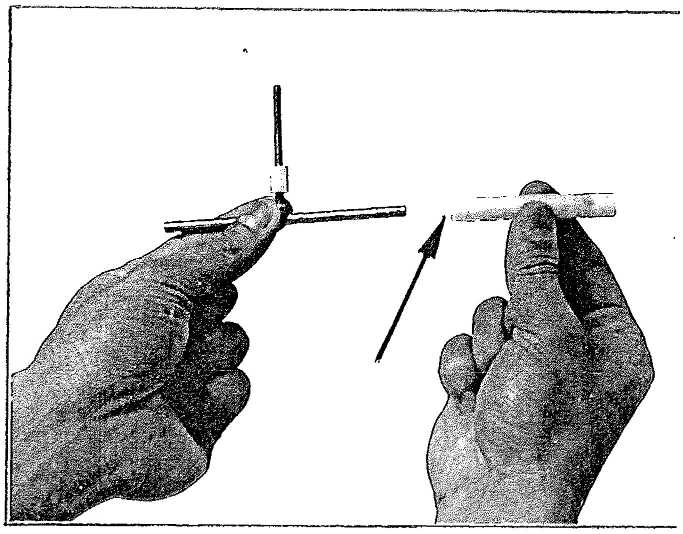
3.1) Hand rod assembly:

1) Select the T-bar.

2) Select the 2 plastic sleeves.



3) Slide the length of the 2 plastic sleeves onto the T-bar.



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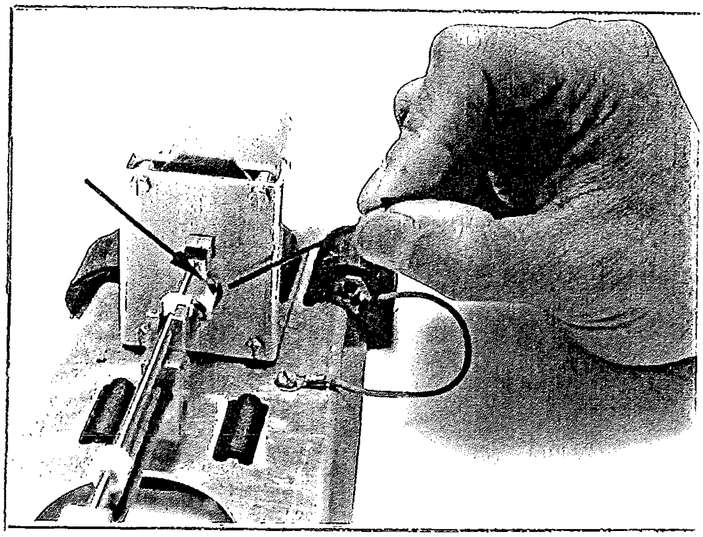
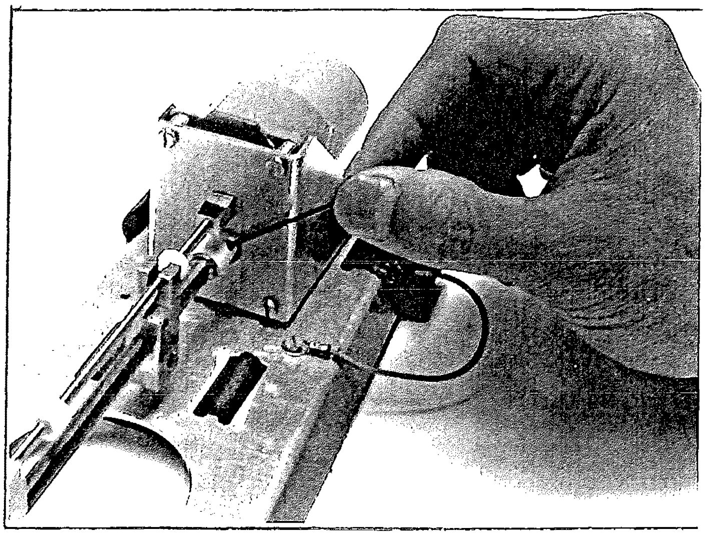
2.4) Tightening Allen Screw:

1) Slot the long-end of the Allen key into the Allen screw.



2) Tighten the Allen screw.

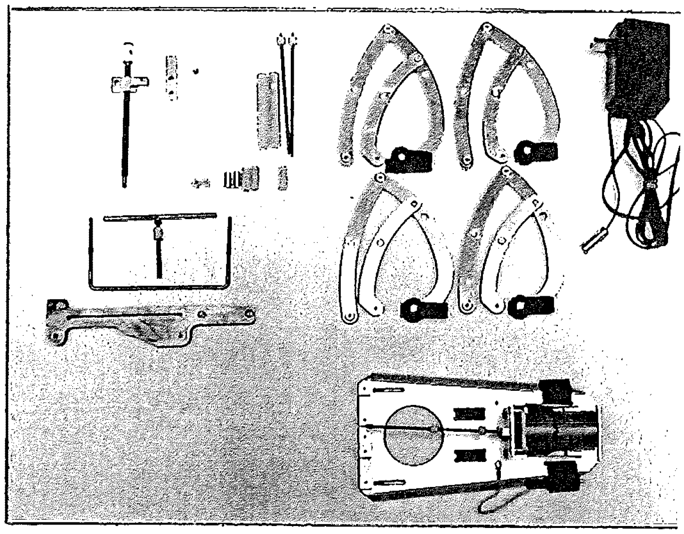


You have finished the cursor shaft assembly.

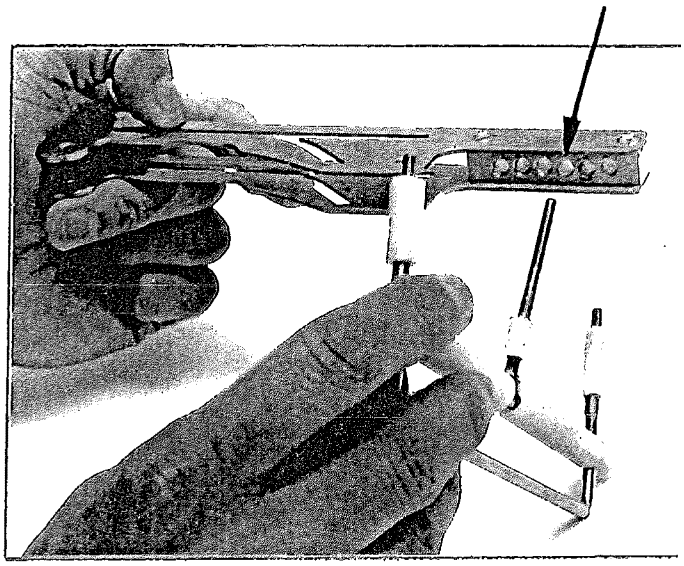
Proceed to the next step.

3.2) Fastening hand rod onto cursor casing:

1) Select the cursor casing.



2) With one hand, hold the cursor casing so that the straightest edge of the cursor casing is on top.



3) With your other hand, position the T-bar underneath the cursor casing.

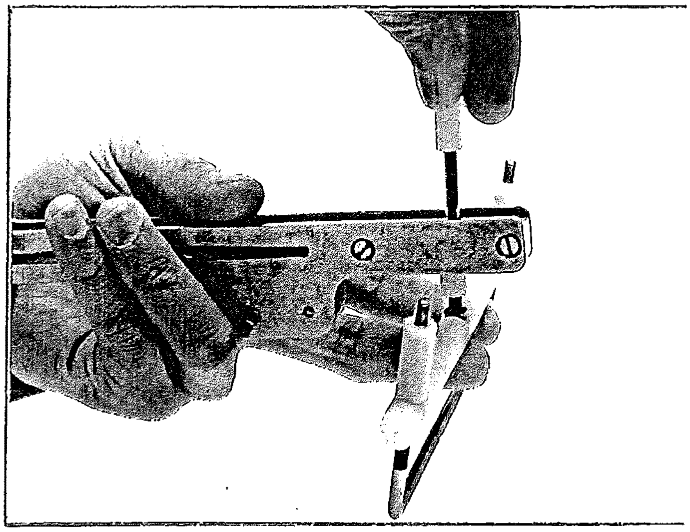
4) Insert the T-bar of the hand rod into the 3rd hole from the front of the cursor casing.

(**Note:** The T-bar should be positioned at a 'cross-angle' with the cursor casing.)

Proceed to the next page.

5) Fasten the T-bar in place with the remaining long plastic nut.

6) Tighten the nut until it stops.



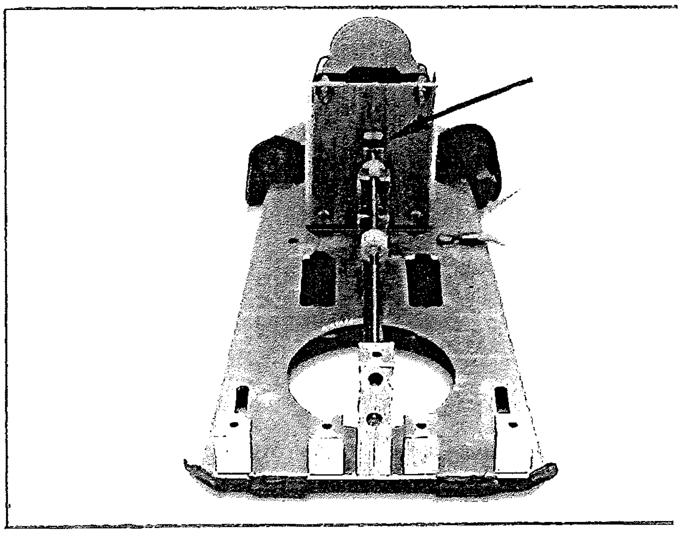
You have finished the hand rod assembly.

Proceed to the next step.

4.0) Cursor Casing Assembly

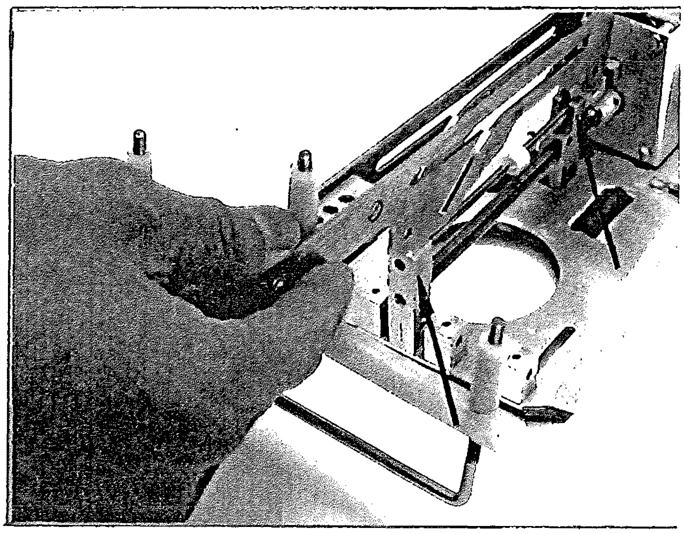
The cursor casing functions as a guide rail for the cursor which ensures the correct movement of the finger linkages.

1) Locate the black square of the aluminium block (connected to the switch rod).



2) Hold the cursor casing so that the straightest edge of the cursor casing is on top.

3) Slot the cursor casing onto the cursor-shaft-block and the cursor.



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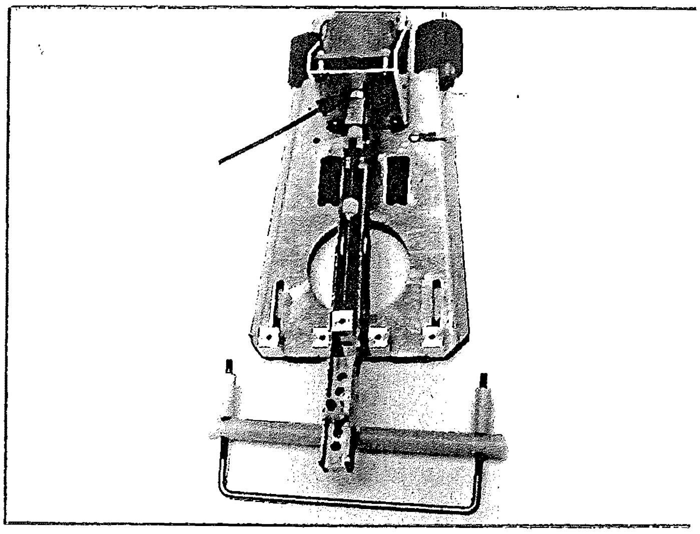
4) Align the back of the cursor casing so that it covers the black square of the aluminium block, leaving a gap between the cursor casing and the motor casing.



(**Note:** This will allow for easier assembly of the finger linkages.)

You have finished the cursor casing assembly.

Proceed to the next step.

5.0) Finger Linkage Assembly

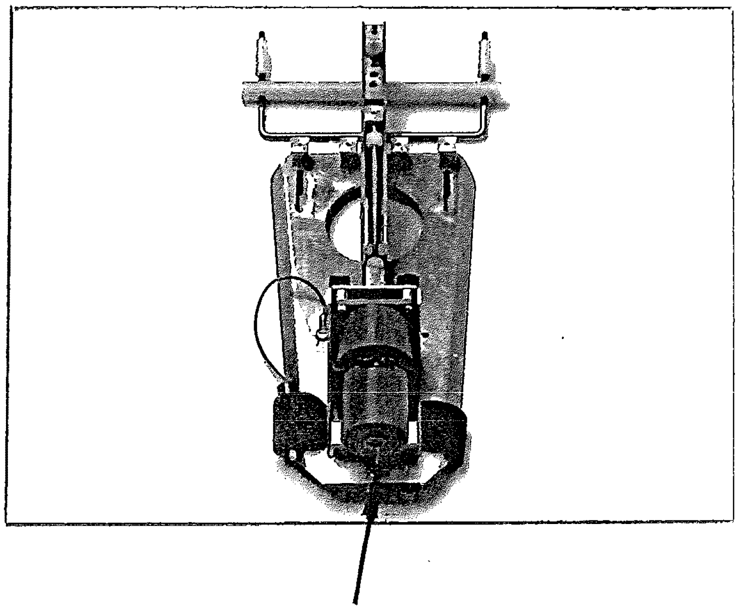
The finger linkages are attached to the CPM base unit in 2 places:

1) The linkage attachment blocks located at the front of the CPM unit base-plate.

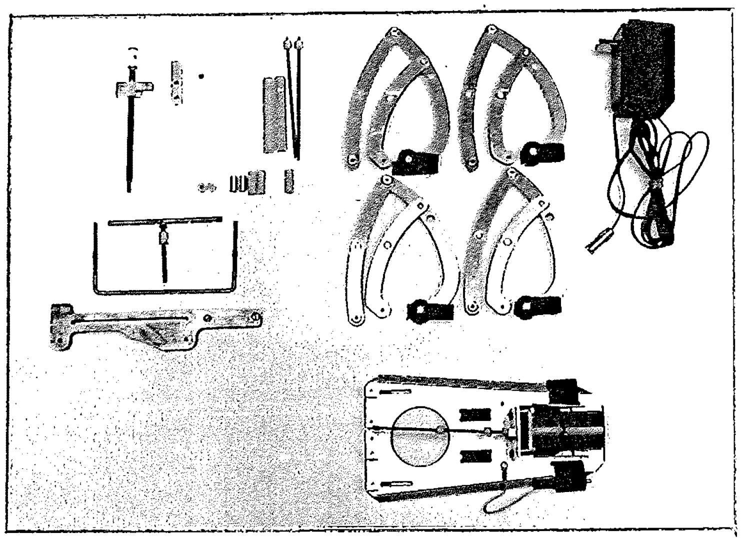
2) The cursor.

5.1) Fastening the (front) finger linkage attachment to the blocks:

1) Position the CPM base unit so that the back of the motor faces towards you.



2) Select one of the finger linkages.



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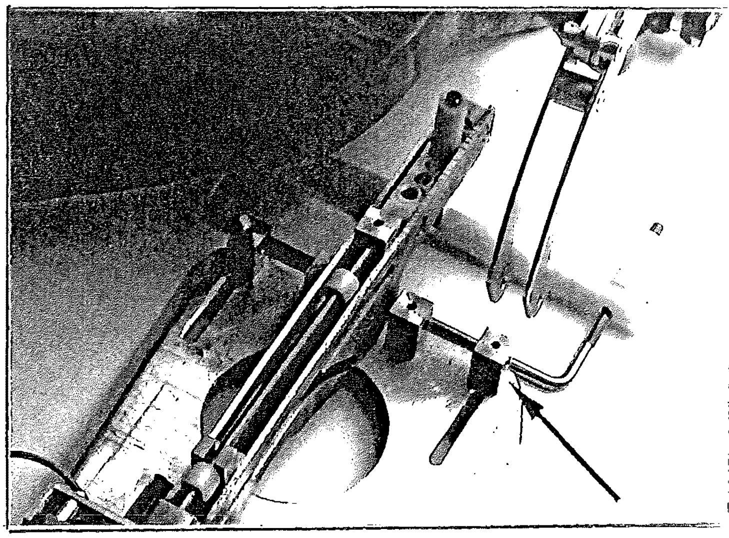
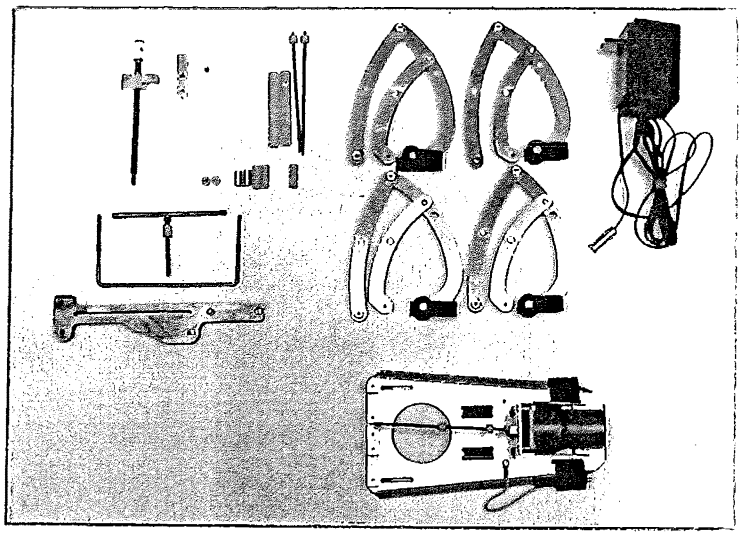
4) Slot the front finger linkage attachment onto the 1st attachment block,located at the right front of the CPM unit.



(**Note:** a) The velcro strip should be positioned in front of the hand rod.

b) The back linkage attachment should be positioned behind the attachment block.)

5) Select one of the bolt rods.



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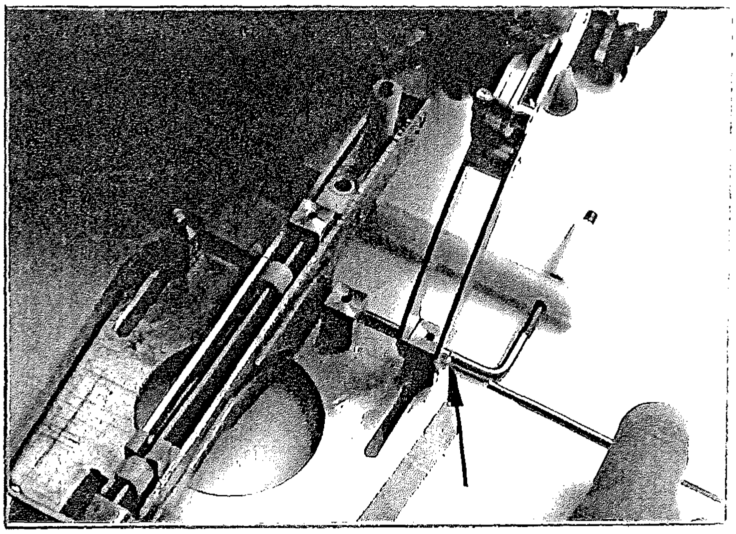
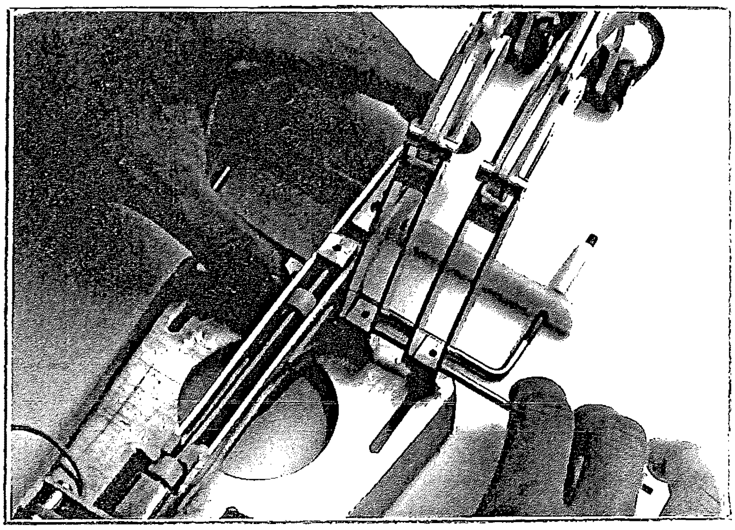
6) Insert the bolt-rod through the hole on the side of the front linkage until it protrudes slightly on the other side of the 1st linkage.

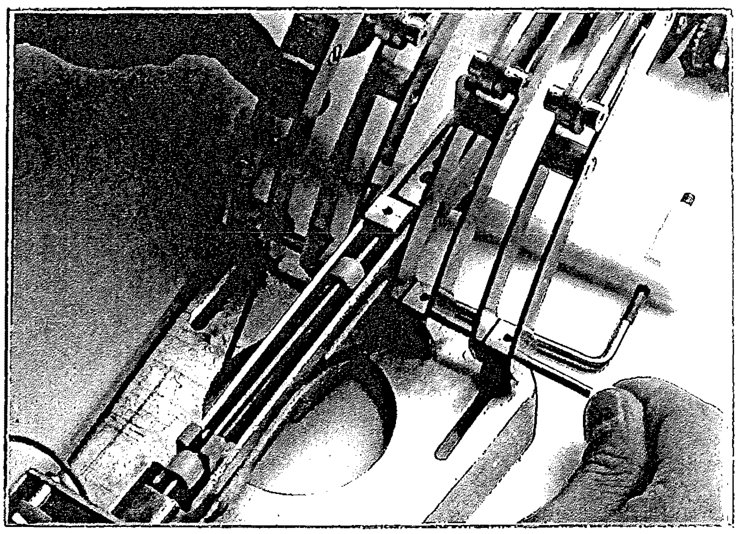


7) Slot a 2nd linkage onto the next block.

8) Push the cursor casing slowly towards the motor at the same time you are inserting the bolt-rod through the 2nd linkage.



9) Continue to fasten the remaining 3rd and 4th linkages.



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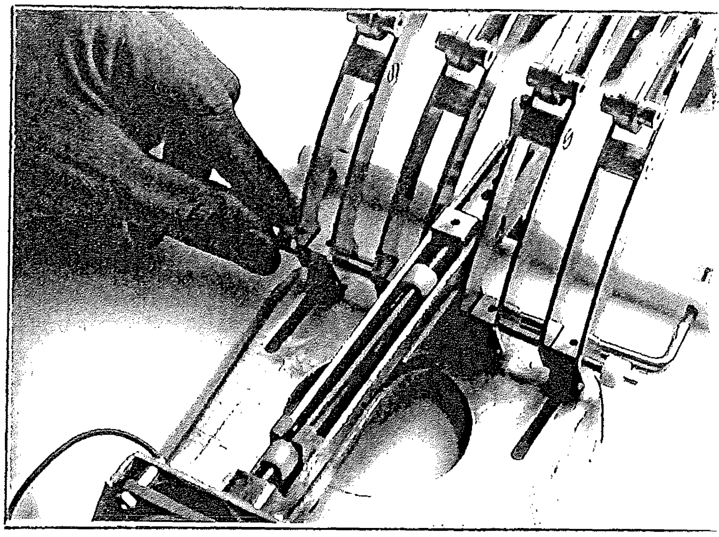
10) Fasten the bolt-rod with one of the plastic nuts.

11) Tighten the nut until it stops.



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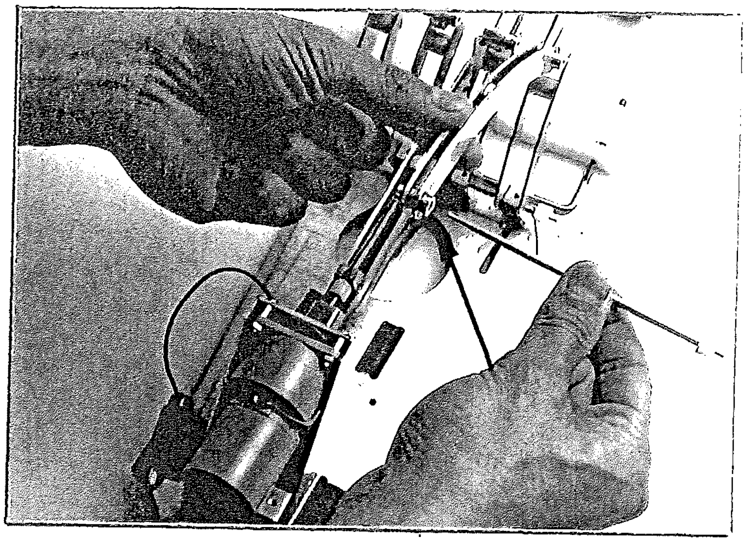
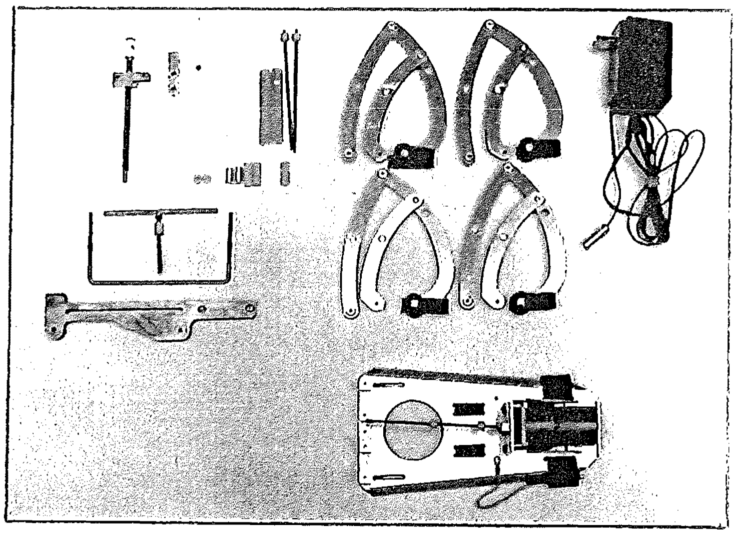
5.2) Fastening the (back) finger linkage attachment to the cursor:

(**Note:** Begin with the right-most finger linkage.)

1) Insert the bolt-rod through the hole at the back-end of the linkage.



2) Select one of the aluminium spacers.



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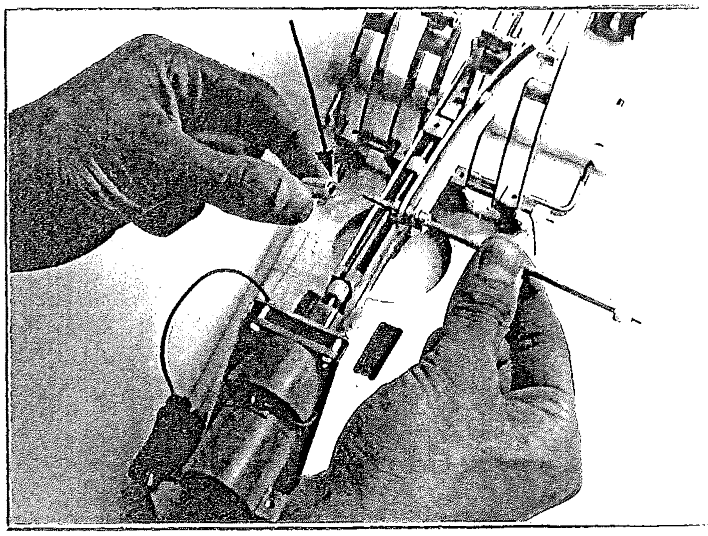
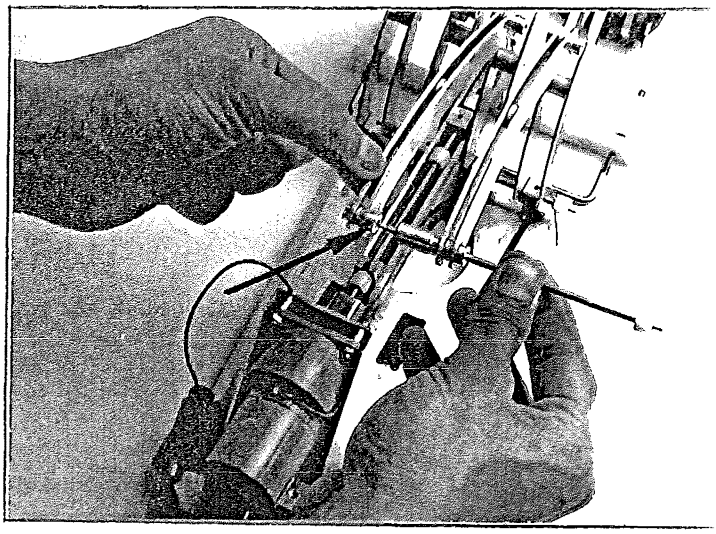
3) Insert the bolt-rod through the aluminium spacer.

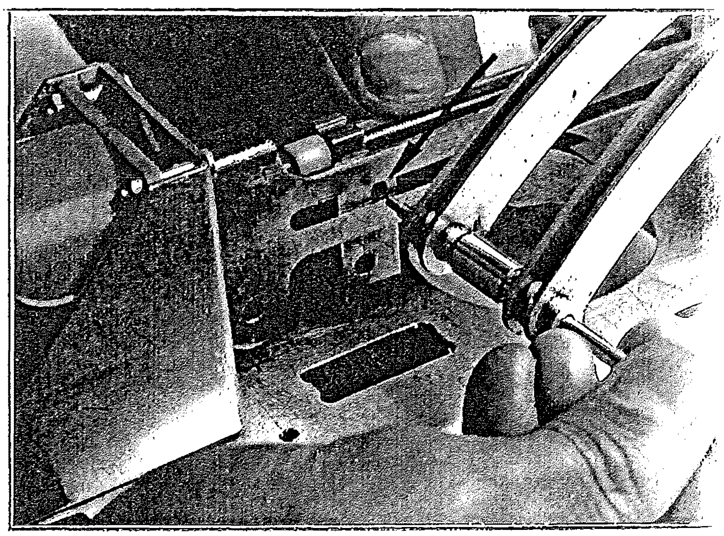


4) Insert the bolt-rod through the hole of the next linkage.



5) Lift the cursor casing slightly and hold it in a position where you can see a 2nd hole on the cursor.

6) Insert the bolt-rod through (both) the gap on the cursor casing and the 2nd hole on the cursor.



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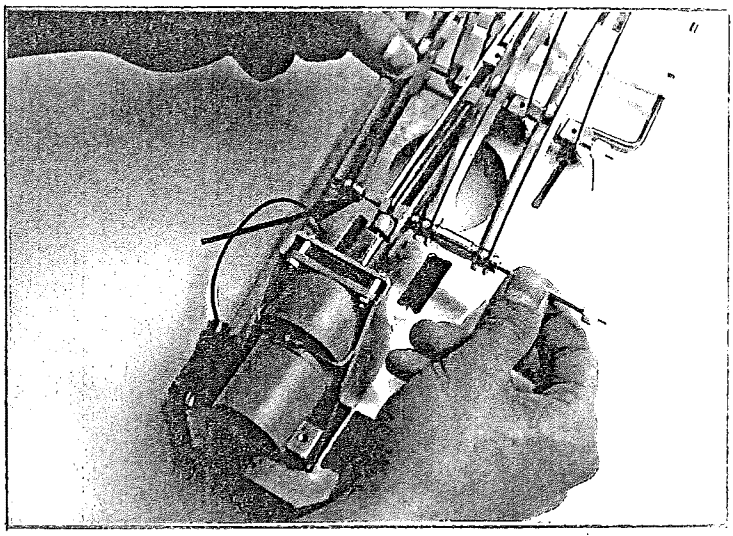
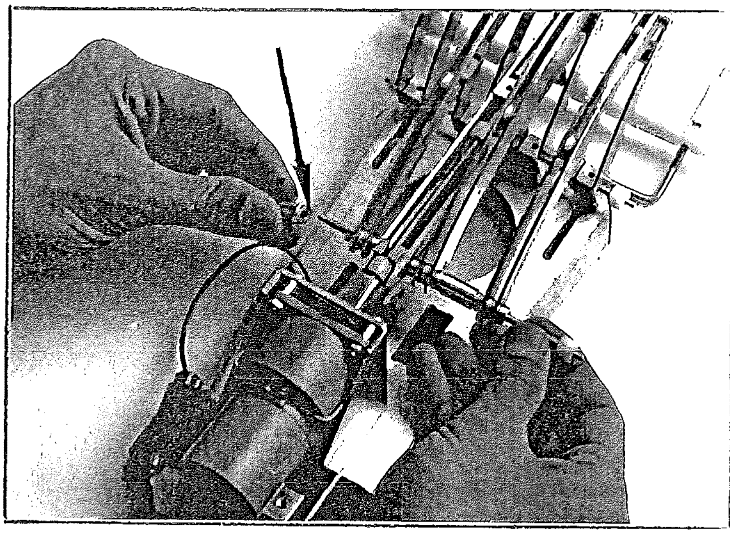
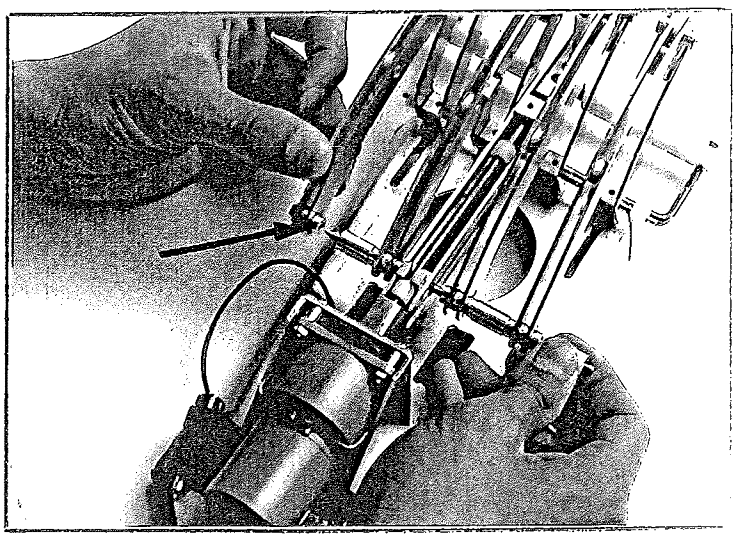
7) Insert the bolt-rod through the next linkage.



8) Insert the bolt-rod through the remaining aluminium spacer.



9) Insert the bolt-rod through the last linkage.



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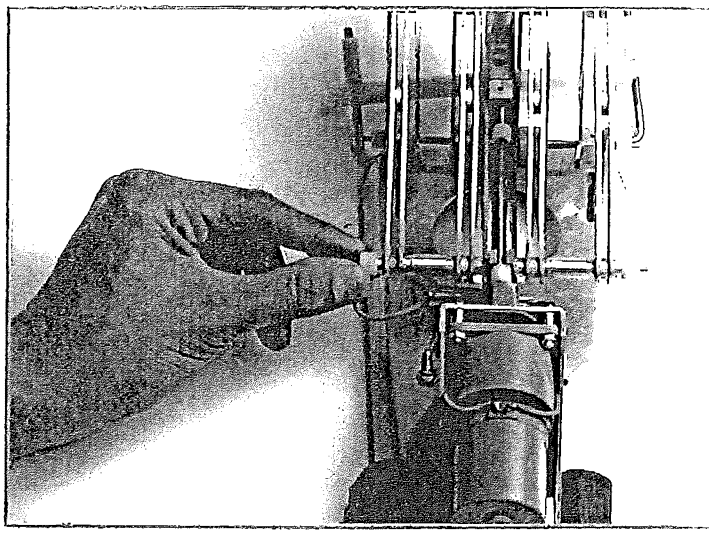
10) Fasten the bolt rod with the remaining plastic nut.

11) Tighten the nut until it stops.



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You have completed the assembly procedure.

Please close the instruction manual.

Testing Procedures

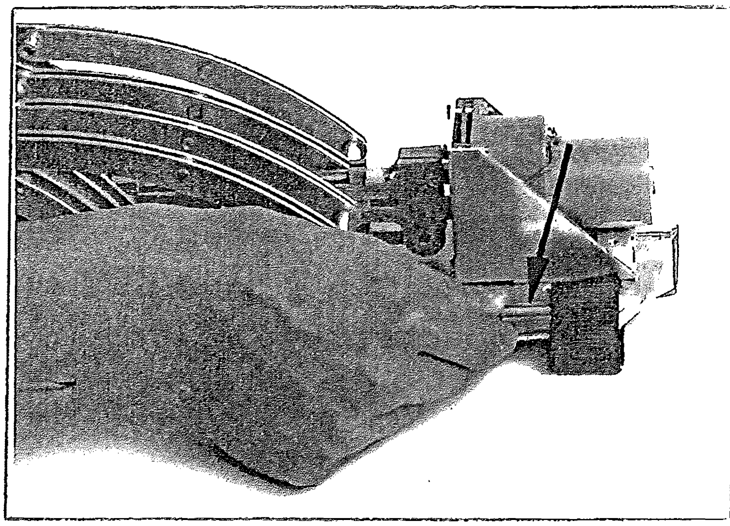
6.0) Testing Procedures

The following procedures allow you to operate and test the finger linkage movements of the CPM unit.

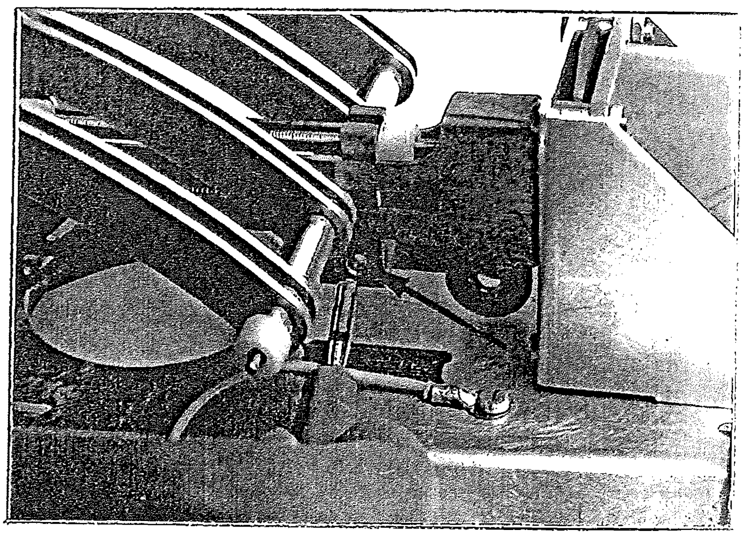
6.1) Inserting the plug into the cursor:

(**Note:** Ensure that the back of the motor unit is facing you).

1) Remove the plug from the velcro strap.



2) Insert the plug through the hole on the cursor up to the black line of the plug.



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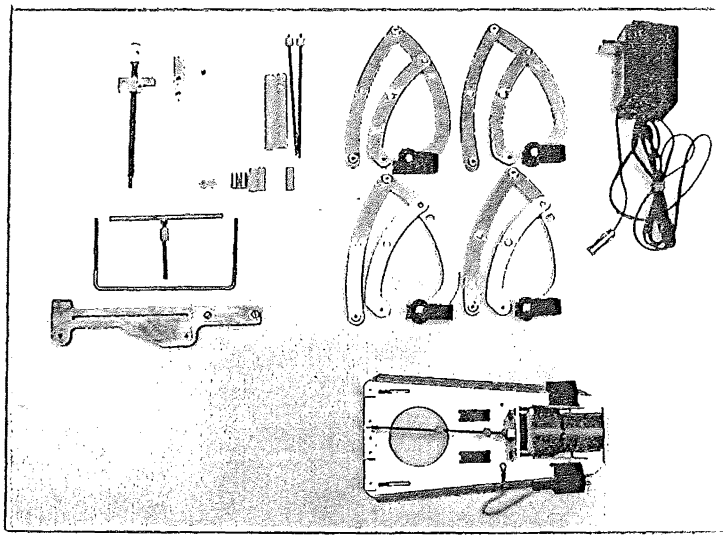
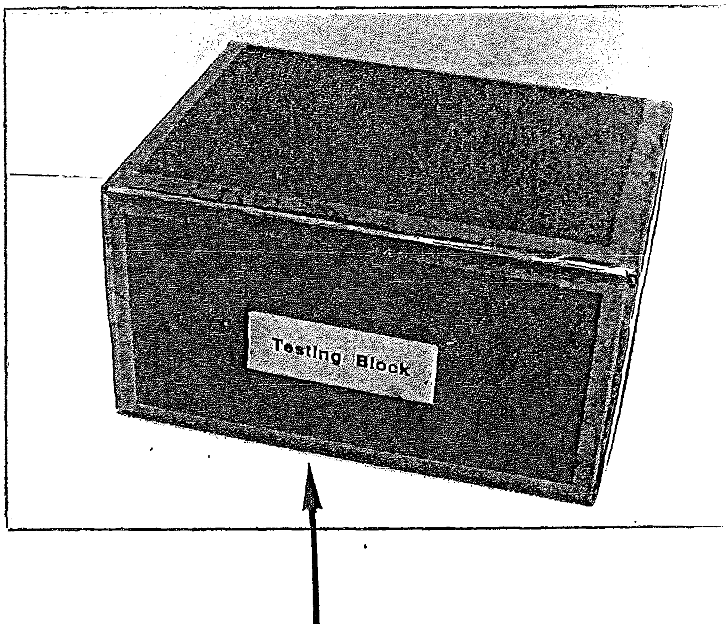
6.2) Testing cursor movement:

1) Select the adapter.



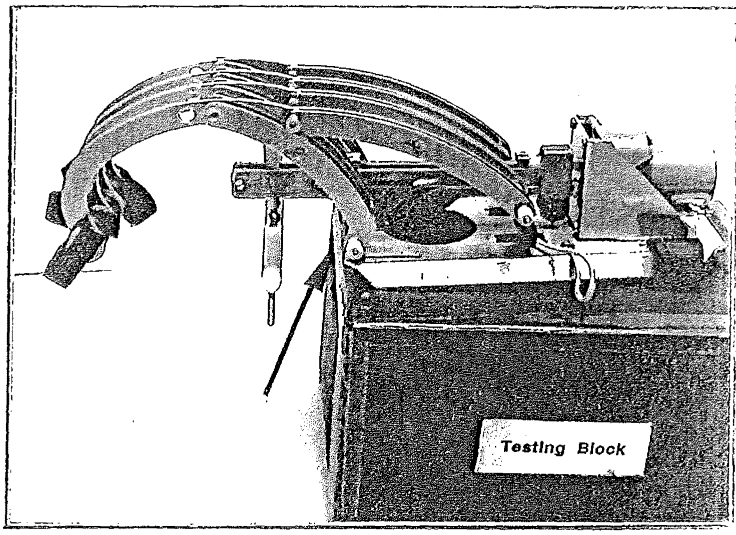
2) Position in front of you the box marked 'TESTING BLOCK'.



(**Note:** The label should be facing you.)

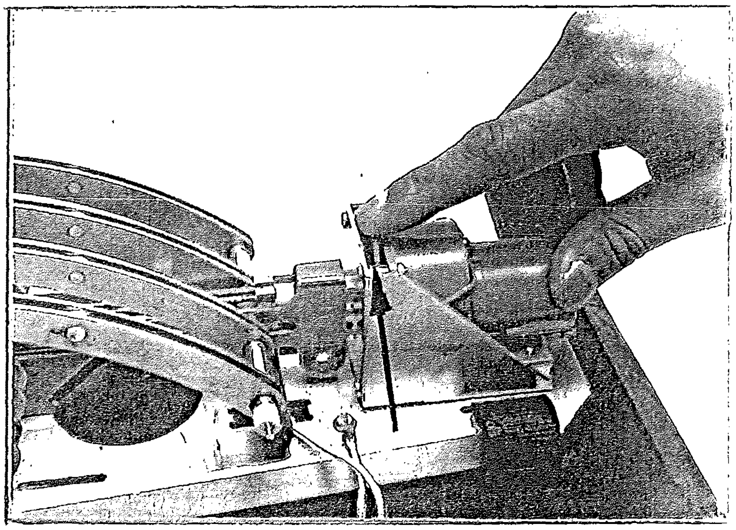
Proceed to the next page.

3) Place the CPM unit on top of the testing block and align the front edge of the CPM unit base-plate with the edge of the block.



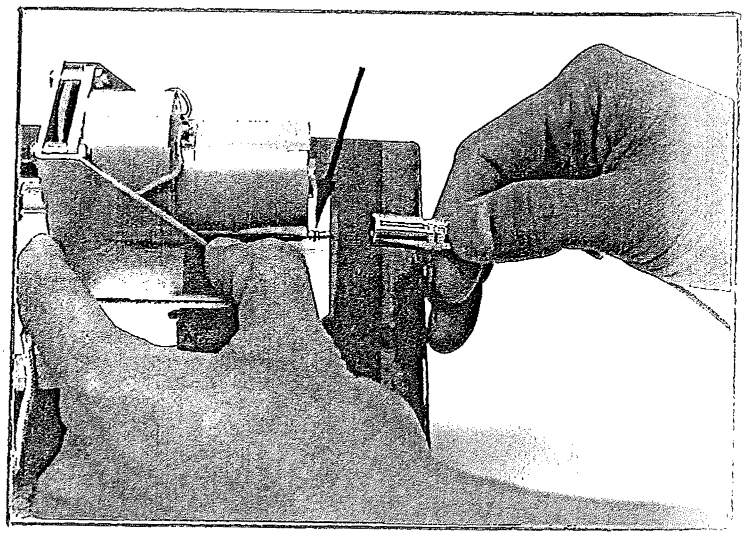
(**Note:** The hand rod should be hanging over the edge of the block.)

4) Pull back the direction switch located at the top of the motor unit until it 'clicks'.



5) With one hand, hold the CPM unit by its motor casing.

6) With your other hand, push the adapter socket into the adapter plug as far as you can (until it 'clicks').



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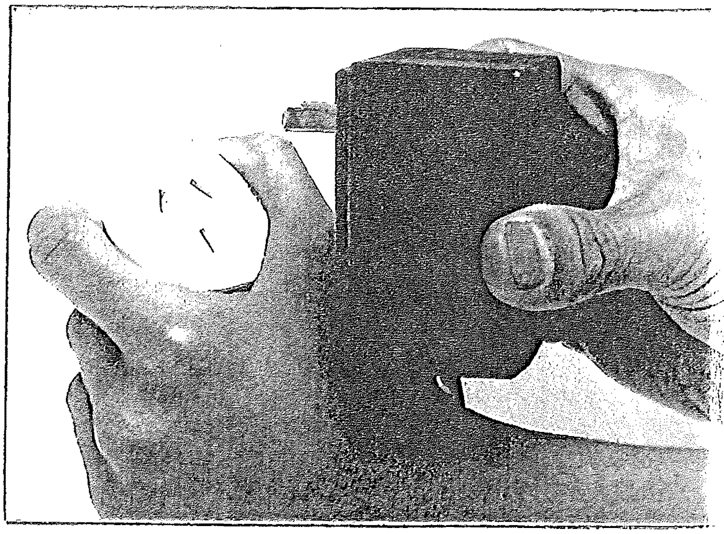
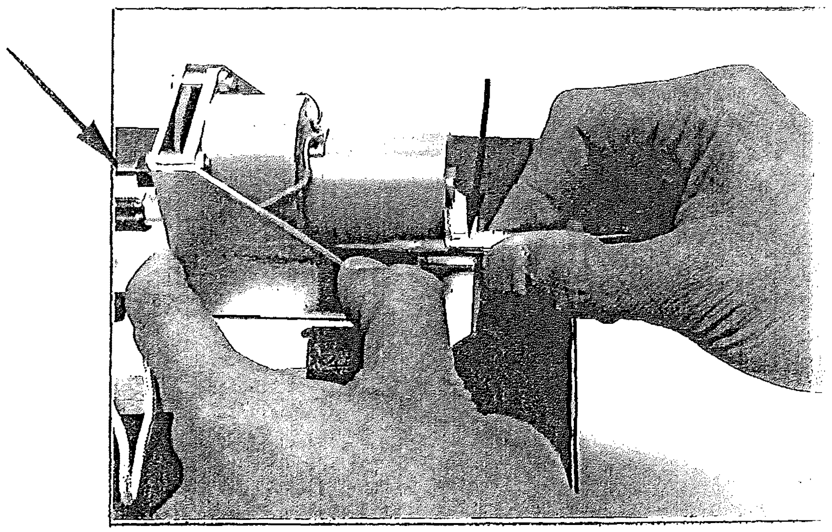
7) Plug the adapter into the extension cord (located on the top right-hand corner of the table.)



(Note: The CPM unit will make a 'roaring' sound as soon as the adapter is plugged into the extension cord.)

The cursor will move forward until it reaches the front (white) plastic nut on the switch rod. The cursor will automatically reverse the motor and move the cursor back towards its original position.

8) Disconnect the adapter socket when the cursor touches the plastic nut on the back end of the switch rod.

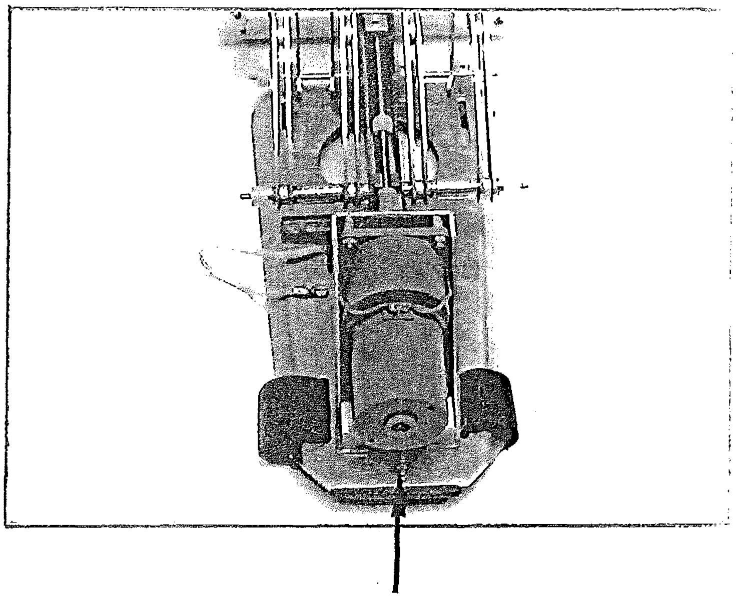


Proceed to the next step.

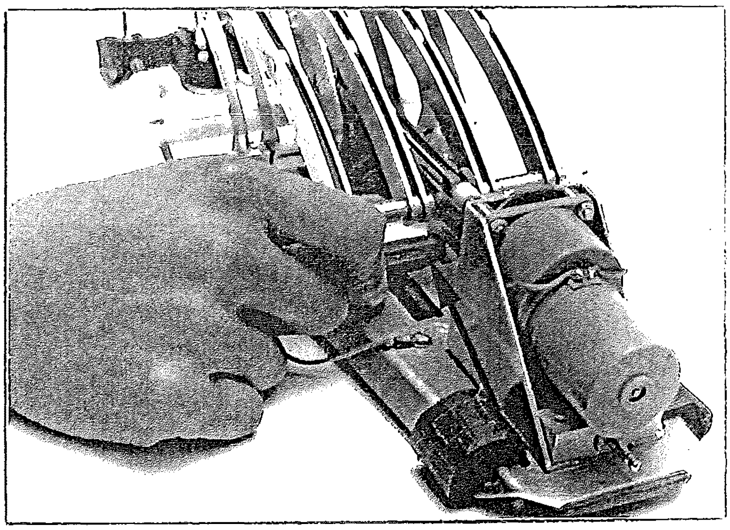
7.0) Test With Plug in Cursor Casing Position

7.1) Inserting plug into the cursor casing:

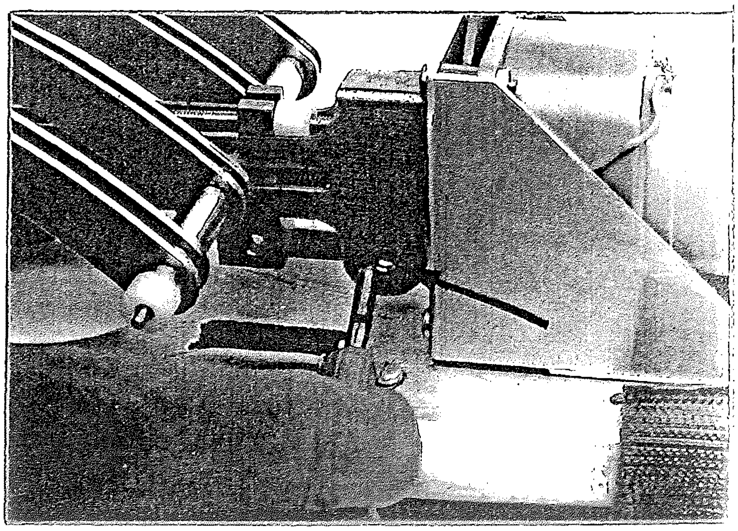
1) Place the CPM unit back on the table so that the back of the motor is facing you.



2) Remove the plug from the cursor.



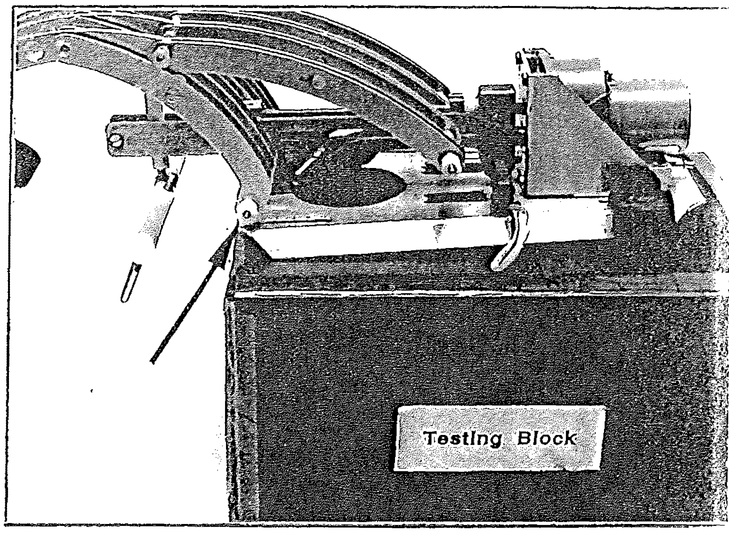
3) Insert the plug through the hole on the back of the cursor casing up to the black line of the plug.



Proceed to the next page.

7.2) Testing cursor movement:

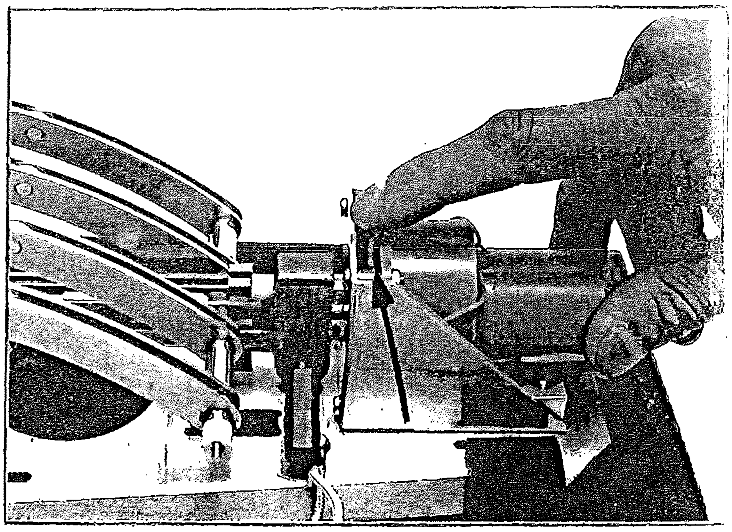
1) Position in front of you the box marked 'TESTING BLOCK'.



2) Place the CPM unit on top of the testing block and align the front edge of the CPM unit base-plate with the edge of the block.

(**Note:** The hand rod should be hanging over the edge of the block.)

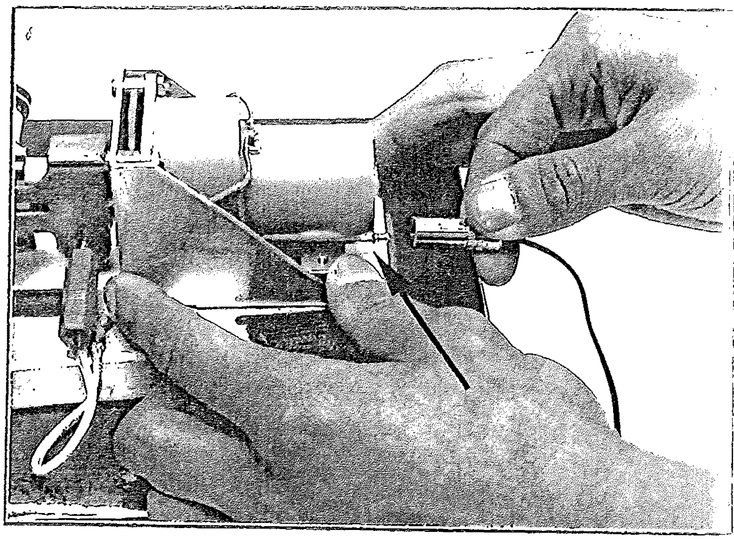
3) Pull back the direction switch located at the top of the motor unit until it 'clicks'.



Proceed to the next page.

4) With one hand, hold the CPM unit by its motor casing.

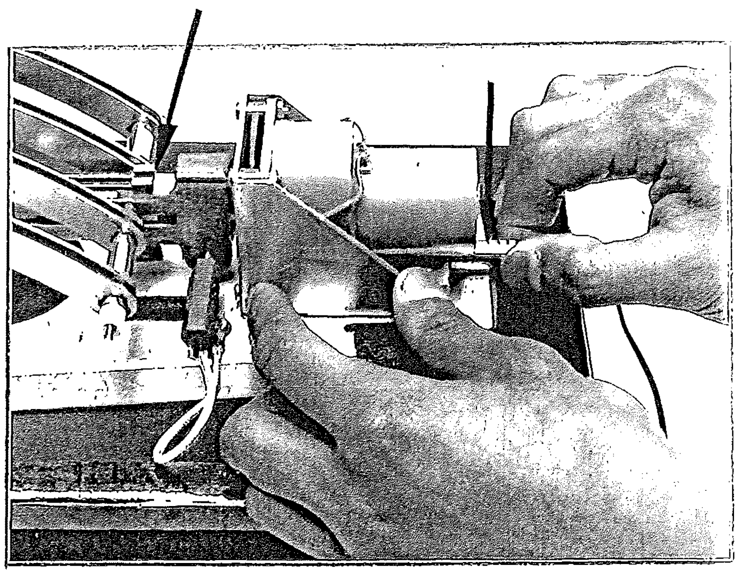
5) With your other hand, push the adapter socket into the adapter plug as far as you can (until it 'clicks').



(**Note:** The CPM unit will make a 'roaring' sound as soon as the adapter socket is pushed into the adapter plug.)

The cursor will move forward until it reaches the front (white) plastic nut on the switch rod. The cursor will automatically reverse the motor and move the cursor back towards its original position.

6) Disconnect the adapter socket when the cursor touches the plastic nut on the back end of the switch rod.



Proceed to the next page.

You have completed the testing procedures.

Please close the instruction manual.

Thank you for your participation.

Appendix 8.

Strategy questionnaire for instruction manual Condition-1.

Questionnaire for instruction manual Condition-1. **Subject code:**________

1) Please report any strategies you used to perform the **assembly** task. (How did you perform the task, did you use any specific method(s) to help you perform the task?)

1a) If you did use a strategy/strategies, please indicate how helpful the strategy/strategies were for you in guiding you to perform the task successfully.

1----------------2---------------3----------------4----------------5---------------6----------------7
Not Helpful ... Very Helpful

1b) Please describe how the strategy/strategies helped you to perform the task.

2) Please indicate the overall effectiveness of the instruction manual (degree of **ease** and/or **understanding**) in guiding you to perform the task successfully.

1----------------2----------------3---------------4----------------5----------------6---------------7
Not Effective ... Very Effective

3) If you were given the task of writing an assembly instruction manual for the CPM unit. What do you think might be helpful in guiding you or another person to perform the task successfully?

Appendix 9.

Strategy questionnaire for instruction manual Condition-2.

Questionnaire for instruction manual Condition-2. **Subject code:____**

1) Please report any strategies you used to perform the **assembly** task.
(How did you perform the task, did you use any specific method(s) to help you perform the task?)

1a) If you did use a strategy/strategies, please indicate how helpful the strategy/ strategies were for you in guiding you to perform the task successfully.

1---------------2----------------3----------------4----------------5----------------6----------------7
Not Helpful ... Very Helpful

1b) Please describe how the strategy/strategies helped you to perform the task.

2) Please indicate the overall effectiveness of the instruction manual (degree of **ease** and/or **understanding**) in guiding you to perform the task successfully.

1---------------2----------------3----------------4----------------5----------------6----------------7
Not Effective ... Very Effective

3) Which type of information in the instruction manual did you find most useful to perform the **assembly** task? Please tick the box.

- ☐ The Picture of the CPM unit.
- ☐ Names of CPM parts.
- ☐ Word instructions.

Condition-2. Subject code:________

3a) **The picture of the CPM unit.**

Please indicate how useful this information was for you in helping you to perform the task successfully.

1---------------2---------------3---------------4---------------5---------------6---------------7
Not Useful — Very Useful

3b) **Names of CPM parts:**

Please indicate how useful this information was for you in helping you to perform the task successfully.

1---------------2---------------3---------------4---------------5---------------6---------------7
Not Useful — Very Useful

3c) **Word instructions:**

Please indicate how useful this information was for you in helping you to perform the task successfully.

1---------------2---------------3---------------4---------------5---------------6---------------7
Not Useful — Very Useful

4) Please describe how the information you found to be **most** useful helped you to perform the task.

5) If you were given the task of writing an assembly instruction manual for the CPM unit. What do you think might be helpful in guiding you or another person to perform the task successfully?

Appendix 10.

Strategy questionnaire for instruction manual Condition-3.

Questionnaire for instruction manual Condition-3. **Subject code:**________

1) Please report any strategies you used to perform the **assembly** task. (How did you perform the task, did you use any specific method(s) to help you perform the task?)

1a) If you did use a strategy/strategies, please indicate how helpful the strategy/ strategies were for you in guiding you to perform the task successfully.

1----------------2----------------3----------------4----------------5----------------6---------------7

Not Helpful | Very Helpful

1b) Please describe how the strategy/strategies helped you to perform the task.

2) Please indicate the overall effectiveness of the instruction manual (degree of **ease** and/or **understanding**) in guiding you to perform the task successfully.

1----------------2----------------3----------------4----------------5----------------6---------------7

Not Effective | Very Effective

3) Which type of information in the instruction manual did you find most useful to perform the **assembly** task? Please tick the box.

☐ Names of CPM parts.

☐ Word instructions.

☐ Step-by-step pictures.

Condition-3. Subject code:_______

3a) **Names of CPM parts:**

Please indicate how useful this information was for you in helping you to perform the task successfully.

1---------------2---------------3---------------4---------------5---------------6---------------7
Not Useful | Very Useful

3b) **Word instructions:**

Please indicate how useful this information was for you in helping you to perform the task successfully.

1---------------2---------------3---------------4---------------5---------------6---------------7
Not Useful | Very Useful

3c) **Step-by-step pictures:**

Please indicate how useful this information was for you in helping you to perform the task successfully.

1---------------2---------------3---------------4---------------5---------------6---------------7
Not Useful | Very Useful

4) Please describe how the information you found to be **most** useful helped you to perform the task.

5) If you were given the task of writing an assembly instruction manual for the CPM unit. What do you think might be helpful in guiding you or another person to perform the task successfully?

Appendix 11.

Strategy questionnaire for instruction manual Condition-4.

Questionnaire for instruction manual Condition-4. **Subject code:_______**

1) Please report any strategies you used to perform the **assembly** task.
(How did you perform the task, did you use any specific method(s) to help you perform the task?)

1a) If you did use a strategy/strategies, please indicate how helpful the strategy/strategies were for you in guiding you to perform the task successfully.

1----------------2----------------3----------------4----------------5----------------6---------------7
Not Helpful — Very Helpful

1b) Please describe how the strategy/strategies helped you to perform the task.

2) Please indicate the overall effectiveness of the instruction manual (degree of **ease** and/or **understanding**) in guiding you to perform the task successfully.

1----------------2----------------3----------------4----------------5----------------6---------------7
Not Effective — Very Effective

3) Which type of information in the instruction manual did you find most useful to perform the **assembly** task? Please tick the box.

☐ Picture of the CPM unit.

☐ Names of CPM parts.

☐ Word instructions.

☐ Step-by-step pictures.

Condition-4 Subject code:_______

3a) **The picture of the CPM unit.**

Please indicate how useful this information was for you in helping you to perform the task successfully.

1---------------2---------------3---------------4---------------5---------------6--------------7
Not Useful | Very Useful

3b) **Names of CPM parts:**

Please indicate how useful this information was for you in helping you to perform the task successfully.

1---------------2---------------3---------------4---------------5---------------6--------------7
Not Useful | Very Useful

3c) **Word instructions:**

Please indicate how useful this information was for you in helping you to perform the task successfully.

1---------------2---------------3---------------4---------------5---------------6--------------7
Not Useful | Very Useful

3d) **Step-by-step pictures:**

Please indicate how useful this information was for you in helping you to perform the task successfully.

1---------------2---------------3---------------4---------------5---------------6--------------7
Not Useful | Very Useful

4) Please describe how the information you found to be **most** useful helped you to perform the task.

5) If you were given the task of writing an assembly instruction manual for the CPM unit. What do you think might be helpful in guiding you or another person to perform the task successfully?

Appendix 12.

Strategy questionnaire for instruction manual Condition-5.

Questionnaire for instruction manual Condition-5. **Subject code:________**

1) Please report any strategies you used to perform the **assembly** task. (How did you perform the task, did you use any specific method(s) to help you perform the task?)

1a) If you did use a strategy/strategies, please indicate how helpful the strategy/strategies were for you in guiding you to perform the task successfully.

1----------------2----------------3----------------4----------------5----------------6---------------7

Not Helpful	Very Helpful

1b) Please describe how the strategy/strategies helped you to perform the task.

2) Please indicate the overall effectiveness of the instruction manual (degree of **ease** and/or **understanding**) in guiding you to perform the task successfully.

1----------------2----------------3----------------4----------------5----------------6---------------7

Not Effective	Very Effective

3) Which type of information in the instruction manual did you find most useful to perform the **assembly** task? Please tick the box.

- ☐ Names of CPM parts.
- ☐ Word instructions.
- ☐ Step-by-step pictures.
- ☐ Arrows depicting manipulation direction or location or parts.

Condition-5 Subject code:________

3a) **Names of CPM parts:**

Please indicate how useful this information was for you in helping you to perform the task successfully.

1---------------2---------------3---------------4---------------5---------------6---------------7
Not Useful   Very Useful

3b) **Word instructions:**

Please indicate how useful this information was for you in helping you to perform the task successfully.

1---------------2---------------3---------------4---------------5---------------6---------------7
Not Useful   Very Useful

3c) **Step-by-step pictures:**

Please indicate how useful this information was for you in helping you to perform the task successfully.

1---------------2---------------3---------------4---------------5---------------6---------------7
Not Useful   Very Useful

3d) **Arrows depicting manipulation direction or location or parts:**

Please indicate how useful this information was for you in helping you to perform the task successfully.

1---------------2---------------3---------------4---------------5---------------6---------------7
Not Useful   Very Useful

4) Please describe how the information you found to be **most** useful helped you to perform the task.

5) If you were given the task of writing an assembly instruction manual for the CPM unit. What do you think might be helpful in guiding you or another person to perform the task successfully?

Appendix 13.

Strategy questionnaire for instruction manual Condition-6.

Questionnaire for instruction manual Condition-6. **Subject code:________**

1) Please report any strategies you used to perform the **assembly** task.
(How did you perform the task, did you use any specific method(s) to help you perform the task?)

1a) If you did use a strategy/strategies, please indicate how helpful the strategy/strategies were for you in guiding you to perform the task successfully.

1----------------2----------------3----------------4----------------5----------------6---------------7
Not Helpful ... Very Helpful

1b) Please describe how the strategy/strategies helped you to perform the task.

2) Please indicate the overall effectiveness of the instruction manual (degree of **ease** and/or **understanding**) in guiding you to perform the task successfully.

1----------------2----------------3----------------4----------------5----------------6---------------7
Not Effective ... Very Effective

3) Which type of information in the instruction manual did you find most useful to perform the **assembly** task? Please tick the box.

- ☐ Picture of the CPM unit.
- ☐ Names of CPM parts.
- ☐ Word instructions.
- ☐ Step-by-step pictures.
- ☐ Arrows depicting manipulation direction or location or parts.

Condition-6 Subject code:_______

3a) **The picture of the CPM unit:**

Please indicate how useful this information was for you in helping you to perform the task successfully.

1---------------2---------------3---------------4---------------5---------------6---------------7
Not Useful ... Very Useful

3b) **Names of CPM parts:**

Please indicate how useful this information was for you in helping you to perform the task successfully.

1---------------2---------------3---------------4---------------5---------------6---------------7
Not Useful ... Very Useful

3c) **Word instructions:**

Please indicate how useful this information was for you in helping you to perform the task successfully.

1---------------2---------------3---------------4---------------5---------------6---------------7
Not Useful ... Very Useful

3d) **Step-by-step pictures:**

Please indicate how useful this information was for you in helping you to perform the task successfully.

1---------------2---------------3---------------4---------------5---------------6---------------7
Not Useful ... Very Useful

3e) **Arrows depicting manipulation direction or location or parts:**

Please indicate how useful this information was for you in helping you to perform the task successfully.

1---------------2---------------3---------------4---------------5---------------6---------------7
Not Useful ... Very Useful

Condition-6 Subject code:________

4) Please describe how the information you found to be **most** useful helped you to perform the task.

5) If you were given the task of writing an assembly instruction manual for the CPM unit. What do you think might be helpful in guiding you or another person to perform the task successfully?

Appendix 14.

Strategy questionnaire for instruction manual Condition-7.

Questionnaire for instruction manual Condition-7. **Subject code:____**

1) Please report any strategies you used to perform the **assembly** task.
(How did you perform the task, did you use any specific method(s) to help you perform the task?)

1a) If you did use a strategy/strategies, please indicate how helpful the strategy/ strategies were for you in guiding you to perform the task successfully.

1----------------2----------------3----------------4----------------5----------------6---------------7
Not Helpful ... Very Helpful

1b) Please describe how the strategy/strategies helped you to perform the task.

2) Please indicate the overall effectiveness of the instruction manual (degree of **ease** and/or **understanding**) in guiding you to perform the task successfully.

1----------------2----------------3----------------4----------------5----------------6---------------7
Not Effective ... Very Effective

3) Which type of information in the instruction manual did you find most useful to perform the **assembly** task? Please tick the box.

- ☐ Picture of the CPM unit.
- ☐ Names of CPM parts.
- ☐ Word instructions.
- ☐ Step-by-step pictures.
- ☐ Arrows depicting manipulation direction or location of parts.

Condition-7 Subject code:_______

3a) **The picture of the CPM unit.**

Please indicate how useful this information was for you in helping you to perform the task successfully.

1---------------2---------------3---------------4---------------5---------------6---------------7
Not Useful — Very Useful

3b) **Names of CPM parts:**

Please indicate how useful this information was for you in helping you to perform the task successfully.

1---------------2---------------3---------------4---------------5---------------6---------------7
Not Useful — Very Useful

3c) **Word instructions:**

Please indicate how useful this information was for you in helping you to perform the task successfully.

1---------------2---------------3---------------4---------------5---------------6---------------7
Not Useful — Very Useful

3d) **Step-by-step pictures:**

Please indicate how useful this information was for you in helping you to perform the task successfully.

1---------------2---------------3---------------4---------------5---------------6---------------7
Not Useful — Very Useful

3e) **Arrows depicting manipulation direction or location of parts:**

Please indicate how useful this information was for you in helping you to perform the task successfully.

1---------------2---------------3---------------4---------------5---------------6---------------7
Not Useful — Very Useful

Condition-7 Subject code: __________

4) Please describe how the information you found to be **most** useful helped you to perform the task.

5) If you were given the task of writing an assembly instruction manual for the CPM unit. What do you think might be helpful in guiding you or another person to perform the task successfully?

Appendix 15.

Strategy questionnaire for instruction manual Condition-8.

Questionnaire for instruction manual Condition-8. **Subject code:________**

1) Please report any strategies you used to perform the **assembly** task.
(How did you perform the task, did you use any specific method(s) to help you perform the task?)

1a) If you did use a strategy/strategies, please indicate how helpful the strategy/strategies were for you in guiding you to perform the task successfully.

1----------------2----------------3----------------4----------------5----------------6---------------7
Not Helpful — Very Helpful

1b) Please describe how the strategy/strategies helped you to perform the task.

2) Please indicate the overall effectiveness of the instruction manual (degree of **ease** and/or **understanding**) in guiding you to perform the task successfully.

1----------------2----------------3----------------4----------------5----------------6---------------7
Not Effective — Very Effective

3) Which type of information in the instruction manual did you find most useful to perform the **assembly** task? Please tick the box.

- ☐ Picture of the CPM unit.
- ☐ Names of CPM parts.
- ☐ Word instructions.
- ☐ Step-by-step pictures.
- ☐ Arrows depicting manipulation location or location of parts.

Condition-8 Subject code:_______

3a) **The picture of the CPM unit.**

Please indicate how useful this information was for you in helping you to perform the task successfully.

1---------------2---------------3---------------4---------------5---------------6---------------7
Not Useful | Very Useful

3b) **Names of CPM parts:**

Please indicate how useful this information was for you in helping you to perform the task successfully.

1---------------2---------------3---------------4---------------5---------------6---------------7
Not Useful | Very Useful

3c) **Word instructions:**

Please indicate how useful this information was for you in helping you to perform the task successfully.

1---------------2---------------3---------------4---------------5---------------6---------------7
Not Useful | Very Useful

3d) **Step-by-step pictures:**

Please indicate how useful this information was for you in helping you to perform the task successfully.

1---------------2---------------3---------------4---------------5---------------6---------------7
Not Useful | Very Useful

3e) **Arrows depicting manipulation location or location of parts:**

Please indicate how useful this information was for you in helping you to perform the task successfully.

1---------------2---------------3---------------4---------------5---------------6---------------7
Not Useful | Very Useful

Condition-8 Subject code:________

4) Please describe how the information you found to be **most** useful helped you to perform the task.

5) If you were given the task of writing an assembly instruction manual for the CPM unit. What do you think might be helpful in guiding you or another person to perform the task successfully?

Appendix 16.

Strategy questionnaire for instruction manual Condition-9.

Questionnaire for instruction manual Condition-9. **Subject code:________**

1) Please report any strategies you used to perform the **assembly** task.
(How did you perform the task, did you use any specific method(s) to help you perform the task?)

1a) If you did use a strategy/strategies, please indicate how helpful the strategy/strategies were for you in guiding you to perform the task successfully.

1----------------2----------------3----------------4----------------5----------------6---------------7
Not Helpful ... Very Helpful

1b) Please describe how the strategy/strategies helped you to perform the task.

2) Please indicate the overall effectiveness of the instruction manual (degree of **ease** and/or **understanding**) in guiding you to perform the task successfully.

1----------------2----------------3----------------4----------------5----------------6---------------7
Not Effective ... Very Effective

3) Which type of information in the instruction manual did you find most useful to perform the **assembly** task? Please tick the box.

- ☐ Picture of the CPM unit.
- ☐ Names of CPM parts.
- ☐ Word instructions.
- ☐ Step-by-step pictures.
- ☐ Arrows depicting manipulation location.

Condition-9 Subject code:_______

3a) **The picture of the CPM unit.**

Please indicate how useful this information was for you in helping you to perform the task successfully.

1---------------2---------------3---------------4---------------5---------------6---------------7
Not Useful ... Very Useful

3b) **Names of CPM parts:**

Please indicate how useful this information was for you in helping you to perform the task successfully.

1---------------2---------------3---------------4---------------5---------------6---------------7
Not Useful ... Very Useful

3c) **Word instructions:**

Please indicate how useful this information was for you in helping you to perform the task successfully.

1---------------2---------------3---------------4---------------5---------------6---------------7
Not Useful ... Very Useful

3d) **Step-by-step pictures:**

Please indicate how useful this information was for you in helping you to perform the task successfully.

1---------------2---------------3---------------4---------------5---------------6---------------7
Not Useful ... Very Useful

3e) **Arrows depicting manipulation location:**

Please indicate how useful this information was for you in helping you to perform the task successfully.

1---------------2---------------3---------------4---------------5---------------6---------------7
Not Useful ... Very Useful

Condition-9 Subject code: __________

4) Please describe how the information you found to be **most** useful helped you to perform the task.

5) If you were given the task of writing an assembly instruction manual for the CPM unit. What do you think might be helpful in guiding you or another person to perform the task successfully?

Appendix 17.

The error feedback sheet.

Appendix 17. Error feedback sheet

Error feedback Subject code: __________

You have incorrectly performed step(s):

During the assembly/testing procedure.

Error Correction Instructions:

1) Perform the task as accurately and as fast as you can.

2) Please follow the procedures and notes in a step by step manner.

3) Please close the instruction manual when you have finished the correction(s).

4) Begin correcting the error(s).

Appendix 18.

Performance data sheet.

Name: ____________________ Condition: ☐ Pre-Pilot test

☐ Pilot test

Date: ________ ☐ Experiment

☐ 1 ☐ 4 ☐ 7

☐ 2 ☐ 5 ☐ 8

Subject Code: ________

☐ 3 ☐ 6 ☐ 9

☐ **Assembly**

PERFORMANCE CLASSIFICATION:

Incorrect procedure(s)	Comment	Extra procedure(s)	Comment	Procedure(s) omitted	Comment	Refer to CPM Names	Pic.	Unsuccessful Assembly
1)								
2)								
3)								
4)								
5)								
6)								
7)								
8)								
9)								
10)								
11)								
12)								
13)								
14)								
15)								
16)								
17)								
18)								
19)								
20)								
21)								
22)								
Total								

☐ **Unsuccessful Assembly**

Incorrect procedure(s)	Comment	Extra procedure(s)	Comment	Procedure(s) omitted	Comment	Refer to CPM Names	Pic.	Unsuccessful Assembly
1)								
2)								
3)								
4)								
5)								
6)								
7)								
8)								
9)								
10)								
Total								

INSTRUCTION READING TIME: __________ 2) __________ 3) __________

ASSEMBLY TIME: __________ 2) __________ 3) __________

TESTING TIME: __________ 2) __________ 3) __________

Name: ____________________ Condition: ☐ Pre-Pilot test

☐ Pilot test

Date: ________ ☐ Experiment

☐ 1 ☐ 4 ☐ 7

Subject Code: ________ ☐ 2 ☐ 5 ☐ 8

☐ Testing ☐ 3 ☐ 6 ☐ 9

PERFORMANCE CLASSIFICATION:

Incorrect procedure(s)	Comment	Extra procedure(s)	Comment	Procedure(s) omitted	Comment	Refer to CPM Names	Refer to CPM Pic.	Unsuccessful Testing
1)								
2)								
3)								
4)								
5)								
6)								
7)								
8)								
9)								
10)								
Total								

☐ **Unsuccessful Testing**

Incorrect procedure(s)	Comment	Extra procedure(s)	Comment	Procedure(s) omitted	Comment	Refer to CPM Names	Refer to CPM Pic.	Unsuccessful Testing
1)								
2)								
3)								
4)								
5)								
6)								
7)								
8)								
9)								
10)								
Total								

Appendix 19.

Incentive scheme raffle form.

Appendix 19. Incentive scheme raffle form.

PILOT RAFFLE

Name: ____________________

Contact number: _____________

Address: ___________________

____

Subject code: ________________

PILOT RAFFLE

Name: ____________________

Contact number: _____________

Address: ___________________

____

Subject code: ________________

EXPERIMENTAL RAFFLE

Name: ____________________

Contact number: _____________

Address: ___________________

____

Subject code: ________________

EXPERIMENTAL RAFFLE

Name: ____________________

Contact number: _____________

Address: ___________________

____

Subject code: ________________

Appendix 20.

Summary of Results.

Table R-1: One-way ANOVA and multiple range comparisons for the mean length of time taken to read the introductory materials.

Oneway Analysis of Variance

Source of Variation

Time to Read Introductory Material by Manual Condition	df	Sum of Squares	Mean Square	F	P
Between groups	8	14.4526	1.8066	0.5934	n.s.
Within groups	90	274.0075	3.0455	—	—
Total	98	288.4601	—	—	—

Multiple Range Test (Newman Keuls', 0.05 level)

* denotes pair of groups significantly different

Source of Variation: Time to Read Introductory Material by Manual Condition

Mean	Condition:	6	5	7	3	4	8	1	2	9

No two Conditions were significantly different at the 0.05 level.

Table R-2: One-way ANOVA and multiple range comparisons for the mean length of time taken to assemble the unit.

Oneway Analysis of Variance

Source of Variation

Time to Assemble by Manual Condition	df	Sum of Squares	Mean Square	F	P
Between groups	8	4540.0292	576.5037	12.0240	0.001
Within groups	90	4247.7796	47.1976	—	—
Total	98	8787.8088	—	—	—

Multiple Range Test (Newman Keuls', 0.05 level)

* denotes pair of groups significantly different

Source of Variation: Time to assemble by Manual Condition

Mean	Condition	6	8	7	5	9	3	4	2	1
29.7855	2	*	*	*	*	*	*	*		
38.9136	1	*	*	*	*	*	*	*	*	

Table R-3: One-way ANOVA and multiple range comparisons for the mean number of incorrect procedures made during the assembly procedures.

Oneway Analysis of Variance

Source of Variation

Incorrect Procedures by Manual Condition	df	Sum of Squares	Mean Square	F	P
Between groups	8	2671.5354	333.9419	14.1963	0.001
Within groups	90	2117.0909	23.5332	—	—
Total	98	4788.6263	—	—	—

Multiple Range Test (Newman Keuls', 0.05 level)

* denotes pair of groups significantly different

Source of Variation: Incorrect Procedures by Manual Condition

Mean	Condition:	6	8	5	9	3	7	4	2	1
9.7273	2	*	*	*	*	*	*	*		
19.9091	1	*	*	*	*	*	*	*	*	

Table R-4: One-way ANOVA and multiple range comparisons for the mean number of procedures omitted during the assembly procedures.

Oneway Analysis of Variance

Source of Variation

Procedures Omitted by Manual Condition	df	Sum of Squares	Mean Square	F	P
Between groups	8	11.7172	1.4646	2.2377	0.05
Within groups	90	58.9091	0.6545	—	—
Total	98	70.6263	—	—	—

Multiple Range Test (Newman Keuls', 0.05 level)

* denotes pair of groups significantly different

Source of Variation: Procedures Omitted by Manual Condition

Mean	Condition:	6	2	9	5	7	8	4	1	3
0.9091	1	*	*	*	*	*				
1.0000	3	*	*	*	*	*	*			

Table R-5: One-way ANOVA and multiple range comparisons for the mean number of extra procedures made during the assembly procedures.

Oneway Analysis of Variance
Source of Variation

Extra Procedures by Manual Condition	df	Sum of Squares	Mean Square	F	P
Between groups	8	353.8182	44.2273	9.1333	0.001
Within groups	90	435 8182	4.8424	—	—
Total	98	789.6364	—	—	—

Multiple Range Test (Newman Keuls', 0.05 level)
*denotes pair of groups significantly different

Source of Variation: Extra Procedures by Manual Condition

Mean	Condition:	7	5	8	9	6	3	4	2	1
4.4545	2	*	*	*	*	*	*	*		
7.2727	1	*	*	*	*	*	*	*	*	

Table R-6: One-way ANOVA and multiple range comparisons for the mean number of references made to the names of CPM parts during the assembly procedures.

Oneway analysis of Variance
Source of Variation

References to names of CPM parts by Manual Condition	df	Sum of Squares	Mean Square	F	P
Between groups	8	2985.8384	373.2298	15.5591	0.001
Within groups	90	2158.9091	23.9879	—	—
Total	98	5144.7475	—	—	—

Multiple range Test Newman Keuls'. 0.05 level)
* denotes pair of groups significantly different

Source of Variation: References to names of CPM parts by Manual Condition

Mean	Condition	6	8	5	9	7	3	4	2	1
4.3636	9	*	*							
4.8182	7	*	*							
8.2727	3	*	*	*						
9.5455	4	*	*	*	*	*				
11.6364	2	*	*	*	*	*				
17.6363	1	*	*	*	*	*	*	*	*	

Table R-7: One-way ANOVA and multiple range comparisons for the mean number of references made to a picture of the goal during the assembly procedures.

Oneway analysis of Variance
Source of Variation

References to a picture of the goal by Manual Condition	df	Sum of Squares	Mean Square	F	P
Between groups	5	78.4314	15.6879	6.3289	0.0001
Within groups	60	148.7273	2.4788	—	—
Total	65	227.1667	—	—	—

Multiple ranqe Test Newman Keuls', 0.05 level)
* denotes pair of groups significantly different

Source of Variation: References to a picture of the goal by Manual Condition

Mean	Condition	6	7	9	8	4	2
3.1818	2	*	*	*	*	*	

Table R-8: One-way ANOVA and multiple range comparisons for the mean number of unsuccessful assemblies in each instruction manual condition.

Oneway Analysis of Variance
Source of Variation

Performance Classification by Manual Condition	df	Sum of Squares	Mean Square	F	P
Between groups	8	7.5960	0.9495	5.6627	0.001
Within groups	90	15.0909	0.1677	—	—
Total	98	22.6869	—	—	—

Multiple Range Test (Newman Keuls', 0.05 level)
* denotes pair of groups significantly different

Source of Variation: Performance Classification by Manual Condition

Mean	Condition:	6	8	4	7	9	5	3	2	1
1.3636	3	*	*							
1.4545	2	*	*	*	*	*				
1.9091	1	*	*	*	*	*	*	*	*	

Table R-9: One-way ANOVA and multiple range comparisons for the mean length of time taken to test the CPM unit.

Oneway Analysis of Variance

Source of Variation

Time to Test CPM unit by Manual Condition	df	Sum of Squares	Mean Square	F	P
Between groups	8	86.2181	10.7773	2.6014	0.01
Within groups	90	372.8611	4.1429	—	—
Total	98	459.0792	—	—	—

Multiple Range Test (Newman Keuls', 0.05 level)

* denotes pair of groups significantly different

Source of Variation: Time to test CPM unit by Manual Condition

Mean	Condition:	6	9	7	4	5	8	3	2	1
8.6455	2	*	*	*	*	*	*			
8.7873	1	*	*	*	*	*	*			

Table R-10: One-way ANOVA and multiple range comparisons for the mean number of incorrect procedures made during the testing procedures.

Oneway Analysis of Variance

Source of Variation

Incorrect Procedures by Manual Condition	df	Sum of Squares	Mean Square	F	P
Between groups	8	80.9293	10.1162	2.2855	0.05
Within groups	90	398.3636	4.4263	—	—
Total	98	479.2929	—	—	—

Multiple Range Test (Newman Keuls', 0.05 level)

* denotes pair of groups significantly different

Source of Variation: Incorrect Procedures by Manual Condition

Mean	Condition:	8	5	6	7	9	4	3	2	1
5.0000	1	*	*	*	*	*	*	*		

Table R-11: One-way ANOVA and multiple range comparisons for the mean number of procedures omitted during the testing procedures.

Oneway Analysis of Variance

Source of Variation

Procedures Omitted by Manual Condition	df	Sum of Squares	Mean Square	F	P
Between groups	8	8.7273	1.0909	0.7171	n.s.
Within groups	90	136.9091	1.5212	—	—
Total	98	145.6364	—	—	—

Multiple Range Test (Newman Keuls', 0.05 level)

* denotes pair of groups significantly different

Source of Variation: Procedures Omitted by Manual Condition

Mean	Condition:	5	6	3	8	9	7	1	4	2
1.2727	2	*								

Table R-12: One-way ANOVA and multiple range comparisons for the mean number of extra procedures made during the testing procedures.

Oneway Analysis of Variance

Source of Variation

Extra Procedures by Manual Condition	df	Sum of Squares	Mean Square	F	P
Between groups	8	29.0909	3.6364	3.0560	0.005
Within groups	90	107.0909	1.1899	—	—
Total	98	136.1818	—	—	—

Multiple Range Test (Newman Keuls', 0.05 level)

* denotes pair of groups significantly different

Source of Variation: Extra Procedures by Manual Condition

Mean	Condition:	6	8	9	7	5	3	4	2	1
1.2727	2	*	*							
2.0909	1	*	*	*	*	*	*	*		

Table R-13: One-way ANOVA and multiple range comparisons for the mean number of references made to the names of CPM parts during the testing procedures.

Oneway analysis of Variance
Source of Variation

References to names of CPM parts by Manual Condition	df	Sum of Squares	Mean Square	F	P
Between groups	8	77.2323	9.6540	5.4614	0.001
Within groups	90	159.0909	1.7677	—	—
Total	98	236.3232	—	—	—

Multiple range Test Newman Keuls', 0.05 level)
* denotes pair of groups significantly different

Source of Variation: References to names of CPM parts by Manual Condition

Mean	Condition	6	8	5	7	9	4	3	2	1
1.3636	2	*	*	*	*	*				
2.8182	1	*	*	*	*	*	*	*	*	

Table R-14: One-way ANOVA and multiple range comparisons for the mean number of references made to a picture of the goal during the testing procedures.

Oneway analysis of Variance
Source of Variation

References to a picture of the goal by Manual Condition	df	Sum of Squares	Mean Square	F	P
Between groups	5	0.3030	0.0606	1.0000	0.4256
Within groups	60	3.6364	0.0606	—	—
Total	65	3.9394	—	—	—

Multiple range Test Newman Keuls', 0.05 level)
* denotes pair of groups significantly different

Source of Variation: References to a picture of the goal by Manual Condition

Mean	Condition	4	6	7	8	9	2
0.1818	2	*	*	*	*	*	

Table R-15: One-way ANOVA and multiple range comparisons for the mean number of unsuccessful testing.

Oneway Analysis of Variance

Source of Variation

Performance Classification by Manual Condition	df	Sum of Squares	Mean Square	F	P
Between groups	8	0.8081	0.1010	0.6849	n.s.
Within groups	90	13.2727	0.1475	—	—
Total	98	14.0808	—	—	—

Multiple Range Test (Newman Keuls', 0.05 level)

* denotes pair of groups significantly different

Source of Variation: Performance Classification by Manual Condition

Mean	Condition:	1	8	2	3	4	5	7	9	6
1.3636	6	*								

Table R-16: One-way ANOVA and multiple range comparisons for the mean ratings of manual effectiveness during the assembly procedures.

Oneway Analysis of Variance

Source of Variation

Effectiveness of Manual by Manual Condition	df	Sum of Squares	Mean Square	F	P
Between groups	8	33.0909	4.1364	2.4346	0.01
Within groups	90	152.9091	1.6990	—	—
Total	98	186.0000	—	—	—

Multiple Range Test (Newman Keuls', 0.05 level)

* denotes pair of groups significantly different

Source of Variation: Effectiveness of Manual by Manual Condition

Mean	Condition:	8	6	3	5	9	4	7	2	1
6.4545	8								*	*
4.3636	1	*	*	*	*	*	*	*		

Table R-17: One-way ANOVA and multiple range comparisons for the mean ratings of strategy effectiveness during the assembly procedures.

Oneway Analysis of Variance

Source of Variation Effectiveness of Strategy by Manual Condition	df	Sum of Squares	Mean Square	F	P
Between groups	8	57.2727	7.1591	17.7371	n.s.
Within groups	90	370.0991	4.1212	—	—
Total	98	428.1818	—	—	—

Multiple Range Test (Newman Keuls', 0.05 level)
* denotes pair of groups significantly different

Source of Variation: Effectiveness of Strategy by Manual Condition

Mean	Condition:	9	4	6	7	2	5	3	8	1
3.3636	1	*	*	*	*	*				

Table R-18: 2 X 3 MANOVA for performance during the assembly procedures.

Multivariate Tests of Significance

Source of Variation	Test Name	df	Error	F	P
Supplementary Information by Base Information	Hotellings	12	108	1.38066	n.s.
Supplementary Information	Hotellings	6	55	2.27859	0.05
Base Information	Hotellings	12	108	9.47482	0.0001

Table R-19: Univariate F-tests for performance effects as a function of a picture of the goal during the assembly procedures.

Univariate F-tests with (1 ,60) D. F

Source of Variation	Variable	Hypothesis Sum of Squares	Hypothesis Mean Square	Error Sum of Squares	Error Mean Square	F	P
Supplementary Information	1) Time	200.274	200.274	3181.988	53.033	3.776	n.s.
	2) Incorrect Procedures	190.061	190.061	1891.636	31.527	6.028	0.05
	3) Procedures Omitted	4.379	4.379	52.182	0.870	5.035	0.05
	4) Extra Procedures	8.015	8.015	372.182	6.203	1.292	n.s.
	5) References to Names of CPM parts	70.061	70.061	1864.182	31.070	2.254	n.s.
	6) Performance Classification	1.833	1.833	13.273	0.221	8.288	0.01

Table R-20: Univariate F-tests for performance effects as a function of step-by-step pictures or the combination of ADD, ADL and ALP during the assembly procedures.

Univariate F-tests with (2,60) D. F.

Source of Variation	Variable	Hypothesis Sum of Squares	Hypothesis Mean Square	Error Sum of Squares	Error Mean Square	F	P
Base Information	1) Time	3378.685	1689.343	3181.988	53.033	31.854	0.0001
	2) Incorrect Procedures	1752.848	876.424	1891.636	31.527	27.800	0.0001
	3) Procedures Omitted	4.576	2.288	52.182	0.870	2.631	n.s.
	4) Extra Procedures	239.121	119.561	372.182	6.203	19.274	0.0001
	5) References to Names of CPM parts	2091.758	1045.879	1864.182	31.070	33.662	0.0001
	6) Performance Classification	3.758	1.879	13.273	0.211	8.493	0.001

Table R-21: Univariate F-tests for performance interaction during the assembly procedures.

Univariate F-tests with (2,60) D. F

Source of Variation	Variable	Hypothesis Sum of Squares	Hypothesis Mean Square	Error Sum of Squares	Error Mean Square	F	P
Supplementary Information by Base Information	1) Time	303.413	151.706	3181.988	53.033	2.861	n.s.
	2) Incorrect Procedures	389.212	194.606	1891.636	31.527	6.173	0.005
	3) Procedures Omitted	1.121	0.561	52.182	0.870	0.645	n.s.
	4) Extra Procedures	37.121	18.561	372.182	6.203	2.992	n.s.
	5) References to Names of CPM parts	148.485	74.242	1864.182	31.070	2.390	n.s.
	6) Performance Classification	0.121	0.061	13.273	0.221	0.274	n.s.

Table R-22: 2 X 3 MANOVA for performance during the testing procedures.

Multivariate Tests of Significance

Source of Variation	Test Name	df	Error	F	P
Supplementary Information by Base information	Hotellings	12	108	1.18783	n.s.
Supplementary Information	Hotellings	6	55	1.97869	n.s.
Base Information	Hotellings	12	108	5.02008	0.0001

Table R-23: Univariate F-tests for performance effects as a function of a picture of the goal during the testing procedures.

Univariate F-tests with (1 ,60) D. F

Source of Variation	Variable	Hypothesis Sum of Squares	Hypothesis Mean Square	Error Sum of Squares	Error Mean Square	F	P
Supplementary Information	1) Time	3.116	3.116	284.784	4.746	0.656	n.s.
	2) Incorrect Procedures	3.409	3.409	317.456	5.291	0.644	n.s.
	3) Procedures Omitted	2.182	2.182	116.909	1.948	1.120	n.s.
	4) Extra Procedures	3.879	3.879	90.000	1.500	2.586	n.s.
	5) References to Names of CPM parts	5.470	5.470	157.273	2.621	2.087	n.s.
	6) Performance Classification	0.242	0.242	9.091	0.152	1.600	n.s.

Table R-24: Univariate F-tests for performance effects as a function of step-by-step pictures or the combination of ADD, ADL and ALP during the testing procedures.

Univariate F-tests with (2,60) D. F.

Source of Variation	Variable	Hypothesis Sum of Squares	Hypothesis Mean Square	Error Sum of Squares	Error Mean Square	F	P
Base Information	1) Time	64.130	32.065	284.784	4.746	6.756	0.005
	2) Incorrect Procedures	51.121	25.561	317.455	5.291	4.831	0.01
	3) Procedures Omitted	5.818	2.909	116.909	1.948	1.493	n.s.
	4) Extra Procedures	13.121	6.561	90.000	1.500	4.374	0.05
	5) References to Names of CPM parts	47.727	23.864	157.272	2.621	9.104	0.0001
	6) Performance Classification	0.364	0.182	9.091	0.152	1.200	n.s.

Table R-25: Univariate F-tests for performance interaction during the testing procedures.

Univariate F-tests with (2,60) D. F

Source of Variation	Variable	Hypothesis Sum of Squares	Hypothesis Mean Square	Error Sum of Squares	Error Mean Square	F	P
Supplementary Information by Base Information	1) Time	1.451	0.725	284.784	4.746	0.153	n.s.
	2) Incorrect Procedures	7.182	3.591	317.455	5.291	0.679	n.s.
	3) Procedures Omitted	2.030	1.015	90.000	1.500	0.678	n.s.
	4) Extra Procedures	0.364	0.182	116.909	1.948	0.093	n.s.
	5) References to Names of CPM parts	6.394	3.197	157.273	2.621	1.220	n.s.
	6) Performance Classification	0.121	0.061	9.091	0.152	0.400	n.s.

Table R-26: ANOVA summary table for the manual effectiveness ratings.

Analysis of Variance

Source of Variation	df	Sum of Squares	Mean Square	F	P
Supplementary Information by Base Information	2	2.758	1.379	0.815	n.s.
Supplementary Information	1	0.742	0.742	0.439	n.s.
Base Information	2	21.485	10.742	6.353	0.005
Error	60	101.455	1.691		

Table R-27: ANOVA summary table for the strategy effectiveness ratings.

Analysis of Variance

Source of Variation	df	Sum of Squares	Mean Square	F	P
Supplementary Information by Base Information	2	5.485	2.742	0.829	n.s.
Supplementary Information	1	28.015	28.015	8.466	0.005
Base Information	2	10.939	5.470	1.653	n.s.
Error	60	198.545	3.309		

Table R-28: Correlation matrix summary table for the subjective ratings in instruction manual Condition-1. Note: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.005$, **** $p < 0.0001$.

Pearson Correlation (1-Tailed)

Condition 1

Subscales	1	2	3	4	5	6	7	8	9
1) Effectiveness of manual	—	.18	-.57 *	-.49	.16	-.001	.003	—	-.39
2) Usefulness of Strategy		—	-.27	-.17	-.12	.09	-.08	—	.17
3) Time			—	.61	-.29	.57	.41	—	.61
4) Incorrect Procedures				—	-.15	.02	.28	—	.61 *
5) Procedures Omitted					—	-.18	-.34	—	.28
6) Extra Procedures						—	-.06	—	.21
7) References to Names							—	—	.40
8) References to Picture								—	—
9) Performance Classification								—	—

Table R-29: Correlation matrix summary table for the subjective ratings in instruction manual Condition-2. Note: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.005$, **** $p < 0.0001$.

Pearson Correlation (1-Tailed)
Condition 2

Subscales	1	2	3	4	5	6	7	8	9
1) Effectiveness of manual	—	.34	-.36	-.46	-.02	-.14	-.45	-.21	-.19
2) Usefulness of Strategy		—	-.39	-.50	.29	-.16	-.14	-.50	-.09
3) Time			—	.54 *	.27	.72 **	-.91 ****	.43	.15
4) Incorrect Procedures				—	-.35	.57 *	.49	.47	-.27
5) Procedures Omitted					—	.37	.37	-.12	.41
6) Extra Procedures						—	.67 **	.28	-.16
7) References to Names							—	.18	.19
8) References to Picture								—	-.10
9) Performance Classification									—

Table R-30: Correlation matrix summary table for the subjective ratings in instruction manual Condition-3. Note: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.005$, **** $p < 0.0001$.

Pearson Correlation (1-Tailed)
Condition 3

Subscales	1	2	3	4	5	6	7	8	9
1) Effectiveness of manual	—	.23	-.10	.27	-.40	-.51	.17	—	.000
2) Usefulness of Strategy		—	.08	-.01	-.18	.02	.16	—	.009
3) Time			—	.58 *	-.03	.80 ***	.17	—	-.11
4) Incorrect Procedures				—	.30	.27	.56 *	—	-.04
5) Procedures Omitted					—	.08	-.01	—	.56 *
6) Extra Procedures						—	-.05	—	-.08
7) References to Names							—	—	-.31
8) References to Picture								—	—
9) Performance Classification									—

Table R-31: Correlation matrix summary table for the subjective ratings in instruction manual Condition-4. Note: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.005$, **** $p < 0.0001$.

Pearson Correlation (1-Tailed)
Condition 4

Subscales	1	2	3	4	5	6	7	8	9
1) Effectiveness of manual	—	.46	-.28	-.72 **	-.68 **	-.65 **	.03	-.77 ***	-.17
2) Usefulness of Strategy		—	-.38	-.63 **	-.31	-.24	-.29	-.24	-.61 *
3) Time			—	.51	.46	.48	.76 ***	.57 *	.16
4) Incorrect Procedures				—	.75 ***	.60 *	.28	.54 *	.67 **
5) Procedures Omitted					—	.46	.31	.70 **	.26
6) Extra Procedures						—	.19	.74 ***	.09
7) References to Names							—	.33	.06
8) References to Picture								—	-.17
9) Performance Classification									—

Table R-32: Correlation matrix summary table for the subjective ratings in instruction manual Condition-5. Note: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.005$, **** $p < 0.0001$.

Pearson Correlation (1-Tailed)
Condition 5

Subscales	1	2	3	4	5	6	7	8	9
1) Effectiveness of manual	—	.07	-.73 ***	.13	-.64 *	-.38	-.43	—	-.22
2) Usefulness of Strategy		—	.21	-.02	.02	.09	.15	—	.14
3) Time			—	.26	.17	.72 **	.72 **	—	.49
4) Incorrect Procedures				—	-.45	.60 *	.45	—	.42
5) Procedures Omitted					—	.05	-.15	—	.24
6) Extra Procedures						—	.61 *	—	.61
7) References to Names							—	—	.51
8) References to Picture								—	—
9) Performance Classification									—

Table R-33: Correlation matrix summary table for the subjective ratings in instruction manual Condition-6. Note: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.005$, **** $p < 0.0001$.

Pearson Correlation (1-Tailed)
Condition 6

Subscales	1	2	3	4	5	6	7	8	9
1) Effectiveness of manual	—	-.17	.21	-.38	.00	-.09	-.06	.43	.00
2) Usefulness of Strategy		—	.09	-.09	.00	-.31	-.05	-.40	.00
3) Time			—	.32	.00	.40	.56 *	.52 *	.00
4) Incorrect Procedures				—	.00	.62 *	-.20	-.07	.00
5) Procedures Omitted					—	.00	.00	.00	.00
6) Extra Procedures						—	-.09	.08	.00
7) References to Names							—	.67 **	.00
8) References to Picture								—	.00
9) Performance Classification									—

Table R-34: Correlation matrix summary table for the subjective ratings in instruction manual Condition-7. Note: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.005$, **** $p < 0.0001$.

Pearson Correlation (1-Tailed)
Condition 7

Subscales	1	2	3	4	5	6	7	8	9
1) Effectiveness of manual	—	.28	-.53 *	-.64 *	-.55	.27	-.07	.12	-.53
2) Usefulness of Strategy		—	-.01	.20	-.35	-.01	-.04	-.66 *	.19
3) Time			—	.79 ***	-.02	.16	.53 *	-.25	.62 *
4) Incorrect Procedures				—	.21	.08	.24	-.44	.63 *
5) Procedures Omitted					—	-.12	.02	-.15	-.15
6) Extra Procedures						—	.64 *	.22	-.38
7) References to Names							—	-.25	-.25
8) References to Picture								—	-.10
9) Performance Classification									—

Table R-35: Correlation matrix summary table for the subjective ratings in instruction manual Condition-8. Note: * p < 0.05, ** p < 0.01, *** p < 0.005, **** p < 0.0001.

Pearson Correlation (1-Tailed)
Condition 8

Subscales	1	2	3	4	5	6	7	8	9
1) Effectiveness of manual	—	.33	-.56 *	-.07	.24	-.49	-.55 *	.18	.00
2) Usefulness of Strategy		—	-.38	-.19	-.40	-.12	-.56 *	.13	.00
3) Time			—	.58 *	-.18	.89 ****	.60 *	-.09	.00
4) Incorrect Procedures				—	.11	.70 **	.04	.20	.00
5) Procedures Omitted					—	-.37	-.25	-.37	.00
6) Extra Procedures						—	.34	.02	.00
7) References to Names							—	-.04	.00
8) References to Picture								—	.00
9) Performance Classification									—

Table R-36: Correlation matrix summary table for the subjective ratings in instruction manual Condition-9. Note: * p < 0.05, ** p < 0.01, *** p < 0.005, **** p < 0.0001.

Pearson Correlation (1-Tailed)
Condition 9

Subscales	1	2	3	4	5	6	7	8	9
1) Effectiveness of manual	—	.47	.41	.07	.05	-.31	.41	.36	.24
2) Usefulness of Strategy		—	-.34	-.17	.04	-.58 *	-.10	.31	.03
3) Time			—	.53 *	.39	.36	.65 *	-.10	-.06
4) Incorrect Procedures				—	.00	.09	.51	.00	-.13
5) Procedures Omitted					—	.11	-.12	-.15	-.10
6) Extra Procedures						—	.03	-.38	.11
7) References to Names							—	.27	-.29
8) References to Picture								—	-.15
9) Performance Classification									—