ABSTRACT

INTELAD: INTELLIGENT COMPUTER WORKSTATION ADJUSTMENT SOFTWARE

by
David W. Venezia

Muscular-skeletal disorders are a significant safety concern for professional computer users. Regard for human health, regulatory emphasis, and the inherent cost of the disorders give rise to this point. In an attempt to reduce the risk of injury to computer operators from Carpal Tunnel Syndrome, this body of work provides an easy to use tool capable of determining the near optimal workstation orientation for any operator/workstation combination. Using a unique algorithm and compiled anthropometric data, computer software has been specially developed to map individual workstations in the Cartesian coordinate system. This mapping yields a recommended orientation that is compared to the ANSI/HFS-100 Standard to determine its feasibility. The program uses knowledge of the operator's sex and standing height to recommend the heights of the chair, keyboard, and monitor; as well as the horizontal distances between the back of the chair and the keyboard and the back of the chair and the monitor. Field trials confirm that ***IntelAd*** is an effective tool which meets its design objectives and offers an orientation that requires only minor adjustments to account for differences between the actual and the modeled computer user.

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INTELLIGENT COMPUTER WORKSTATION ADJUSTMENT SOFTWARE

by
David W. Venezia

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APPROVAL PAGE

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David W. Venezia

Dr. Howard Gage, Thesis Advisor — Date
Associate Professor of Industrial Engineering and
Director of the Occupational Safety and Health Program, NJIT

Dr. Suebsak Nanthavanij, Committee Member — Date
Associate Professor of Industrial Engineering and
Associate Chairperson of Industrial Engineering,
Engineering (English) Program, Thammasat University, Rangsit Campus,
Klong Luang Patumtani, Thailand

Dr. Layek Abdel-Malek, Committee Member — Date
Professor of Industrial and Management Engineering and
Associate Chairperson of Industrial Engineering, NJIT

BIOGRAPHICAL SKETCH

Author: David W. Venezia

Degree: Master of Science in Occupational Safety and Health Engineering

Date: January 1994

Undergraduate and Graduate Education:

- Master of Science in Occupational Safety and Health Engineering,
  New Jersey Institute of Technology,
  Newark, NJ, 1994

- Bachelor of Science in Industrial Engineering,
  New Jersey Institute of Technology
  Newark, NJ 1987

Major: Occupational Safety and Health Engineering

This thesis is dedicated to
my youngest son, Benjamin.

Born during the first week of my graduate education, Benjamin was denied many hours of attention a father should have given a newborn son. This document represents my enduring efforts to learn, develop, and master a single concept new to my world. Yet in comparison, my accomplishments of these past 16 months pale against those of my young son, Benjamin, who learned, developed and mastered thousands of concepts new to his world.

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CHAPTER 1

INTRODUCTION

1.1 Background

Professional computer users, such as those in clerical and office jobs whose work requires repeated flexing of the fingers while the wrist is bent, have been identified as a risk group for a cumulative trauma disorder, specifically carpal tunnel syndrome.

Cumulative trauma disorders have been labeled as the "occupational illness of the 1990's" by the Occupation Safety and Health Administration (OSHA). In fact, in 1991, OSHA targeted cumulative trauma disorder's as one of its major concerns.[1] Consider the following: surgery for the symptomatic relief from carpal tunnel syndrome is currently the second most commonly performed operation in the United States.[2] At a time when OSHA is demonstrating a willingness not to levy a single fine per violation, but rather issue separate fines for each individual exposed to a violation, managers must be aware of workplace safety. Complacency towards a well known health risk (such as carpal tunnel syndrome) has the potential to result in a severe financial penalties for an organization.. Thus, safety concerns in the workplace, including the office environment, should not be ignored.

The threat of OSHA penalties, however, provides little deterrent for some employers. They merely point to OSHA's limited ability to monitor dangerous conditions in the workplace and conclude that these dangerous conditions have a limited probability of resulting in a fine. Managers with this mind-set need to be addressed on a different level; one that demonstrates to them the real costs of cumulative trauma disorders that their organizations are already incurring.

The number of cumulative trauma disorders cases increased four fold in the second half of the 1980's reflecting, in part, a greater awareness and reporting of muscular-skeletal injuries that were once brushed aside.[3] Companies that push their employees to the point of injury incur a cost due to a loss of productivity when their injured workers can no longer perform their assigned tasks. In addition, this cost can be justifiably increased when one considers, for example, that one half of the patients diagnosed with carpal tunnel syndrome have suffered symptoms which have affected their productivity for up to two years prior to their diagnosis.[4]

Studies conducted by the North Carolina Industrial Commission report that the average cost to an employer for a worker's hand injury is $5,000. Other studies noted that 11% of all workers with hand injuries never return to their jobs.[5] Thus industry is not only incurring the costs associated with medical care and disability due to carpal tunnel syndrome, but also that of training an injured worker's replacement.

To provide a safer industrial environment, ergonomic experts have researched and published information on the prevention of carpal tunnel syndrome. This information calls for measures ranging from early diagnosis to job reassignment and tool and/or workplace redesign. However, neither management nor the worker him/herself is necessarily privy to such information since it is primarily published only in technical journals to which neither subscribes.

In a liaison role, the office furniture manufacturing industry has spanned the gap between the ergonomics experts and the computer users. Ergonomically designed computer workstations have been available to enlightened consumers for several years. Through careful adjustment, these workstations allow the user to position him/herself in the recommended work posture, i.e., arms parallel to the ground, elbows in at the side of the body, and wrists straight.[6] Theoretically, the increasing use of these ergonomically designed workstations should play an important role in reducing the incidence of carpal tunnel syndrome in professional computer users. Theory deviates from reality, however, on two levels. The first stems from the previous paragraph: users have little if any knowledge as to what constitutes a correct body position. The second concerns the limits of human capabilities.

Consider that an ergonomic computer workstation may have as many as seven independently adjustable features. This places the total number of possible workstation orientations in the thousands. The adjustment of these workstations frequently proves to be too taxing for human mental capacity. Additionally, adjustment likely occurs in an iterative form spread over the course of an entire operating session, and thus fosters reduced productivity due to the diversion of attention from the job task. In practice, a total disregard for the entire adjustment process often occurs.[7] Thus, the intended benefits of ergonomic computer workstations are not fully realized.

1.2 Objective

Carpal tunnel syndrome is a significant concern to safety professionals who deal with computer users. In an attempt to reduce the risk of injury, different varieties of ergonomic workstations have been designed and discussed. But many of these workstations have had only a limited effect on reducing the incidence of carpal tunnel syndrome due to the complexity of their adjustment process and the user's inability to determine the optimal settings.

The objective of this project, therefore, is to minimize the human involvement in the adjustment/decision making process via the development of a computer software package that calculates a near optimal workstation orientation given the computer user's sex and height, and the adjustment capability of the computer workstation. After application of the software to the work environment, only minor adjustment would be necessary to account for differences between the modeled and the actual computer user.

1.3 Organization

This body of work is divided into ten chapters and three appendices. Chapters 2 and 3 expand on the information introduced here regarding carpal tunnel syndrome and computer workstations. Chapters 4 through 9 detail the development and testing of the workstation orientation software. Chapter 10 offers conclusions and also recommends possible extensions of this work. Appendices A, B, C, and D contain supplemental material.

CHAPTER 2

CUMULATIVE TRAUMA DISORDERS

2.1 Definition

Cumulative Trauma Disorders (CTDs), Repetitive Strain Injuries (RSIs), and Repetitive Motion Disorders (RMDs) are technical names given to a group of upper extremity muscular-skeletal injuries that are currently attracting headlines and raised public consciousness. However, the recent emergence of CTDs into the limelight is somewhat misleading. CTDs have been around for as long as humans have done forceful, repetitive work in constrained or awkward postures. In years past, our parents and grandparents may have known these conditions by names such as "washerwoman's sprain", "telegraphist's cramp", "trigger finger", "writer's cramp", and "tennis elbow".[8]

In clinical terms, a CTD is "a disorder of the muscular and/or tendinous and/or osseous and/or nervous system(s); caused, precipitated, or aggravated by repetitive exertions, or movements of the body."[9] In lay terms, CTDs are "...characterized by discomfort, impairment, disability, or persistent pain in joints, muscles, tendons, and other soft tissues, with or without physical manifestations."[10]

2.2 Etiology of a CTD

Contrasting acute or traumatic injuries, which result from a single incident, CTDs are a synergistic accumulation of many "microtraumas"[11] CTDs are believed to be caused in most individuals by repetitive, forceful motions. A review of 54 studies by Stock (1991) indicated that there was "strong evidence of a causal relationship between repetitive, forceful work and the development of muscular-skeletal disorders."[12] Other research indicates that confounding factors including age, sex, body position, body weight, and circumstances of pregnancy or menopause may also play a role in a CTD's development.[13] Additionally, it is believed that some individuals may be predisposed to developing a CTD due to interspecies variations.

The etiology of a CTD can be summarized as follows. Each instance of a potentially-CTD-producing motion results in a small injury or microtrauma to the soft tissue, tendon, tendon sheath, and/or nerve of an at-risk individual. Considered separately, each motion and the resulting small injury appears harmless to the individual. However, when taken collectively, these microtraumas synergistically combine into clinically measurable disorders that can eventually inhibit the individual's ability to perform his or her normal work functions.

> Symptomatically speaking, CTDs "...initially manifest as an aching of the effected body part, which occurs at work, disappears with rest, and does not interfere with work capacity. The symptoms resolve completely if the affected individual avoids repetitive work for a brief period or the relevant work conditions are altered appropriately. If the exposure continues unabated, the condition may progress to an intermediate stage in which the recurrent pain may occur throughout the work day and persist after work. If untreated, and if exposure continues, the condition may reach a chronic stage. Pain occurs at work and at rest and is aggravated by even non repetitive movements. There may be considerable disability in performing not only work but also tasks involving daily living. These chronic states persist for months to years or may never reverse despite treatment and cessation of work."[14]

2.3 CTDs in the Office Environment

While most of the regulatory attention toward CTDs has been directed at more traditional industrial settings (e.g., meat packing plants), agencies such as the Occupational Health and Safety Administration (OSHA) and the New Jersey Department of Health (NJDOH) have recognized the potential risk for CTDs in other environments.

Table 2.1: Common Cumulative Trauma Disorders in Office Workers

Carpal Tunnel Syndrome	A compression of the median nerve in the wrist that may be caused by swelling and irritation of the tendons and tendon sheaths.
Tendinitis	An inflammation (swelling) or irritation of a tendon. It develops when the tendon is repeatedly tensed from overuse or unaccustomed use of the hand, wrist, arm, or shoulder
Tenosynovitis	An inflammation (swelling) or irritation of a tendon sheath associated with extreme flexion and extension of the wrist.
Lower Back Disorders	These include pulled or strained muscles, ligaments, tendons, or ruptured disks. They may be caused by cumulative effects of faulty body postures, and/or improper lifting techniques.
Synovitis	An inflammation (swelling) or irritation of a synovial lining (joint lining).
DeQuervain's Disease	A type of synovitis that involves the base of the thumb.
Bursitis	An inflammation (swelling) or irritation of the connective tissue surrounding a joint, usually the shoulder.
Epicondylitis	Elbow pain associated with extreme rotation of the forearm and bending of the wrist. The condition is also called tennis elbow or golpher's elbow.
Thoracic Outlet Syndrome	A compression of nerves and blood vessels between the first rib, clavicle (collar bone), and accompanying muscles as they leave the thorax (chest) and enter the shoulder

(Adapted from New Jersey Department of Health, August, 1992)

These governmental agencies have indicated that office workers with jobs involving computers represent a non-industrial occupation grouping of individuals at risk of developing some form of CTD. Typical jobs within this category include: secretary, data entry clerk, travel agent, air-line reservation clerk, etc. Additionally, since computers now have achieved wide spread use in service industries, education, and private homes, it should be noted that workers in these environments share the same potential risks.

In August 1992, the NJDOH issued a bulletin concerning CTDs in office workers in which it identified nine muscular-skeletal disorders which may be seen in office workers. These are detailed in Table 2.1. Of the nine, only the first will be discussed in detail as the scope of this body of research involves the reduction of risk factors contributing to the occurrence of Carpal Tunnel Syndrome (CTS) in computer users.

2.4 Carpal Tunnel Syndrome

2.4.1 Recognizing Why CTS is an Increased Concern

While CTS has taken on buzz-word status in the politically correct, safety conscious 1990s, it is by no means a new disorder for those engaged in clerical professions. As early as the 1960s typists and others who frequently worked for extended periods of time with keyboards were afflicted by the disorder.[15] However, the level of technology present at that time precluded that only the idiosyncratic sub-populations, those most predisposed to the disorder, probably developed CTS.

By design, typing was a limited speed task (typewriters would jam if an operator exceeded the mechanical limits of the machine) with built-in breaks to change the paper, make corrections, etc. In contrast, modern computers enable an operator to make in excess 23,000 keystrokes in a single operating session. Gone are the inherent rest periods; gone are mechanical limits on typing speed. In their place are high speed work rates from jobs that have been redesigned and narrowed to the point where a data entry clerk might perform a limited number of keystrokes tens of thousands of times per day.[16] With the combination of repetition, speed, and lack of built-in rests, a contemporary computer operator's wrist is exposed to conditions which can exceed the anatomical limits it was designed to handle.[17]

2.4.2 Etiology

While the etiology of CTS remains unclear, it is generally considered to be associated with a reduction in the effective cross-sectional area in the wrist at the point through which the median nerve passes. The reduction in area can be from physical compression or it can be from expansion of tissues such as tendons and ligaments which pass through the wrist. Known as the carpal tunnel, this wrist-passage area can be constricted from acute injury, systemic swelling (as with pregnancy), disease (e.g., arthritis), or chronic injury from forceful, repetitive hand movements. When the area in the carpal tunnel is reduced, the passageway in the wrist for the median nerve is constricted and nerve damage is likely to result. Symptoms of damage first manifest themselves as numbness and/or pain in the hand, wrist and/or fingers. If left unchecked after the recognition of early symptoms, CTS can eventually degrade to a complete loss of function of the afflicted hand.[18]

2.4.3 Risk Factors and Control

There are four major risk factors associated with CTS: force, repetition, lack of rest, and posture. In terms of computer operators, the first three risk factors can be controlled administratively. Fore example; rest periods of at least 10 minutes per hour can be imposed and a worker can be trained to reduce unnecessarily forceful keystrokes. Risk from repetition can be controlled by implementing clerical job designs that include rotation of tasks between keying and non-keying tasks (such as filing). Work posture can be controlled and improved through proper workstation design and orientation.

2.5 Work Posture and Lowering the risk of CTS

To reduce the risk of CTS when working with hand tools, ergonomists have recommended that workers maintain a straight wrist position. Following the same goal, this recommendation can be extended to computer users.[19] A straight wrist posture reduces the mechanical friction between tendons and tendon sheaths in the carpal tunnel. Thus, during keying operations a straight wrist posture can reduce the risk of injury to these soft tissues, the resultant swelling that follows, the damaging constriction of the median nerve, and therefore, the risk of CTS.

Obtaining a proper workstation design can be facilitated by adhering to published technical standards such as the ANSI/HFS-100. However, as will be discussed in Chapter 3, proper workstation design and proper workstation orientation may introduce independent and sometimes conflicting concepts.

CHAPTER 3

THE COMPUTER WORKSTATION

3.1 Introduction

The typical computer workstation consists of a chair, keyboard, monitor, and suitable support surfaces for the keyboard and the monitor (usually a desk). The chair and each of the support surfaces should be independently adjustable to permit every operator to position the workstation to satisfy his or her own comfort and safety. However, with the user adjustable workstation, it becomes necessary to factor in a limiting element. Specifically, computer workstations with adjustable chairs, monitors, and keyboards offer an overwhelming number of possible configurations to the user. In the adjustment process, each iteration in the sequence must be comparatively judged by the operator with regard to his or her own comfort and safety. When one considers the many degrees of freedom of adjustment and how humans characteristically struggle with absolute judgment, it is understandable why so many sub-optimal workstation orientations exist in practice.

3.2 Hardware Considerations - Key Concepts

Figure 3.1 illustrates an adjustable ergonomic computer workstation whose furniture and hardware comply with certain general concepts meeting the challenge of comfort and safety. The following list outlines important hardware and furniture considerations while

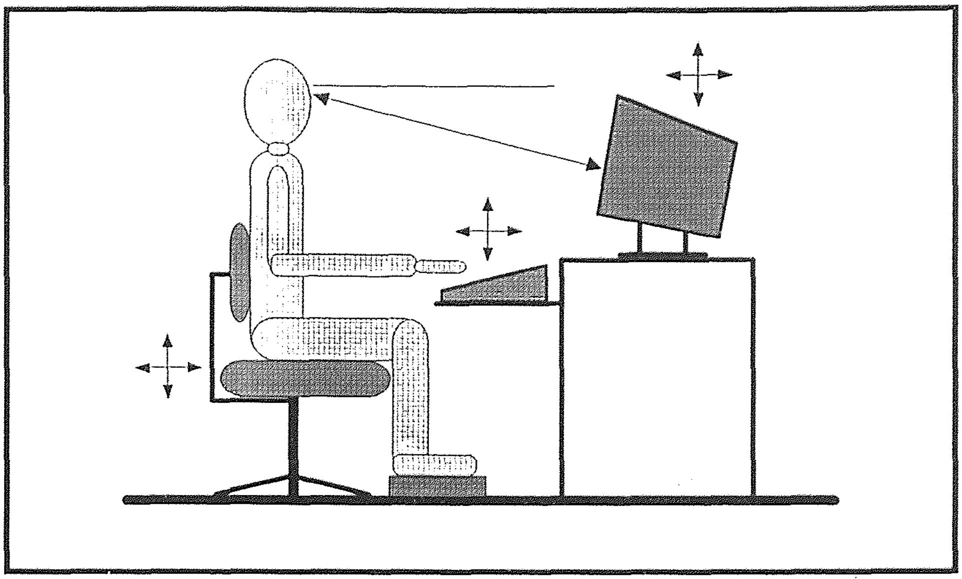

Figure 3.1 The Computer Workstation

published documents noted in the references, such as the ANSI/HFS-100 Standard, provide specific information which is more technical in nature.

- All workstation components should be easily adjustable without a need for tools or training.
- The chair should be sufficiently wide and deep.
- The chair height should be adjustable.
- The chair seat should tilt slightly back and have a rounded front edge.
- The chair backrest should have a height adjustable lumbar support.
- The chair bases should have five legs for stability and should swivel.
- The computer monitor should tilt and swivel to reduce glare and permit comfortable viewing.
- The workstation lighting should be adjusted to avoid glare on the monitor screen.
- The monitor support surface should be height adjustable to allow for a comfortable viewing angle and distance.
- The keyboard support surface should be height adjustable to allow for a neutral wrist position. Bent wrists can lead to Carpal Tunnel Syndrome.

- The monitor and keyboard support surfaces should permit adequate clearance to allow for free movement of thighs and feet.
- An adjustable foot rest should be available if required.
- Supplemental items such as document holders and soft wrist rests should be available if required or desired.[20]

3.3 Workstation Adjustment

3.3.1 Degrees of Freedom

Consider the computer workstation shown in Figure 3.1. As illustrated, this workstation has seven independently adjustable degrees of freedom. Specifically these are:

1) chair height (vertical placement),
2) chair location (horizontal placement),
3) keyboard height (vertical placement),
4) keyboard location (horizontal placement),
5) monitor height (vertical placement),
6) viewing distance (horizontal placement), and
7) viewing angle.

3.3.2 Combinations of Adjustment

Typically, the above mentioned degrees of freedom are afforded continues adjustment within specified limits (e.g., the chair can be adjusted to any height between 16 inches and 20.5 inches). However, to illustrate the large number of possible workstation combinations, each degree of freedom is assumed to have only five discrete adjustments within its range.

The total number of combinations of adjustment (N) of a computer workstation with n degrees of freedom where S_i is the number of discrete adjustment steps of the i^{th} degree of freedom, is given by:

$$N = \prod_{i=1}^{n} S_i$$

In the illustrated example, a workstation with seven degrees of freedom, each with five discrete adjustments, would have a total of 5^7 or 78,125 possible combinations.[21]

3.3.3 Manual Workstation Adjustment.

Eliminating the most extreme and awkward of the 78,125 possible workstation orientations still leaves an overwhelming number of possible configurations for the computer user to test and evaluate.

Figure 3.2 illustrates the decision making process that the computer user subconsciously employs to evaluate different workstation orientations. The process requires the user to make absolute judgments regarding the relative increase or decrease in comfort and safety of each successive iteration. In fact, though, humans do not excel at absolute judgment. Additionally, the typical computer operator does not posses the technical background to adequately assess the suitability of each successive workstation orientation. Proper determination of workstation safety necessitates an understanding of promulgated standards and general information on the subject. Since this knowledge is frequently only published in technical journals and documents circulated to engineers and researchers, it is likely that the average computer operator does not posses sufficient knowledge to properly evaluate the safety of their workstation orientation.

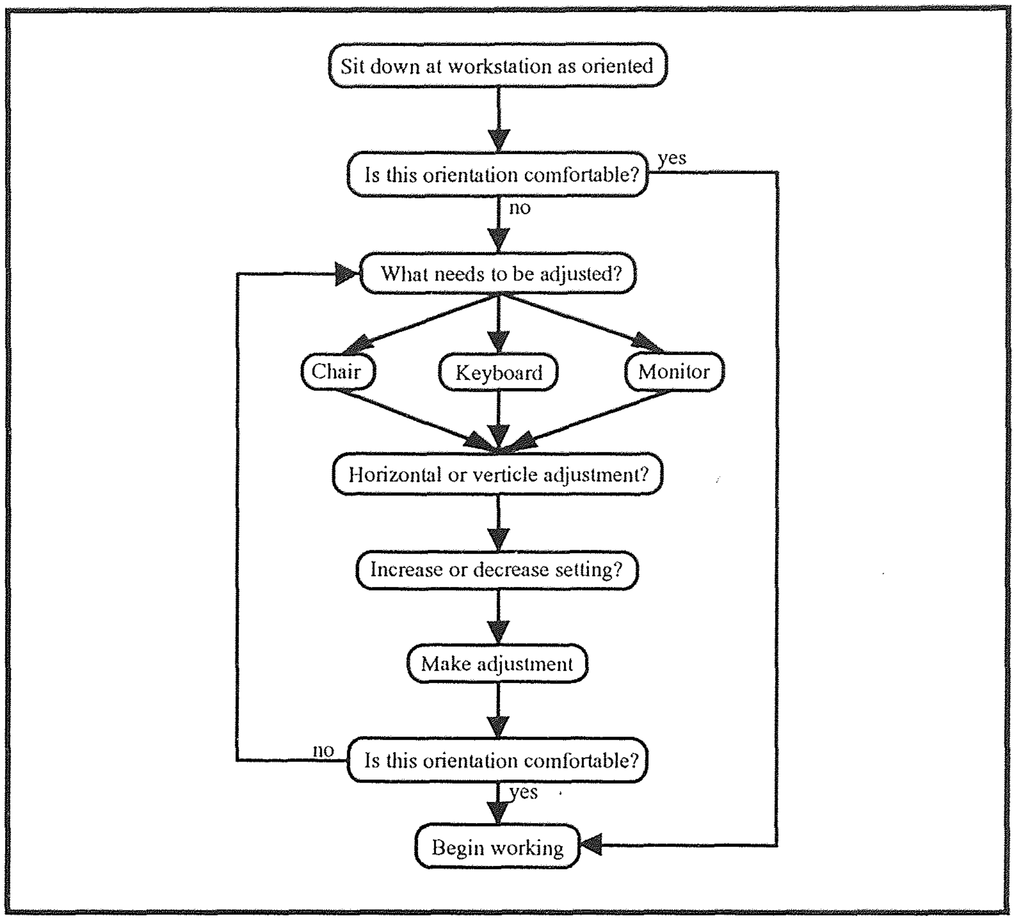

Figure 3.2 Decision Making Process: Workstation Adjustment
(Adapted from Nanthavanij, 1992)

The manual adjustment of a computer workstation has been shown to be an iterative process of modification and judgment that typical results in a sub-optimal orientation. However, the time factor must also be considered. The proper adjustment of the workstation can be a time consuming task. The average office worker is a busy individual with little spare time in his or her schedule. Therefore, many workers "make do" with sub-optimal orientations due to time constraints even when they posses a good understanding of the safety requirements.

3.4 The Future of Workstation Adjustment.

Given the above discussion on user-guided adjustments, the health risks associated with poor worker posture resulting from poor workstation orientation, and the importance that regulatory agencies have placed on the prevention of muscular skeletal disorders, an alternative to user guided adjustments of computer workstations was developed.

IntelAd, Intelligent Computer Workstation Adjustment Software, utilizes ergonomic principles, anthropometric data, and mathematical algorithms to assists computer operators in adjusting their workstations. For each unique workstation/user combination, ***IntelAd*** calculates a near optimal orientation. This interactive software package removes a majority of decision making from the adjustment process and reduces the number of iterations to one or two for minor modification only.

CHAPTER 4

THE DESIGN OF *INTELAD*

IntelAd is written in GWBASIC version 3.23 for IBM and IBM compatible computers. There are 1,141 program lines numbered in increments of 50. A complete program listing can be found in Appendix D.

4.1 Goals, Design Criteria, and Assumptions

4.1.1 Goals

In a perfect world, the goal of ***IntelAd*** would be to provide an optimal workstation layout for every computer user regardless of the cost. However, in the real world cost cannot be disregarded; certain sacrifices must be made to bring an idea from concept to completion.

IntelAd's goal is to recommend for a computer operator his or her <u>near</u> optimal workstation layout. ***IntelAd*** recommends a layout which allows the user to sit comfortably, keep his or her wrists straight, and view the monitor at a comfortable distance, without becoming burdened by an infinite number individual anthropometrics. In aiming for this near optimal configuration, ***IntelAd*** is permitted to recommend an ergonomically correct position with the understanding that everyone may need to make minor adjustments to account for individual differences between the actual and modeled computer users.

4.1.2 Design Criteria

IntelAd is built around two non-negotiable design criteria: (1) it must be easy to use, and (2) in an effort to reduce a computer user's risk of CTS, it must follow the "straight wrist" principle.

To satisfy the first criteria, ***IntelAd*** was developed to be "user friendly". The program is menu driven and flows in a logical sequence from the title screen to the recommended workstation layout. All data entries are error-trapped in case there is an inappropriate response. Those interfaces with disk drives and printer ports are like-wise error-trapped to prevent the inadvertent program crash that is characteristic of GWBASIC in these delicate areas. In addition, simplicity is achieved using only two common knowledge parameters as the sole <u>required</u> inputs for ***IntelAd's*** algorithms. From an indication of operator sex and standing height ***IntelAd*** calculates all other necessary parameters using the anthropometric formulas described in Chapter 5.

The second criteria is held firm by fixing the wrist joint at 180 degrees with no exceptions.

4.1.3 Assumptions

In order to limit the number of variables ***IntelAd*** manipulates, it was necessary to make two assumptions.:

1) The back of the workstation chair is fixed perpendicular to the floor.
2) The seat of the workstation chair is fixed parallel to the floor.

Table 4.1 Default Workstation Adjustment Ranges

Parameter	Centimeters	Inches
Seat Height	40.6 - 52.0	16.0 - 20.5
Keyboard Height	46.0 - 74.0	22.8 - 28.0
Monitor Height	74.0 - 91.0	29.1 - 35.8
Viewing Distance	33.0 - 71.0	13.0 - 28.0

Additionally, all default workstation adjustment ranges (Table 4.1) are assumed to be those recommended by the ANSI/HFS-100 Standard.

4.2 Interface and Architecture

4.2.1 Interface

IntelAd is menu driven from start to finish. Moving from one menu to the next requires that the user input a number which corresponds to the next desired menu. For example, the Main Menu lists five choices:

1) Select units
2) Input personal/hardware information
3) Calculate suggested workstation settings
4) Print information/results
5) Exit the program

If one wishes to move from the Main Menu to the Print/Display Menu, a "4" followed by [ENTER] would be typed at the prompt. (Note: all data entries must be followed by [ENTER]). If anything other than a "1", "2", "3", "4", or "5" were entered at the Main Menu prompt, this would constitute an inappropriate or unrecognized response. All unrecognized responses will trigger a re-prompt and an error message, such as "PLEASE ENTER 1, 2, 3, 4, OR 5 ONLY".

Some menus require the user to input letters or words. When alpha/numeric entries are required, such as for the user's sex on the Personal Information Menu, either the upper or the lower case forms will be recognized.

All numeric measures are requested showing the current unit selection as a reminder to the user. ***IntelAd*** does default to the units of "inches" when the program is initiated However, the interface units can be changed to "centimeters" from the Main Menu by selecting "1" at the Main Menu Prompt.

4.2.2 Architecture

As shown in Figure 4.1, ***IntelAd*** has a hierarchical organization. Users are first welcomed to ***IntelAd*** by its title screen where they also are asked to select which disk drive they are using (Figure 4.2). After a disk drive is selected, the Main Menu appears.

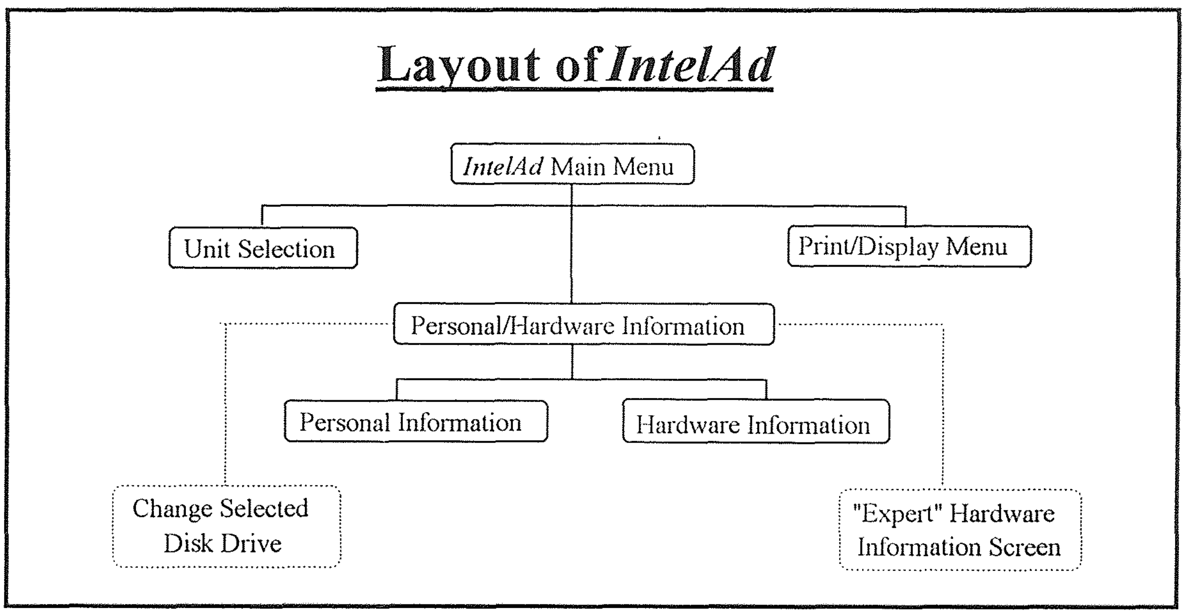

Figure 4.1 The Architecture of ***IntelAd***

From the Main Menu (Figure 4.3), ***IntelAd*** can be directed to: the Personal Information Menu, the Hardware Information Menu, the calculation routines, the Print/Display Menu, or back to the DOS prompt. The order of the listed choices deliberately coincides with the intended order of their accomplishment. Certainly ***IntelAd*** cannot calculate the suggested workstation settings before the user's height and sex are entered. Attempts to proceed to any level before that level's prerequisites are met will result in an error message and the highlighting of the missed step on the Main Menu.

IntelAd - Intelligent Computer Adjustment Software
Version 1.2 - Updated on 28 July 1992

Developed and Written by David W. Venezia
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Please indicate which disk drive you are using
(1) A Drive
(2) B Drive
(3) C Drive

Enter 1, 2, or 3: ?___

Figure 4.2 Title Screen

IntelAd Main Menu

(1) Select units (current = in.)
(2) Input personal/hardware information
(3) Calculate suggested workstation settings
(4) Print information/results

(5) Exit this program

Please enter your selection: ?___

Figure 4.3 Main Menu

Main Menu choice #1 - select units

The first choice on the Main Menu allows the user to select which units he or she will be using. ***IntelAd*** defaults to "inches" when the program is initiated. However, using the Unit Selection Screen (Figure 4.4) the operating units can be easily switched from inches to centimeters (or back). ***IntelAd*** will automatically perform all necessary conversions.

Unit Selection

(1) Use centimeters (cm.)
(2) Use Inches (in.)

(3) Exit this program

Please enter your selection: ?___

Figure 4.4 Unit Selection Screen

Main Menu choice #2 - personal/hardware information

The Personal/Hardware Information Menu is the second choice on the Main Menu. As shown in Figure 4.5, the Personal/Hardware Information Menu has five options. The user can input or change personal information or hardware information in the first or second menu items, respectively. From this menu users can also access stored data as well as save their current information to a disk file. Lastly, the Main Menu can be re-accessed by entering "5" at the Personal/Hardware Information Menu prompt.

The Personal Information Screen is an interactive display that requests and reports the personal information. Initially, this screen appears as shown in Figure 4.6. The user is prompted for data inputs at the screen locations where that information would be displayed. Future visits to this screen in the same operating session will exhibit the current personal data in the blanks shown in Figure 4.6.

Personal/Hardware Information
(1) Input/change personal information
(2) Input/change hardware information
(3) Retrieve data from a file
(4) Save current information
(5) Go back to the Main Menu
Please enter your selection: ?___

Figure 4.5 Personal/Hardware Information Menu

Personal Information
(1) Last name:_______________
(2) First name:_______________
(3) Sex:________
(4) Height:________ (in.)
(5) Return to the Personal/Hardware Menu
Please enter your selection: ?___

Figure 4.6 Personal Information Screen

Figures 4.7 and 4.8 represent two in the series of six possible screens under the Hardware Information heading. The Seat Height Screens exemplified are followed by similar screens for the keyboard height and the monitor height, respectively. Note the adjustment values shown in Figure 4.8 which represent the default range discussed in section 4.1.3.

Hardware Information

SEAT HEIGHT

Is the height of your chair adjustable? (1) Yes (2) No ?____

Figure 4.7 Initial Hardware Information Screen for Seat Height

Hardware Information

SEAT HEIGHT

Currently the lower seat adjustment limit is 15.75 in.

Please input the lower seat adjustment limit: ?__________
or press [ENTER] to use the current value.

Currently the upper seat adjustment limit is 19.29 in.

Please input the upper seat adjustment limit: ?__________
or press [ENTER] to use the current value

Figure 4.8 Hardware Information Screen for Seat Height Adjustment Range

Those users who become comfortable with ***IntelAd*** may elect to bypass the six Hardware Information Screens and use one advanced screen where all of the hardware information may be entered (Figure 4.9). This screen is a hidden feature that is accessed by typing "Expert", "EXPERT", or "expert" at the Personal/Hardware Information Menu prompt. (Note that Figure 4.9 represents a workstation with a fixed position monitor and a fixed position keyboard.) Items 2 and 4 are not incorporated into the algorithms of the current version of ***IntelAd***. Advanced versions of ***IntelAd*** may allow these parameters to vary in an effort to explore improving the program's goal achievement.

Hardware Information

		Lower Limit	Upper Limit	
(1)	Seat Height:	17.00 in.	21.00 in	
(2)	Elbow Height	18.11 in.	29.13 in.	
(3)	Keyboard Height	27.50 in.	27.50 in.	(FIXED)
(4)	Keyboard Angle	0.00 deg.	25.00 deg.	
(5)	Monitor Height	37.50 in.	37.50 in.	(FIXED)
(6)	Viewing Distance	12.99 in.	27.95 in.	
(7)	Viewing Angle	0.00 deg.	60.00 deg.	

(8) Return to the Personal/Hardware Information Menu

Please enter 1 to 7 to change information or 8 to exit: ?_____

Figure 4.9 Expert Hardware Information Screen

The third option on the Personal/Hardware Information Menu retrieves previously entered or calculated information from a disk file. This is useful when a user wishes to modify or update a workstation layout. ***IntelAd*** can store all operator specific data, all calculated parameters, and any error messages appearing in user named data files for future reference. The opportunity to save this information in a data file occurs as the fourth selection on the Personal/Hardware Information Menu. An additional opportunity to store this data occurs in the Print/Display Menu (see Figure 4.11).

It is possible that the wrong disk drive could be inadvertently selected at the program's start-up. Therefore, a hidden feature exists to allow a user to go back and re-select the correct disk drive. Typing "Disk" or "DISK" or "disk" at the

Personal/Hardware Information Menu prompt will return the program to the disk drive selection portion of ***IntelAd's*** Title Screen. After the correct drive is selected, the program will return to the Personal/Hardware Information Menu.

One additional hidden feature available at the Personal/Hardware Information Menu prompt allows the user to reset the workstation adjustment parameters to their default values. To do this, type "Reset", "RESET", or "reset" at the Personal Hardware Information Menu prompt.

Main Menu choice #3 - calculating suggested workstation settings

After all of the personal and hardware information is entered into the program the suggested workstation settings may be calculated. Entering a "3" at the Main Menu prompt will initiate ***IntelAd's*** calculating routines which place the computer user and the workstation hardware together into the Cartesian coordinate system. As this step occurs, the user is kept apprised of ***IntelAd's*** progress via an updating display (see Figure 4.10) which lists each step as it is completed. Since solutions containing uncorrectable constraint violations will trigger descriptive error messages as exemplified by the reference to a foot rest in Figure 4.10, the program prompts the user to continue. This assures the user enough time to read any displayed error messages.

When the ***IntelAd*** resumes, it automatically transfers to the Print/Display Menu, the fourth item on ***IntelAd's*** Main Menu.

```
Calculating body measurements.
Placing the individual into the X-Y plane.
Placing the hardware into the X-Y plane.
Checking for constraint violations.

A foot rest is required to prevent the feet from dangling.

Press [ENTER] to continue:  ?_____
```

Figure 4.10 Solution Progress Display

<u>**Main Menu choice #4 - print information/results**</u>

```
Print/Display Menu

(1)  Adjust your monitor for correct
     vertical height (Aspect Ratio)
(2)  See results displayed on screen
(3)  Print results (Hard Copy)
(4)  Save results to disk

(5)  Return to Main Menu

Please enter your selection:  ?___
```

Figure 4.11 Print/Display Menu

The Print/Display Menu (Figure 4.11) offers several output oriented options. The first choice from the Print/Display Menu allows the user to adjust the vertical height control of his or her monitor so that when ***IntelAd*** graphically displays the recommend workstation layout, the picture on the screen does not appear elongated or condensed. This Aspect Ratio Adjustment Screen is represented by Figure 4.12.

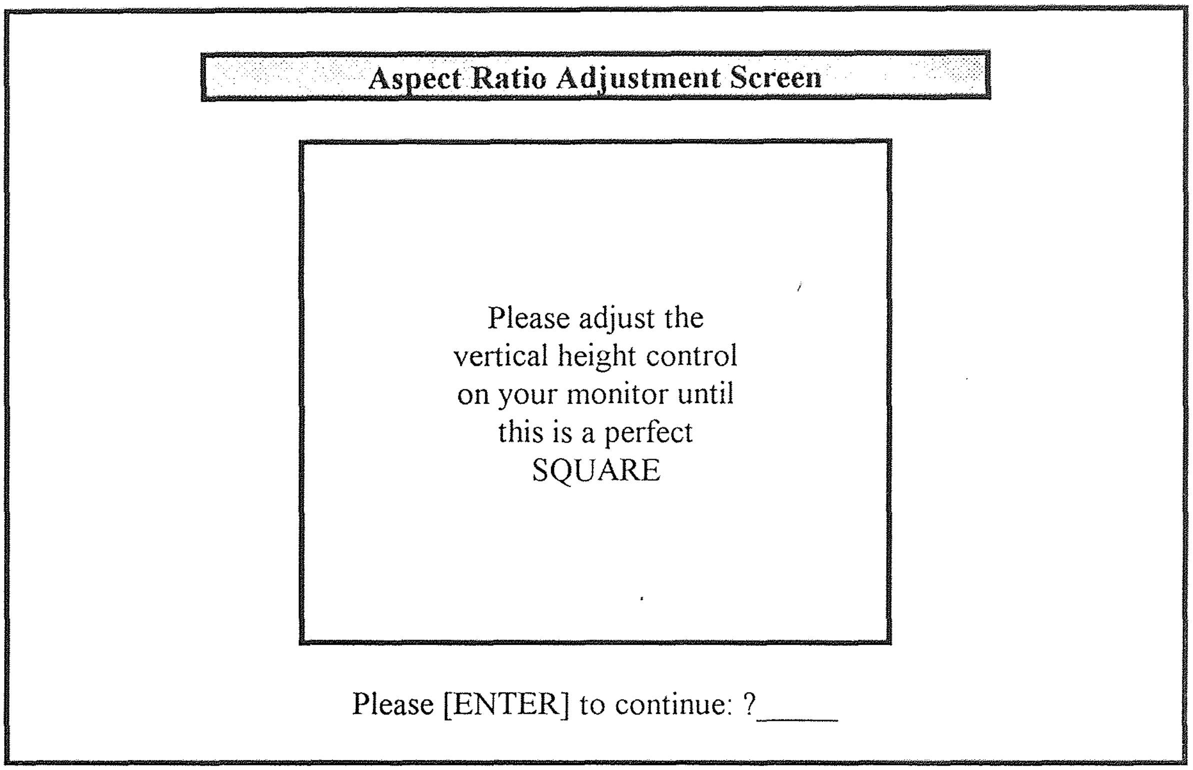


Figure 4.12 Aspect Ratio Adjustment Screen

A color, on-screen visual display of the calculated workstation settings is available by entering "2" at the Print/Display Menu prompt; a hard copy of the results is available by entering "3". Examples of each of these steps can be seen in the next section, 4.3, entitled Sample Output.

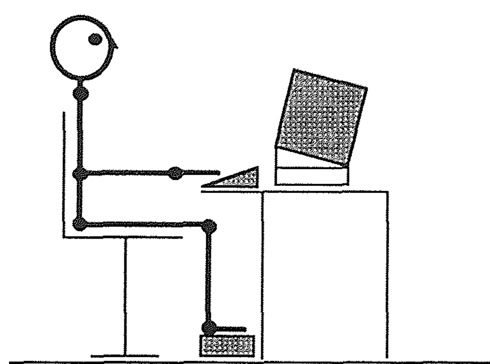
Selecting "4" from the Print/Display menu will open a save-to-disk screen where the user may define a file name (up to eight alpha-numeric characters) and save the calculated workstation settings, the entered data, and any error messages in a disk file for future reference.

4.3 Sample Output

To illustrate its output, ***IntelAd*** was asked to calculate the near optimal workstation layout for a 67.5 inch tall male using an adjustable chair (17.0 to 21.0 inches), a fixed height keyboard (27.5 inches), and a fixed height monitor (37.5 inches). Figures 4.13 and 4.14 represent ***IntelAd's*** visual display and printout, respectively.

John Doe
67.5 in. tall male

- Height of seat base: .... 18.1 in.
- Height of keyboard home row: ....27.5 in.
- Height of center of monitor: ....37.5 in.
- Horizontal distance from seat back to keyboard home row: .... 18.5 in.
- Horizontal distance from seat back to center of monitor: ....23.6 in.
- Footrest height: .... 1.0 in.



Press [ENTER] to continue: ?_____

Figure 4.13 Sample Output - Visual Display

IntelAd - Computer Workstation Adjustment Software

Personalized workstation adjustment settings for John Doe

Sex: .... Male
Height:.................. .67.5 in.

- Height of seat base: .... 18.1 in.
- Height of keyboard home row: .... 17.5 in.
- Height of center of the monitor:. .... 37.5 in.
- Horizontal distance from
  seat back to keyboard home row: .... 18.5 in.
- Horizontal distance from
  seat back to center of monitor: .... 23.6 in.
- Foot rest height: .... 1.0 in.

Workstation constraints:

Seat height adjustment limits: .... 17.0 to 21.0 in.
Keyboard height adjustment limits: .... 27.5 to 27.5 in. (FIXED)
Monitor height adjustment limits: .... 37.5 to 37.5 in. (FIXED)

Viewing distance: .... 24.21 in. (Optimal: 12.99 to 27.95 in.)
Viewing angle: .... 25.56 deg. (Optimal: 0.00 to 60.00 deg.)

Figure 4.14 Sample Output - Printed Display

CHAPTER 5

ANTHROPOMETRIC DATA AND THE CALCULATION OF BODY DIMENSIONS

5.1 Anthropometric Data

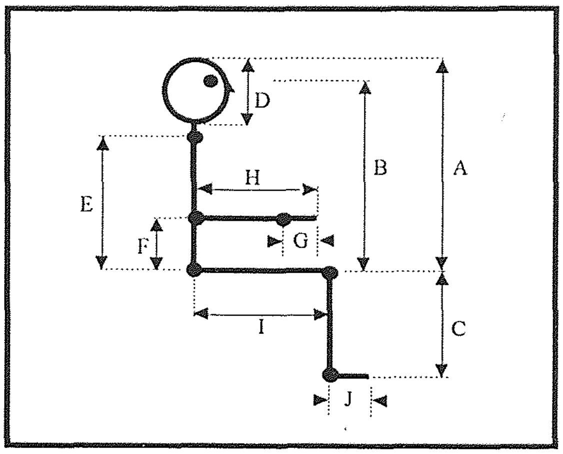
5.1.1 Introduction

As discussed in chapter 4, one major design criteria of ***IntelAd*** is that it be able to perform it's function using a limited amount of information. There should be no need to input detailed measurements of the computer user's body. Instead, ***IntelAd*** must be able to determine all needed measurements from only two input variables, the computer operator's sex and his or her standing height.

Table 5.1 Body Measures as a Percent of Standing Height

Body Measurement	Males	Females
1. Standing Height	100.%	100.%
2. Seated Height	52.19%	52.91%
3. Seated Eye Height	45.67%	46.41%
4. Seat Length (Upper Leg)	28.45%	29.97%
5. Seat Height (Lower Leg)	25.33%	24.84%
6. Hip to Shoulder (Trunk)	33.68%	33.88%
7. Elbow to Fingertip	27.46%	26.66%
8. Elbow Rest Height	13.88%	14.44%
9. Chin to Top of Head	12.75%	12.31%
10. Hand	10.80%	10.80%
11. Foot Length	15.20%	15.20%

Table 5.1 expresses the key body measures critical to ***IntelAd's*** objective as a function of an individual's sex and standing height. Figure 5.1 provides a visual reference of the same measures. This chapter details how these values were compiled and how they are applied by ***IntelAd***.



A = Seated Height
B = Seated Eye Height
C = Seat Height (Lower Leg)
D = Chin to Top of Head
E = Hip to Shoulder (Trunk)

F = Elbow Rest Height
G = Hand Length
H = Elbow to Fingertip
I = Seat Length (Lower Leg)
J = Foot Length

Figure 5.1 Anthropometric Reference

5.1.2 Compiling the Anthropometric Data

In order to obtain a single multiple useful in determining a specific body measurement from an individual's standing height, it was necessary to compile information from a series of published anthropometric sources.

Table 5.2 (a) Body Measures as a Percent of Standing Height for Males
(All measurements are reported in inches)

Population Percentile	Standing Height	Sitting Height	Percent of Standing Height	Seated Eye Height	Percent of Standing Height
5	63.6	33.2	52.20%	28.7	45.13%
10	64.5	33.8	52.40%	29.3	45.43%
20	66.0	34.4	52.12%	30.0	45.45%
30	68.0	34.9	51.32%	30.5	44.85%
40	67.6	35.3	52.22%	30.9	45.71%
50	68.3	35.7	52.27%	31.3	45.83%
60	68.8	36.0	52.33%	31.7	46.08%
70	69.7	36.5	52.37%	32.0	45.91%
80	70.6	36.9	52.27%	32.5	46.03%
90	71.8	37.6	52.37%	33.0	45.96%
95	72.8	38.0	52.20%	33.5	46.02%
Average:	68.3	35.7	**52.19%**	31.2	**45.67%**
Standard. Dev.:	2.7	1.5	0.29%	1.4	0.39%

Population Percentile	Standing Height	Seat Length (Upper Leg)	Percent of Standing Height	Seat Height (Lower Leg)	Percent of Standing Height
5	63.6	17.3	27.20%	15.5	24.37%
10	64.5	17.9	27.75%	16.0	24.81%
20	66.0	18.4	27.88%	16.4	24.85%
30	68.0	18.8	27.65%	16.7	24.56%
40	67.6	19.2	28.40%	17.0	25.15%
50	68.3	19.5	28.55%	17.3	25.33%
60	68.8	19.8	28.78%	17.6	25.58%
70	69.7	20.1	28.84%	17.8	25.54%
80	70.6	20.5	29.04%	18.2	25.78%
90	71.8	21.0	29.25%	18.8	26.18%
95	72.8	21.6	29.67%	19.3	26.51%
Average:	68.3	19.5	**28.45%**	17.3	**25.33%**
Standard. Dev.:	2.7	1.3	0.72%	1.1	0.64%

Population Percentile	Standing Height	Elbow to Fingertip	Percent of Standing Height	Hip to Shoulder (Trunk)	Percent of Standing Height
5	63.6	17.5	27.52%	21.0	33.02%
50	68.3	18.7	27.38%	--	--
95	72.8	20.0	27.47%	25.0	34.34%
Average:	68.2	18.7	**27.46%**	23.0	**33.68%**
Standard. Dev.:	3.8	1.0	0.06%	2.0	0.66%

Table 5.2 (a) (Continued)

Population Percentile	Standing Height	Elbow Rest Height	Percent of Standing Height
5	63.6	7.4	11.64%
10	64.5	8.0	12.40%
20	66.0	8.5	12.88%
30	68.0	8.9	13.09%
40	67.6	9.2	13.61%
50	68.3	9.5	13.91%
60	68.8	9.8	14.24%
70	69.7	10.2	14.63%
80	70.6	10.6	15.01%
90	71.8	11.0	15.32%
95	72.8	11.6	15.93%
Average:	68.3	35.7	**13.88%**
Standard. Dev.:	2.7	1.5	1.25%

Table 5.2 (b) Body Measures as a Percent of Standing Height for Females
(All measurements are reported in inches)

Population Percentile	Standing Height	Sitting Height	Percent of Standing Height	Seated Eye Height	Percent of Standing Height
5	59.0	30.9	52.37%	27.4	46.44%
10	59.8	31.4	52.51%	27.8	46.49%
20	61.1	32.2	52.70%	28.4	46.48%
30	61.8	32.6	52.75%	28.7	46.44%
40	62.4	33.1	53.04%	29.0	46.47%
50	62.9	33.4	53.10%	29.3	46.58%
60	63.7	33.8	53.06%	29.6	46.47%
70	64.4	34.2	53.11%	29.8	46.27%
80	65.1	34.6	53.15%	30.2	46.39%
90	66.4	35.2	53.01%	30.7	46.23%
95	67.1	35.7	53.20%	31.0	46.20%
Average:	63.1	33.4	**52.91%**	29.3	**46.41%**
Standard. Dev.:	2.5	1.5	.027%	1.1	0.11%

Table 5.2 (b) (Continued)

Population Percentile	Standing Height	Seat Length (Upper Leg)	Percent of Standing Height	Seat Height (Lower Leg)	Percent of Standing Height
5	59.0	17.0	28.81%	14.0	23.73%
10	59.8	17.3	28.93%	14.2	23.75%
20	61.1	17.9	29.30%	14.7	24.06%
30	61.8	18.2	29.45%	15.1	24.43%
40	62.4	18.6	29.81%	15.4	24.68%
50	62.9	18.9	30.05%	15.7	24.96%
60	63.7	19.2	30.14%	16.0	25.12%
70	64.4	19.5	30.28%	16.3	25.31%
80	65.1	19.9	30.57%	16.6	25.50%
90	66.4	20.6	31.02%	17.0	25.60%
95	67.1	21.0	31.30%	17.5	26.08%
Average:	63.1	18.9	**29.97%**	15.7	**24.84%**
Standard. Dev.:	2.5	1.2	0.77%	1.1	0.74%

Population Percentile	Standing Height	Elbow to Fingertip	Percent of Standing Height	Hip to Shoulder (Trunk)	Percent of Standing Height
5	59.0	15.5	26.27%	18.0	30.51%
50	62.9	16.8	26.71%	--	--
95	67.1	18.0	26.83%	25.0	37.26%
Average:	63.0	16.8	**26.60%**	21.5	**33.88%**
Standard. Dev.:	3.3	1.0	0.24%	3.5	3.37%

Population Percentile	Standing Height	Elbow Rest Height	Percent of Standing Height
5	59.0	7.1	12.03
10	59.8	7.6	12.71
20	61.1	8.2	13.42
30	61.8	8.5	13.75
40	62.4	8.9	14.26
50	62.9	9.2	14.63
60	63.7	9.5	14.91
70	64.4	9.7	15.06
80	65.1	10.1	15.51
90	66.4	10.7	16.11
95	67.1	11.0	16.39
Average:	63.1	9.1	**14.44**
Standard. Dev.:	2.5	1.2	1.33

Table 5.1 items 2 through 7

The multiplication factors listed in Table 5.1 for items 2 through 7 are calculated based upon anthropometric data tables published in the *Human Factors Handbook*.[22] For population percentiles from 5% to 95%, the six measures are expressed as a percent of the population percentile's corresponding standing height. The resulting percentages are then averaged to obtain a single multiplication factor applicable across the entire population. Tables 5.2 (a) and 5.2 (b) detail this process for males and females, respectively.

Table 5.1 items 9, 10 and 11

Although ***IntelAd*** is able to attain it's goal of calculating the near optimal workstation orientation using only measures 2 through 7 from Table 5.1, the visual depiction of the computer user seated at the workstation would be incomplete. Missing from the graphic representation are the computer user's foot, wrist, and neck. These are calculated as follows.

The segment lengths of (0.108) x (standing height) and (0.152) x (standing height) for the hand and foot, respectively, are derived from segment link length research published in *Anthropometry for Occupational Biomechanics*.[23] From this information, ***IntelAd*** is able to compute and draw the computer user's foot and place the wrist joint at the appropriate location along the forearm-hand line.

To find the length of an individual's neck as a function his or her standing height, it is necessary to back-calculate from the head size and the location of the shoulder. Table 5.3, an adaptation of work copywritten by Henry Dreyfus in 1959[24], lists head size (from the chin to the top of the head) as a percentage of an individual's standing height for both males and females.

Table 5.3 Head Size as a Percent of Standing Height
(All measurements are reported in inches)

MALES			
Population Percentile	**Standing Height**	**Chin to top of Head**	**Percent of Standing Height**
2.5	64.4	8.0	12.42%
50.0	69.1	8.7	12.59%
97.5	74.0	9.8	13.24%
Average	69.2	8.8	**12.75%**
Std. Dev.	3.9	0.7	.035%

FEMALES			
Population Percentile	**Standing Height**	**Chin to top of Head**	**Percent of Standing Height**
2.5	64.4	8.0	12.42%
50.0	69.1	8.7	12.59%
97.5	74.0	9.8	13.24%
Average	69.2	8.8	**12.75%**
Std. Dev.	3.9	0.7	.035%

5.2 Equations for Calculating Body Dimensions

In Chapter 6 the equations that ***IntelAd*** uses to map the computer operator into the Cartesian coordinate system are discussed. The independent variables in these equations are termed "body measurement variables" and are based upon the anthropometric data previously described in this chapter.

5.2.1 Body Measure Variables for Males

LOWER LEG = 0.2533 x STANDING HEIGHT

UPPER LEG = 0.2845 x STANDING HEIGHT

TRUNK = 0.3368 x STANDING HEIGHT

EYE HEIGHT ABOVE SHOULDER = 0.4567 x STANDING HEIGHT - TRUNK

UPPER ARM = (0.3368-0.1388) x STANDING HEIGHT

ELBOW TO FINGERTIP = 0.2746 x STANDING HEIGHT

FOREARM = ELBOW TO FINGERTIP - 0.108 x STANDING HEIGHT

SEATED HEIGHT = 0.5219 x STANDING HEIGHT

CHIN TO TOP OF HEAD = 0.1275 x STANDING HEIGHT

FOOT = 0.152 x STANDING HEIGHT

5.2.2 Body Measure Variables for Females

LOWER LEG = 0.2484 x STANDING HEIGHT

UPPER LEG = 0.2997 x STANDING HEIGHT

TRUNK = 0.3388 x STANDING HEIGHT

EYE HEIGHT ABOVE SHOULDER = 0.4641 x STANDING HEIGHT - TRUNK

UPPER ARM = (0.3388-0.1444) x STANDING HEIGHT

ELBOW TO FINGERTIP = 0.2666 x STANDING HEIGHT

FOREARM = ELBOW TO FINGERTIP - 0.108 x STANDING HEIGHT

SEATED HEIGHT = 0.5291 x STANDING HEIGHT

CHIN TO TOP OF HEAD = 0.1231 x STANDING HEIGHT

FOOT = 0.152 x STANDING HEIGHT

CHAPTER 6

EQUATIONS FOR PLACING THE INDIVIDUAL AND THE COMPUTER HARDWARE IN THE X-Y PLANE

6.1 Equations for Placing the Individual in the X-Y Plane

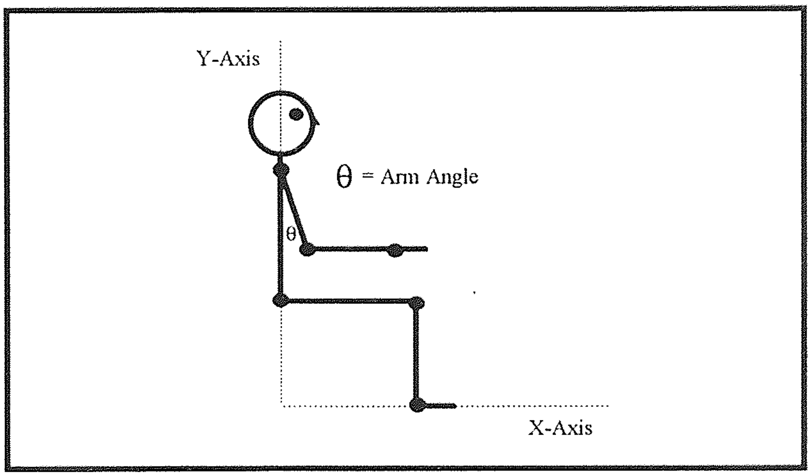


Figure 6.1 Computer User in the X-Y Plane

This section details the equations used by ***IntelAd*** in mapping the computer user into the Cartesian coordinate system. The hardware placement, an extension of this mapping, is described in sections 6.2 and 6.3.

6.1.1 Convention

The X and Y coordinates of each of key body parameter are given variable names as exemplified below:

X coordinate of the wrist:	XWRIST
Y coordinate of the wrist:	YWRIST

6.1.2 Equations

Ankle: XANKLE = TRUNK + UPPER LEG

YANKLE = 0

Toe: XTOE = XANKLE + FOOT

YTOE = 0

Hip: XHIP = 0

YHIP = UPPER LEG

Shoulder: XSHOULDER = 0

YSHOULDER = YHIP + TRUNK

Elbow: XELBOW = UPPER ARM • sin(ARM ANGLE)

YELBOW = YSHOULDER - UPPER ARM • cos(ARM ANGLE)

Forearms parallel to the ground:

Wrist: XWRIST = XELBOW + FOREARM

YWRIST = YELBOW

Fingertip: XFINGERTIP = XWRIST + HAND

YFINGERTIP = YWRIST

Forearms when there is a 90° bend at the elbow:

Wrist: XWRIST = XELBOW + FOREARM • cos(ARM ANGLE)

YWRIST = YELBOW + FOREARM • sin(ARM ANGLE)

Fingertip: XFINGERTIP = XWRIST + HAND • cos (ARM ANGLE)

YFINGERTIP = YWRIST + HAND • sin(ARM ANGLE)

Eyes: XEYES = 5 (Eyes assumed to be 5 centimeters in front X-axis)

YEYES = YSHOULDER + EYE HEIGHT ABOVE SHOULDER

Top of Head: XTOPOFHEAD = 0

YTOPOFHEAD = YSHOULDER + SITTING HEIGHT - TRUNK

Chin: XCHIN = 0

YCHIN = YTOPOFHEAD - HEAD SIZE

6.2 Equations for Placing the Keyboard in the X-Y Plane

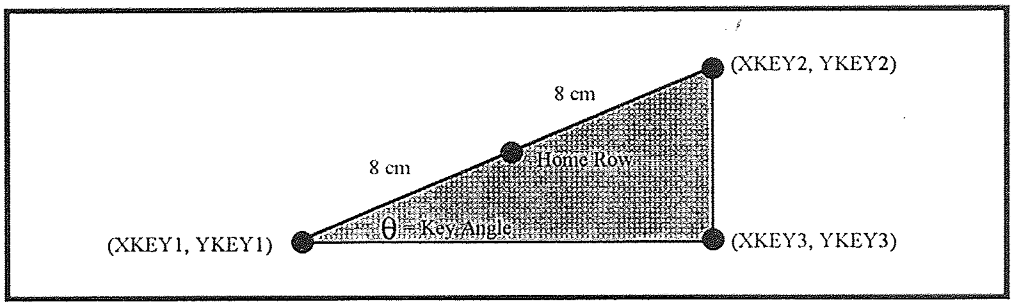


Figure 6.2 Computer Keyboard

6.2.1 Discussion

The keyboard is mapped into the X-Y plane with the computer user's fingertips placed on home row (the row containing the letters a,s,d,f,g,h,j,k, and l). The representative keyboard used is 16 cm along the diagonal with the home row located in the middle. The "Key Angle" is the degree of incline of the keyboard and defaults to 20 degrees in ***IntelAd***. (This value can be changed by changing the limits given to the keyboard angle in the "expert" hardware information screen.)

6.2.2 Equations

XKEY1 = XFINGERTIP - 8 • cos(KEY ANGLE)

YKEY1 = YFINGERTIP - 8 • sin(KEY ANGLE)

XKEY2 = XFINGERTIP + 8 • cos(KEY ANGLE)

YKEY2 = YFINGERTIP + 8 • sin(KEY ANGLE)

XKEY3 = XKEY1 + 16 • cos(KEY ANGLE)

YKEY3 = YKEY1

6.3 Equations for Placing the Monitor in the X-Y Plane

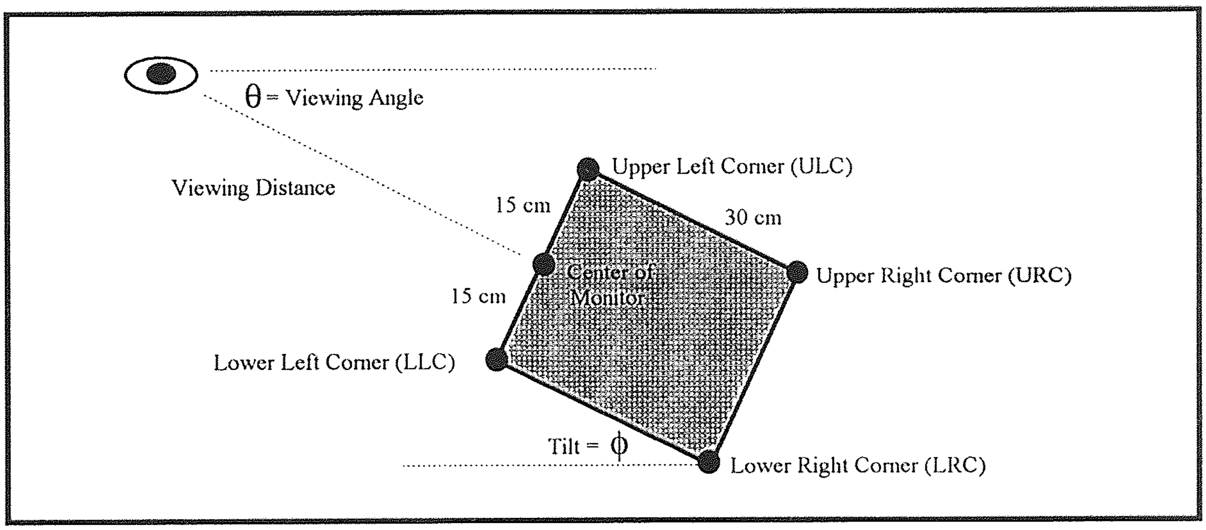


Figure 6.3 Computer Monitor

6.3.1 Discussion

The representative 30 centimeter by 30 centimeter computer monitor is mapped into the X-Y plane based on the location of the computer user's eye, the viewing distance, and the viewing angle. The viewing distance defaults to 61.5 centimeters (lower limit + 75% of the difference between the upper and lower limits) while the viewing angle defaults to 30 degrees. These values are subject to change when ***IntelAd*** checks for hardware constraint violations (e.g. the calculated monitor height exceeds the physical limitations of the workstation). Advanced users may alter the default viewing distance and viewing angle values using ***IntelAd's*** "expert" hardware information screen.

The angle monitor tilt is set at either 15 degrees or at the actual viewing angle, which ever is less.

6.3.2 Equations

Center of the monitor:

$$XCENTERMONITOR = XEYES + VIEW\ DISTANCE \bullet \cos(VIEW\ ANGLE)$$

$$YCENTERMONITOR = YEYES - VIEW\ DISTANCE \bullet \sin(VIEW\ ANGLE)$$

Corners of the monitor:

$$XULC = XCENTERMONITOR + 15 \bullet \sin(TILT)$$

$$YULC = YCENTERMONITOR + 15 \bullet \cos(TILT)$$

$$XURC = XULC + 30 \bullet \cos(TILT)$$

$$YURC = YURC - 30 \bullet \sin(TILT)$$

$$XLLC = XCENTERMONITOR - 15 \bullet \sin(TILT)$$

$$YLLC = YCENTERMONITOR - 15 \bullet \cos(TILT)$$

$$XLRC = XLLC + 30 \bullet \cos(TILT)$$

$$YLRC = YLLC - 30 \bullet \sin(TILT)$$

CHAPTER 7

VERIFYING THE FEASIBILITY OF A PROPOSED WORKSTATION ORIENTATION

7.1 Introduction

In Chapters 5 and 6 ***IntelAd's*** algorithms for calculating a proposed workstation orientation are detailed. These chapters discuss how ***IntelAd*** first determines the key body measures of the user, then calculates the individual's sitting posture, and concludes by placing the workstation hardware around the seated individual. This is the classic human factors; fit the workstation to the user, not the user to the workstation. However, when dealing with existing hardware, this method does not always yield a feasible solution. When a calculated layout is determined to be in conflict with the physical limitations of the intended workstation hardware, it becomes necessary to review the proposed layout from the hardware perspective in order to find a compromise solution. Recall, ***IntelAd's*** goal is to determine the near optimal workstation orientation for a computer user based upon his or her own anthropometrics as well as the actual workstation hardware. This chapter discusses how ***IntelAd*** makes the necessary changes in a conflicted proposed solution in determining a feasible workstation orientation.

7.2 Constraints

Constraints are the physical limitations imposed on a calculated orientation by the workstation hardware. For example, the height adjustment range of a workstation chair or the height of a fixed desk supporting the computer keyboard, are two possible constraints.. These physical limitations placed upon each calculated layout may originate from one of two sources: (1) built-in default values or (2) user defined values.

Initially, all workstation adjustment parameters are the default values defined in the actual program listing that constitutes ***IntelAd***. These default values, listed in Table 7.1, are the recommended computer workstation adjustment ranges promulgated by the 1988 American National Standards Institute/Human Factors Society 100 Standard. (ANSI/HFS-100). However, many workstations in current use are comprised of non-adjustable components and/or components whose adjustment ranges may deviate from those recommended by the ANSI/HFS-100 Standard. ***IntelAd*** permits users to input workstation specific adjustment parameters to replace the default values used in ***IntelAd's*** constraint violation checking procedures. This is the second source of hardware constraints.

Table 7.1 ANSI/HFS-100 Standard Recommended Ranges for Computer Workstation Adjustment

Feature	Adjustment Range
Seat Height	40.6-52 cm.
Keyboard Height	58.5-71 cm.
Monitor Height	78-91 cm.
Viewing Distance	33-71 cm
Viewing Angle	0-60 deg.

7.3 Error Messages

Error messages are comments ***IntelAd*** collects and reports as the program tries to adjust its initially calculated workstation orientation to the imposed constraints, which may be either default or user defined. There are six possible error messages:

1) *A foot rest is required to prevent the feet from dangling.*

2) *The optimal keyboard height is lower than constraints will allow.*

3) *The optimal keyboard height is higher than constraints will allow.*

4) *The optimal monitor height is lower than constraints will allow.*

5) *The optimal monitor height is higher than constraints will allow.*

6) *The optimal viewing distance has been exceeded to avoid a physical conflict between the monitor and the keyboard.*

An unresolved constraint violation will trigger one of these six error messages. Error messages are reported by ***IntelAd*** on the Calculation Progress Display screen (Figure 4.9) and on the hard-copy printout (Figure 4.10).

Error messages #1 and #6 are the most commonly encountered. Specifically, message #1, adding a foot rest, can be found in solutions for shorter individuals whose feet would dangle even when the workstation chair is adjusted to its lowest setting. Message #6, exceeding optimal viewing distance, is common for taller individuals whose long arms push the keyboard back into the normal location of the monitor. Messages #2 through #5 typically result only if extremely unrealistic workstation constraints are artificially imposed upon ***IntelAd***.

7.4 Checking for Constraint Violations in a Proposed Solution

7.4.1 Overview

IntelAd compares it's initially calculated orientation (hereafter referred to as the trial solution) to each constraint as it tests for possible violations. This is done using a sequential logic process. Step-by-step, the trial solution is compared to each constraint. If the trial solution can pass a constraint test without requiring modification, then the next constraint is considered. A trial solution that can pass all constraint tests is considered a feasible solution.

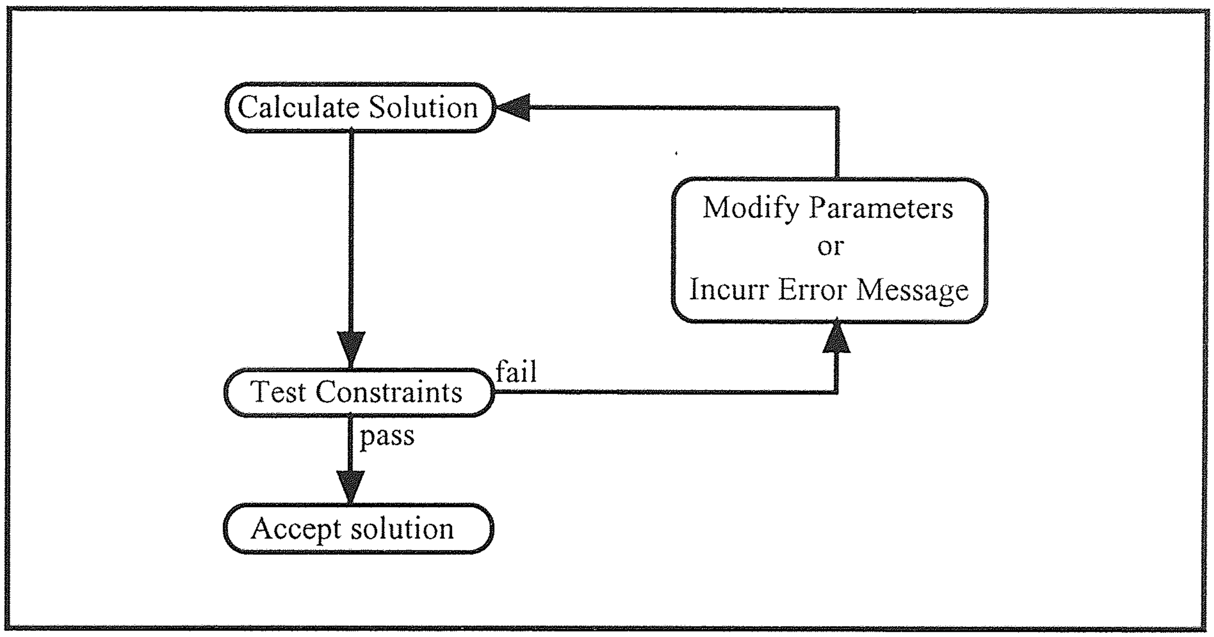


Figure 7.1 Testing for Constraint Violations - Macro Level

Many trial solutions, however, will fail a constraint test at some point in the testing process. Some modifications to the trial solution are required to overcome such violations. A "new" trial solution which incorporates the modification is determined by ***IntelAd***. This new trial solution is then reverted to the beginning of the constraint violation testing procedure; a necessity since the modifications required to satisfy one constraint may, in turn, cause the violation of another. When a constraint cannot be satisfied through modification of the trial solution, an error message is incurred and the constraint is passed over. A modified trial solution will be deemed feasible only after all constraints have either been satisfied or have forced an error message.

7.4.2 Testing Procedures and Logic

While Figure 7.1 outlines in an overall sense how ***IntelAd*** tests the feasibility of a proposed workstation orientation, Figures 7.2 (a through f) detail the exact logic employed to test each possible constraint violation.

Figure 7.2 (a) initiates the testing routines by looking at chair height. If ***IntelAd*** calculates an initial chair height that is less than the chair's lower limit, then the chair must be raised to satisfy the constraint. In addition, a foot rest whose thickness is equal to the height the chair was raised, is added to the solution. Since ***IntelAd*** initially calculates the computer user with his/her feet flat on the ground, the foot rest is required to keep the user's feet from dangling while sitting in a raised chair. In the case when the calculated value of the chair height is found to be higher than the chair's upper adjustment limit, the chair height is lowered. A chair that must be lower than ***IntelAd*** initially calculates will cause the computer user's knees to lift off the front edge of the chair.

Figure 7.2 (b) outlines the how ***IntelAd*** tests and corrects for a keyboard that is lower than the constraints allow. If the keyboard height fails this test, up to three correction attempts are made. First, ***IntelAd*** tries to raise the chair (and consequently the body of the person in the chair) to satisfy the keyboard constraint. Recall that the hardware is placed around the seated individual. By raising the chair and the user, the fingertips are raised allowing the keyboard to reside at a higher location. If the chair can not be raised enough (or at all) in an attempt to satisfy the constraint, then ***IntelAd*** tries a second type of modification. ***IntelAd*** simultaneously rotates the shoulder joint forward and the elbow joint downward (keeping the arms parallel to the ground) by up to fifteen degrees. This change raises the operator's fingertips and consequently the keyboard. If this second step also fails to satisfy the lower keyboard height constraint, then the shoulder and elbow joints are returned to their initial positions in preparation for a third modification attempt. The shoulder joint is again rotated up to fifteen degrees. This time, however, the elbow joint is fixed at ninety degrees and the fingertips are raised a considerable amount. Typically this last method resolves the constraint violation but is least desirable since in practice it reduces the operator's ability to maintain a straight wrist. If all three procedures fail to satisfy the constraint, then an error message is collected.

Figure 7.2 (c) illustrates how a constraint violation for an upper limit keyboard height violation is resolved. When this violation occurs, ***IntelAd*** rotates the elbow joint downward by up to fifteen degrees. By rotating the forearm downward around the elbow joint, the fingertips and the keyboard are lowered. If the constraint can be satisfied by this modification, the program moves on. If not, an error message is incurred.

In Figure 7.2 (d), monitor height violations are addressed. When the monitor height is calculated above the upper constraint limit, the monitor is lowered. The viewing angle is then recalculated with the monitor residing at its maximum allowed height. The new viewing angle is then compared against it's own constraints. If lowering the monitor forces the viewing angle beyond its upper limit, then the viewing angle is reset to its upper value and the monitor position is recalculated. As with the other constraints, a modification that satisfies the constraint allows the program to continue; one that can not satisfy the constraint forces an error message. Correcting a monitor position that is lower than constraints allow follows a similar pattern and is also detailed by Figure 7.2 (d).

Figure 7.2 (e) describes how ***IntelAd*** resolves a situation where the calculated monitor position causes the monitor to be partially blocked by the keyboard. When this occurs, ***IntelAd*** attempts a resolution by incrementally decreasing the viewing angle until the monitor is raised to a point where it can either clear the keyboard or the lower limit on the viewing angle is observed. If the conflict can not be resolved, an error message indicating that the optimal height of the monitor is higher than the constraint allows is collected.

In the last of the constraint violation tests (Figure 7.2 (f)), ***IntelAd*** looks to see if the calculated position of the monitor is physically on top of the keyboard. If this occurs, as often is the case with taller individuals, then ***IntelAd*** incrementally increases the viewing distance until the monitor sits behind the keyboard by at least one inch. If in the process of moving the monitor, the maximum viewing distance is exceeded, an appropriate error message is triggered. However since it is physically impossible for the monitor to share the same space as the keyboard, ***IntelAd*** will allow a violated maximum viewing distance to exist in a final solution. Once it is determined that the monitor clears the keyboard, this constraint is considered satisfied.

When all of the constraint tests are be successfully completed as indicated above, then ***IntelAd*** has determined the near optimal workstation orientation.

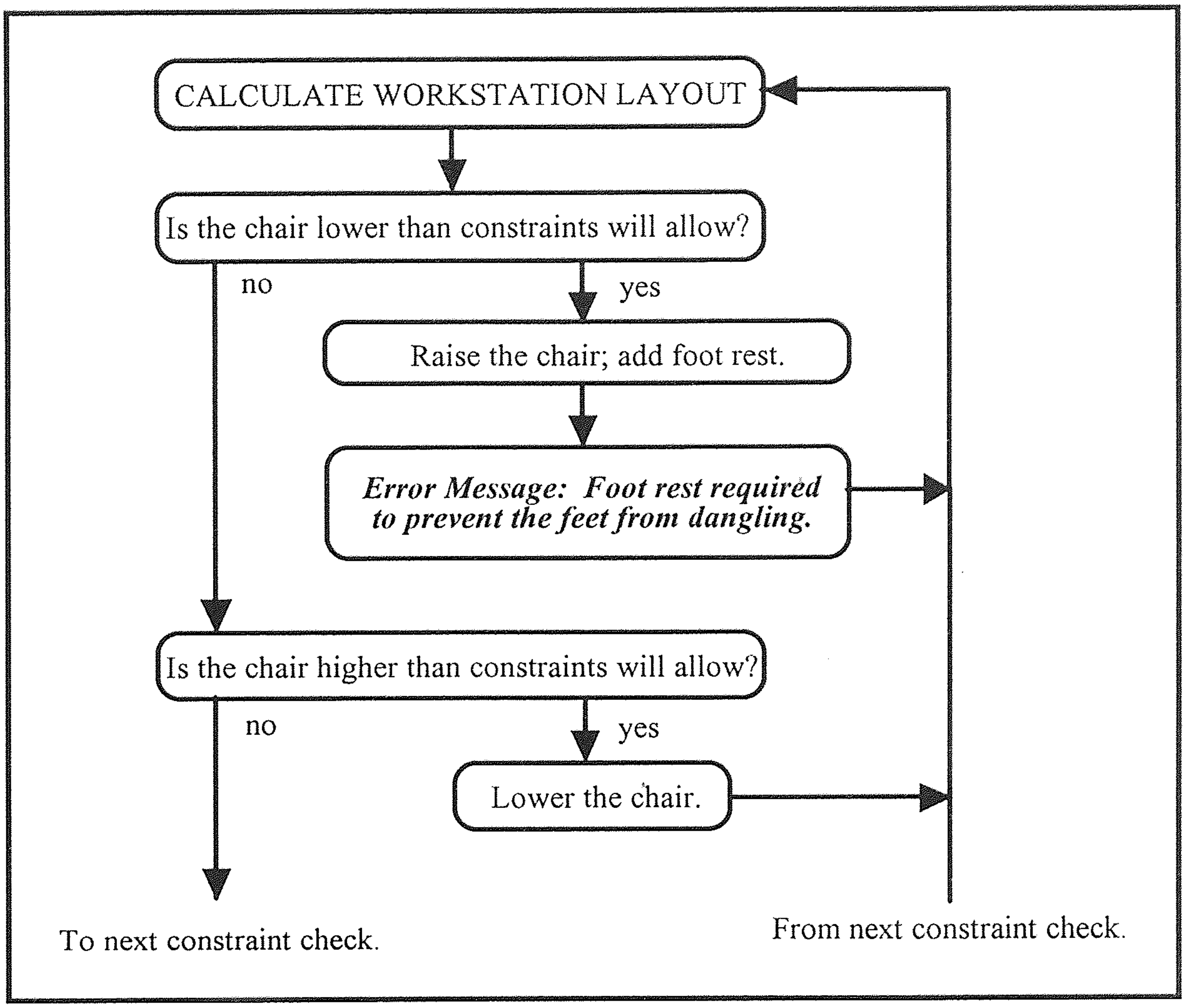


Figure 7.2 (a) Testing for Seat Height Constraint Violations

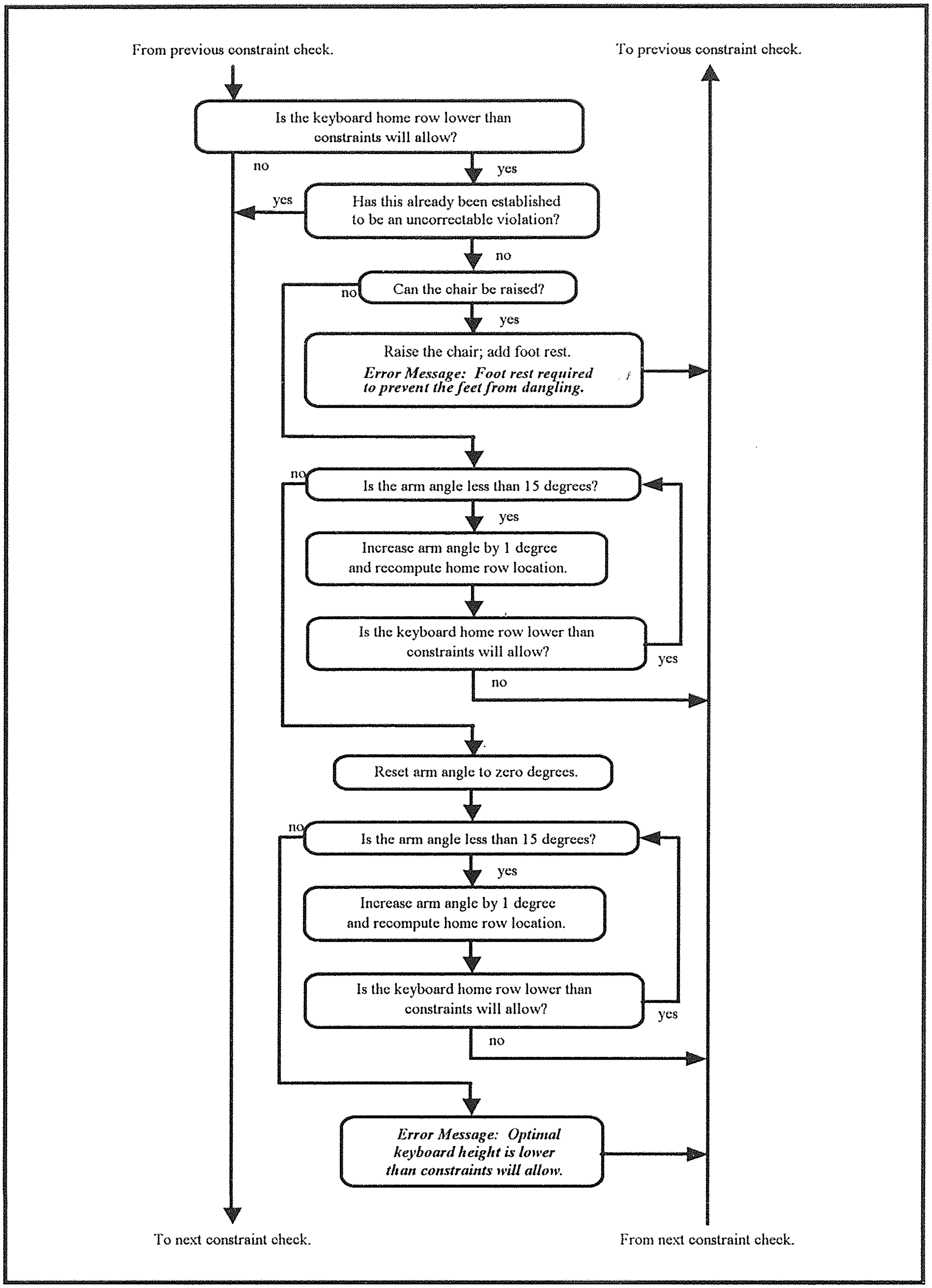


Figure 7.2 (b) Testing for Keyboard Height Constraint Violations (Under Limit)

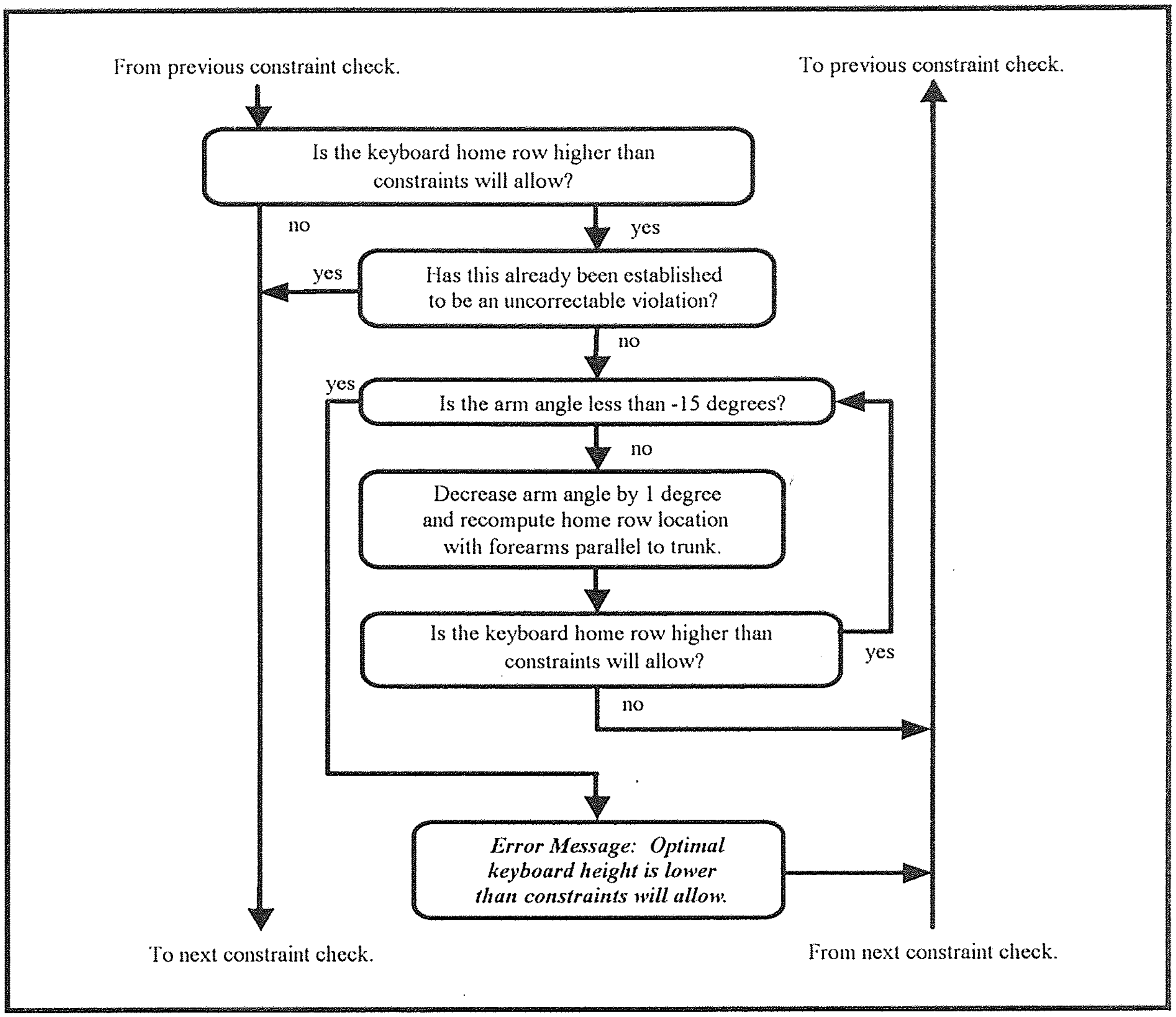


Figure 7.2 (c) Testing for Keyboard Height Constraint Violations (Over Limit)

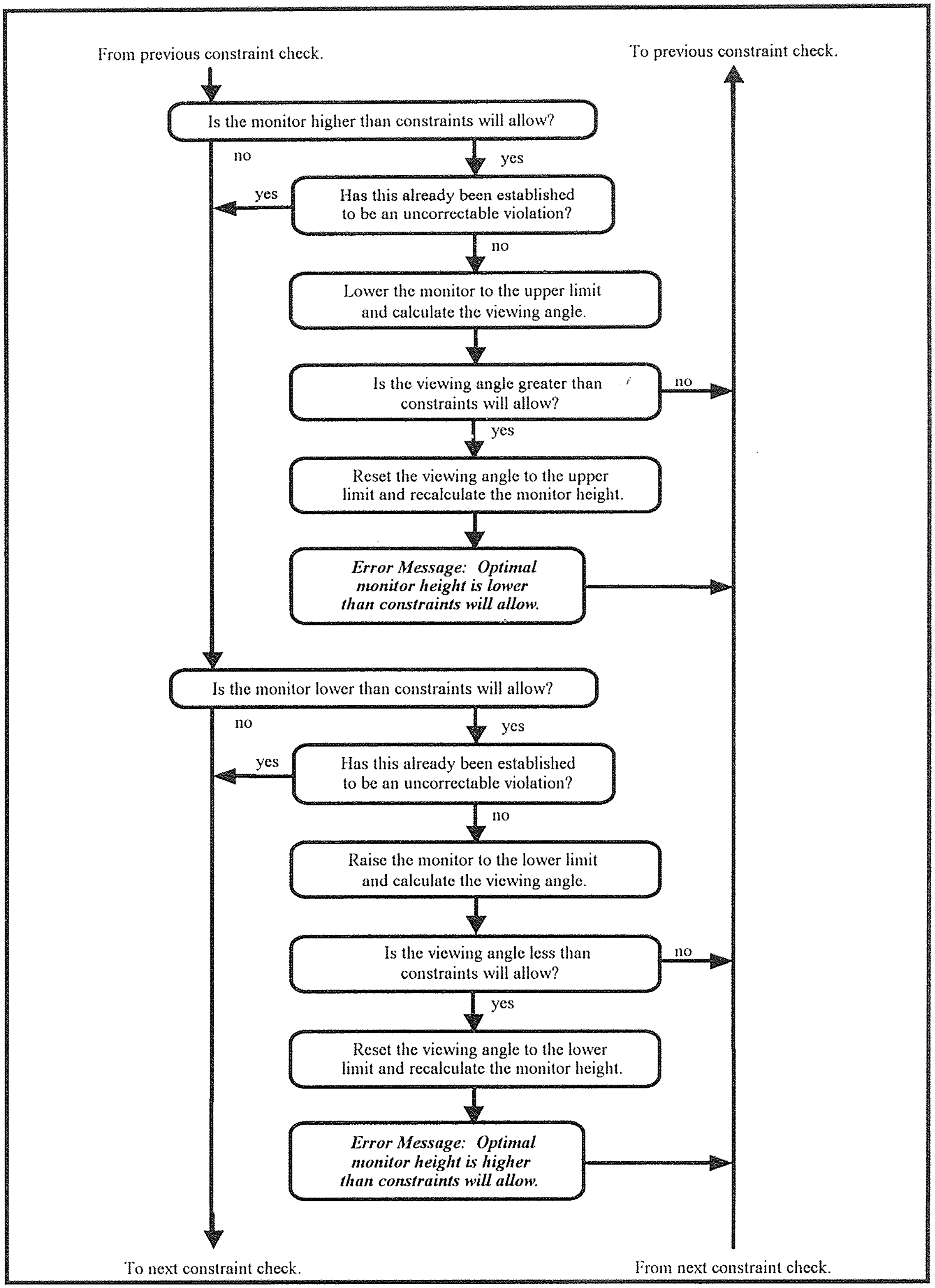


Figure 7.2 (d) Testing for Monitor Height Constraint Violations

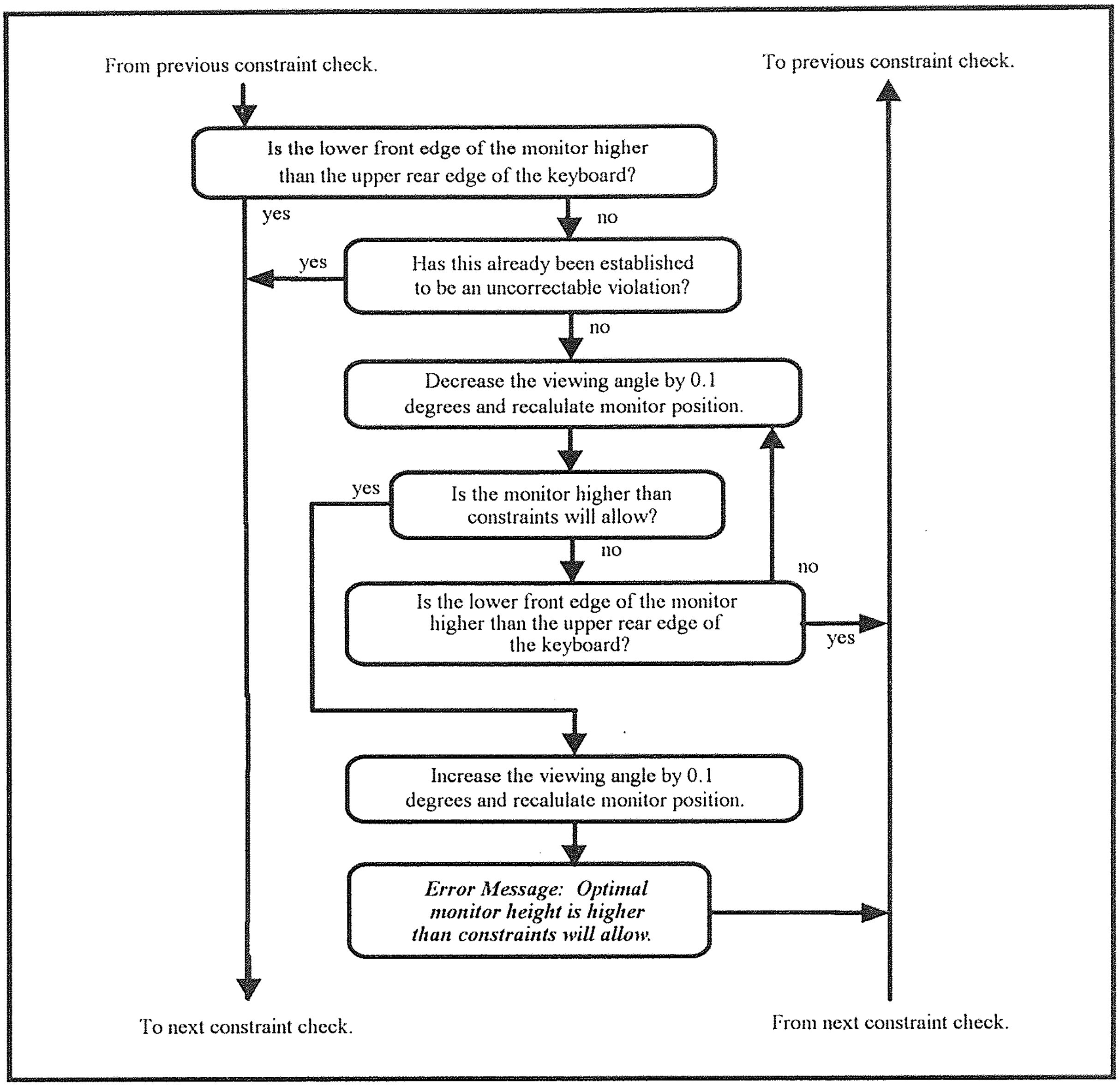


Figure 7.2 (e) Testing for Monitor-Keyboard Conflict in the Vertical Plane

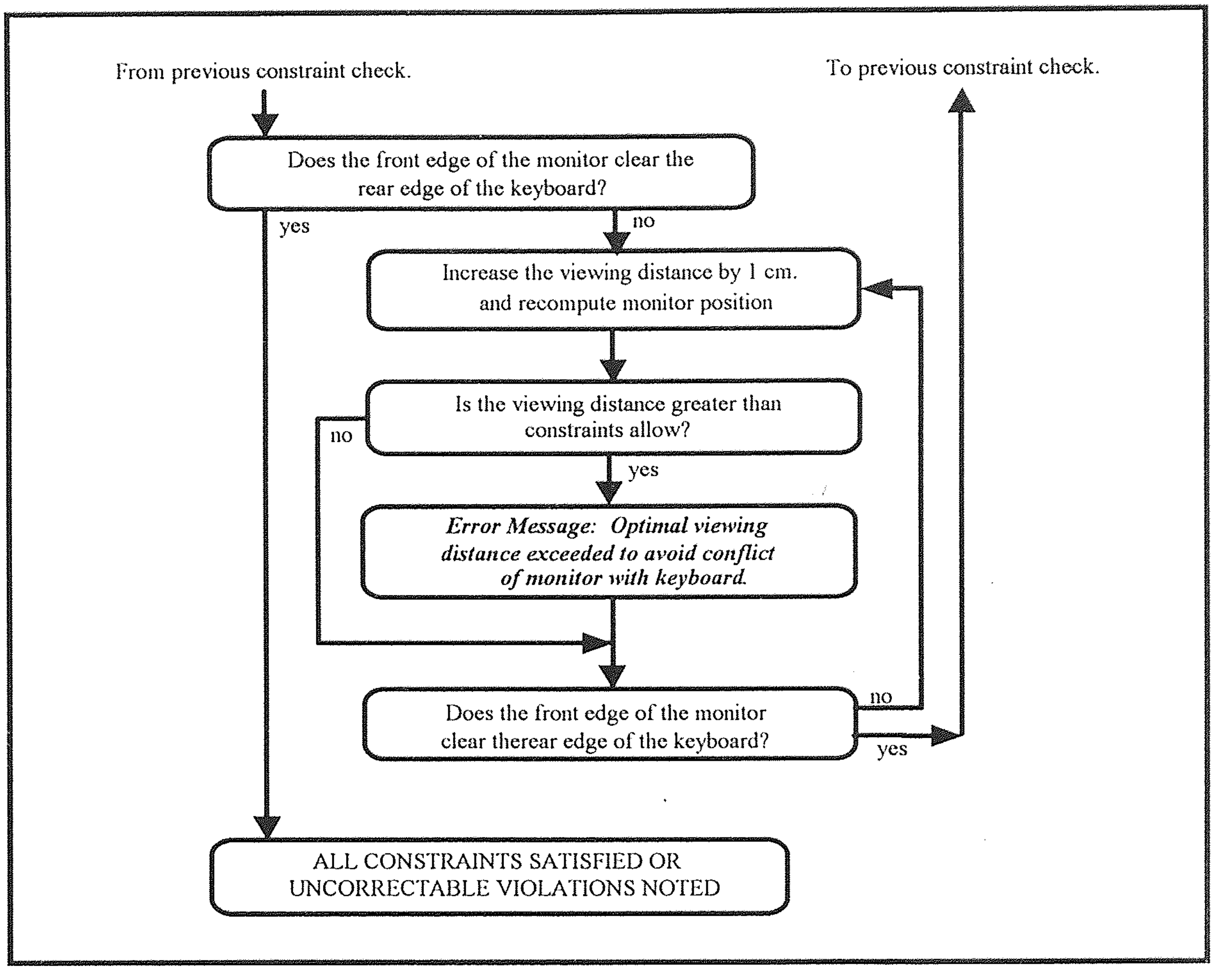


Figure 7.2 (f) Testing for Monitor-Keyboard Conflict in the Horizontal Plane

CHAPTER 8

FIELD TRIALS

8.1 Objective

To verify ***IntelAd's*** effectiveness in a real-world setting, field trials were conducted in several office environments. ***IntelAd*** was applied to twelve workstations, seven with female users, and five with male users. Table 8.1 summarizes the general information regarding these computer operators and their respective workstations. Note that a broad range of individuals is represented, including a small female and a large male.

Table 8.1 Field Trials

Trial Round	Figure No.	Individual		Component Adjustable?		
		Sex	Height	Chair	Keyboard	Monitor
1	8.3	Female	58.0 in.	Yes	Yes	No
2	8.4	Female	61.8 in.	Yes	No	No
1	8.5	Female	63.0 in.	Yes	Yes	No
1	8.6	Female	65.0 in.	Yes	Yes	No
1	8.7	Female	65.0 in.	Yes	No	No
1	8.8	Female	66.0 in.	Yes	Yes	No
1	8.9	Female	68.0 in.	Yes	No	No
1	8.10	Male	67.0 in.	Yes	Yes	No
2	8.11	Male	67.5 in.	Yes	No	No
1	8.12	Male	71.0 in.	Yes	No	No
2	8.13	Male	71.0 in.	Yes	No	No
2	8.14	Male	78.0 in.	Yes	Yes	Yes

8.2 Round #1

Eight trials were conducted in the first application of ***IntelAd*** to a working office environment. While ***IntelAd*** was able to recommend a satisfactory solution for each worker/workstation pair, in practice several of the solutions indicated a design flaw in ***IntelAd's*** constraint violation and correction routines.

As discussed in Chapter 7, ***IntelAd*** builds a workstation orientation around a seated computer user. In ***IntelAd's*** initial form, a worker was seated comfortably in a chair and the chair height was fixed and not permitted to change. When faced with a keyboard height constrained above ***IntelAd's*** initially calculated value, the program would attempt to satisfy the constraint by rotating the operator's arms upward at the shoulder. In theory, this satisfied the constraint while maintaining a "straight wrist" posture. However, practical observations indicated that a worker in this posture needed to bend his or her wrists in order to perform keying operations. See Figure 8.1

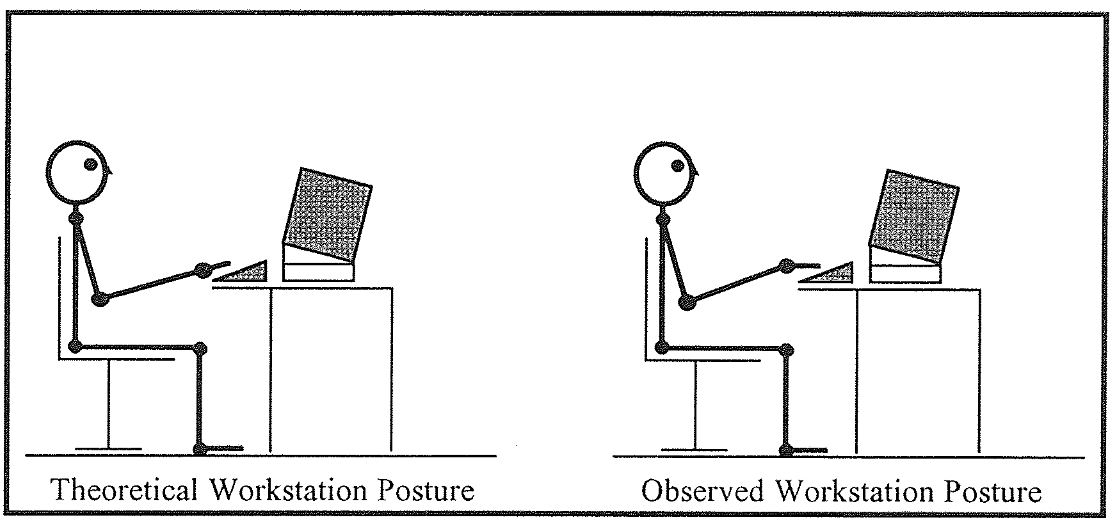
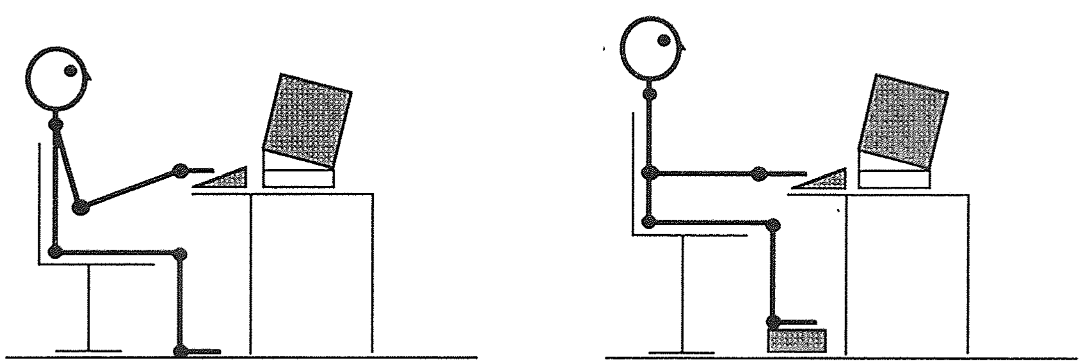


Figure 8.1 Theoretical vs. Observed Workstation Posture

8.3 Round #2

Based upon the initial field trials, ***IntelAd*** was modified to raise the chair and add a foot rest when the above described constraint violation is encountered. In this form, ***IntelAd*** maintains the worker's arms parallel to the ground and permits the "straight wrist" principle to be observed in practice as well as in theory. See Figure 8.2.

A detailed discussion of how ***IntelAd*** tests and satisfies such constraint violations is given in Chapter 7. This discussion reflects the modifications made to ***IntelAd*** after the initial round of field trials.


Round #1 Workstation Posture

Round #2 Workstation Posture

Figure 8.2 Comparing Workstation Postures for Pre- and Post-Modified ***IntelAd***

Four additional trials were conducted with the modified program and the eight initial trials were recalculated. In all twelve cases, ***IntelAd*** recommended a feasible solution that satisfied its ergonomic objectives and was considered comfortable by the computer operator with only minor adjustments. The results from each field trial, represented by ***IntelAd's*** printed output, are presented in Appendix B.

CHAPTER 9

OPERATOR SPECIFIC STANDARDS TABLES FOR WORKSTATIONS WITH ANSI/HFS-100 RECOMMENDED ADJUSTMENT CAPABILITY

9.1 Motivation

IntelAd's flexibility allows it to recommend the near optimal workstation orientation for an infinite number of circumstances. The program is able to ergonomically arrange workstation hardware which is either fixed, semi-adjustable, or fully adjustable as recommended by the ANSI/HFS-100 Standard. Indeed, this is ***IntelAd's*** true strength.

However, as office environments begin to reflect a more concerned approach to ergonomics and worker safety, truly flexible workstations will become the norm, rather than the exception. When ANSI/HFS-100 compatible workstations are present, ***IntelAd's*** diversity may no longer be necessary.

9.2 Operator Specific Standards Tables

By removing the variation in workstation adjustment capability, the near optimal workstation orientation becomes a function of only two independent variables, standing height and sex. Figures 9.1 (a) and 9.1 (b) are "Operator Specific Standards Tables" for males and females, respectively. These tables use the knowledge of the operator's sex and standing height to recommend the heights of the chair, keyboard, and monitor; as well as the horizontal distances between the back of the chair and the keyboard, and the back of the chair and the monitor. With this information, an operator may be quickly provided with a near optimal workstation orientation that should only need minor adjustment to account for any individual variations between the actual and the modeled computer operator.

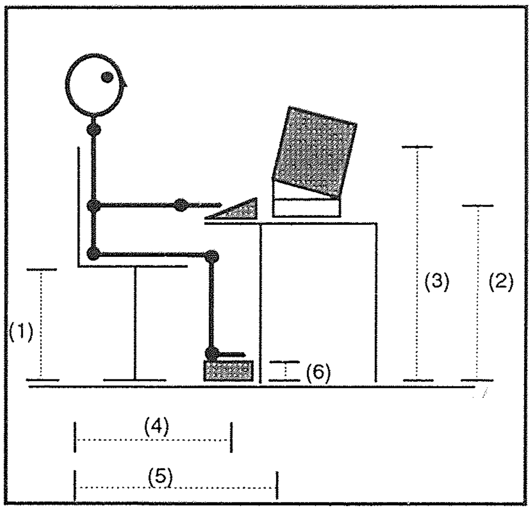
The Operator Specific Standards Tables represent, perhaps, the most widely applicable portion of this body of work. For example, workstation furniture manufacturers could include these charts in the literature accompanying their products, making a proper workstation orientation available for all of their consumers. Additionally, the charts could be added to safety pamphlets, such as *The Video Display Terminal and You*[25]. Many companies purchase and distribute these materials to their office employees. In the opinion of the author, these charts represent the best mechanism to transfer this research from academia to the masses.

9.3 Development

The information in Figures 9.1 (a) and 9.1 (b) is compiled from repeated applications of ***IntelAd,*** using the default adjustment parameters, for males and females of incremental heights from 58 to 78 inches .

Recommended Workstation Adjustment Settings for Males

(All entries are in inches)



(1) Seat Height
(2) Keyboard Height (to Home Row)
(3) Monitor Height (to Center Screen)
(4) Seatback to Home Row Distance
(5) Seatback to Center Screen Distance
(6) Footrest Height

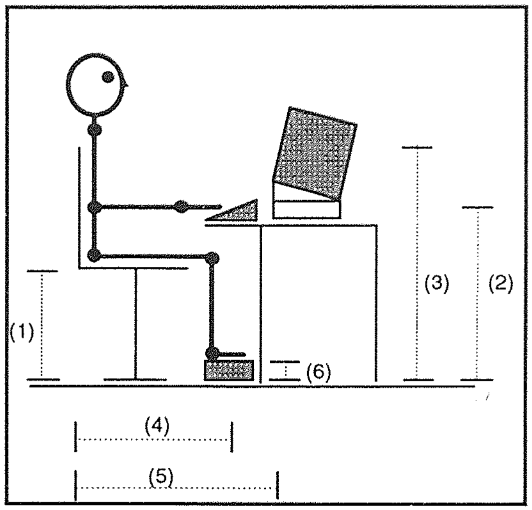
Standing Height	(1)	(2)	(3)	(4)	(5)	(6)	Notes
58.0	16.0	24.0	31.7	15.9	23.3	1.3	A
59.0	16.0	24.2	31.9	16.2	23.2	1.0	A
60.0	16.0	24.3	32.0	16.5	23.0	0.8	A
61.0	16.0	24.5	32.1	16.8	22.8	0.5	A
62.0	16.0	24.6	32.3	17.0	22.7	0.3	A
63.0	16.0	24.7	32.8	17.3	22.7	0.0	
64.0	16.2	25.1	33.5	17.6	22.7	0.0	
65.0	16.5	25.5	33.8	17.8	23.4	0.0	
66.0	16.7	25.9	34.3	18.1	23.7	0.0	
67.0	17.0	26.3	34.8	18.4	24.0	0.0	
68.0	17.2	26.7	35.8	18.7	24.7	0.0	
69.0	17.5	27.1	35.8	18.9	24.7	0.0	
70.0	17.7	27.4	35.8	19.2	24.7	0.0	
71.0	18.0	27.8	35.6	19.5	25.1	0.0	
72.0	18.2	28.0	35.7	19.8	25.6	0.0	B
73.0	18.5	28.0	35.7	20.0	26.1	0.0	B
74.0	18.7	28.0	35.7	20.3	26.6	0.0	B
75.0	19.0	28.0	35.7	20.5	27.0	0.0	B
76.0	19.3	27.9	35.7	20.8	27.5	0.0	B
77.0	19.5	27.9	35.7	21.0	27.9	0.0	B
78.0	19.8	27.9	35.6	21.3	28.4	0.0	B

NOTES: A = Footrest is required to prevent feet from dangling.
B = Optimal viewing distance exceeded to avoid conflict of monitor with keyboard.

Figure 9.1 (a) Operator Specific Standards Table for Males

Recommended Workstation Adjustment Settings for Males

(All entries are in inches)



(1) Seat Height
(2) Keyboard Height (to Home Row)
(3) Monitor Height (to Center Screen)
(4) Seatback to Home Row Distance
(5) Seatback to Center Screen Distance
(6) Footrest Height

Standing Height	(1)	(2)	(3)	(4)	(5)	(6)	Notes
58.0	16.0	24.4	32.0	15.4	23.3	1.6	A
59.0	16.0	24.5	32.2	15.7	23.1	1.3	A
60.0	16.0	24.6	32.3	16.0	22.9	1.1	A
61.0	16.0	24.8	32.5	16.2	22.8	0.8	A
62.0	16.0	24.9	32.8	16.5	22.7	0.6	A
63.0	16.0	25.1	33.3	16.8	22.7	0.3	A
64.0	16.0	25.2	33.7	17.0	22.7	0.1	A
65.0	16.1	25.5	34.4	17.3	22.7	0.0	
66.0	16.4	25.9	35.1	17.6	22.7	0.0	
67.0	16.6	26.3	35.4	17.8	23.4	0.0	
68.0	16.9	26.7	35.8	18.1	24.2	0.0	
69.0	17.1	27.1	35.8	18.4	24.2	0.0	
70.0	17.4	27.5	35.8	18.6	24.7	0.0	
71.0	17.6	27.9	35.8	18.9	24.7	0.0	
72.0	17.9	27.9	35.8	19.1	24.7	0.0	
73.0	18.1	28.0	35.7	19.4	25.0	0.0	B
74.0	18.4	28.0	35.7	19.7	25.5	0.0	B
75.0	18.6	28.0	35.7	19.7	25.9	0.0	B
76.0	18.9	28.0	35.7	20.1	26.4	0.0	B
77.0	19.1	28.0	35.7	20.4	26.8	0.0	B
78.0	19.4	28.0	35.7	20.6	27.2	0.0	B

NOTES: A = Footrest is required to prevent feet from dangling.
B = Optimal viewing distance exceeded to avoid conflict of monitor with keyboard.

Figure 9.1 (b) Operator Specific Standards Table for Females

CHAPTER 10

OBSERVATIONS, EXTENSIONS, AND CONCLUSIONS

10.1 Observations

The culmination of any body of research satisfies one inquiry or observation and often conceives others. The work presented here has led the author to the following observations, thoughts, and questions.

- Nearly every computer workstation that was either studied, observed, or even noticed needed improvement.
- ***IntelAd*** has shown that a footrest is almost always necessary when a fixed height keyboard support is used. However, footrests do not appear to be widely used in industry.
- Viewing distances observed in practice are typically beyond acceptable limits. This is often justified by the computer operator as a necessity to provide desktop space for notes, supplies, etc. How can desktops be redesigned to provide sufficient work space while allowing an acceptable viewing distance?
- Workstations are not always set-up in the same vertical plane. Monitors are often placed to one side of the desk or the other thus requiring the computer user to turn his or her head in order to view the screen. Such situations increase the risk of neck injury and likely add to eye strain.
- How did the 101-key computer keyboard become an industry standard when it is inherently and obviously flawed? Even accepting the sub-optimal "QWERTY" text key arrangement, this keyboard fosters an awkward work posture due to the physical arrangement of its three major key groupings.

10.1.1 The 101-Key Computer Keyboard

The 101-key standard keyboard has all of its text keys grouped to the left of center, its cursor keys grouped to the right of center, and its numeric pad to the right of that. For most applications, a majority of keying operations are performed on the text keys. However, since the keyboard unit as a whole is typically centered in front of the computer user, by design it forces the computer operator to assume an awkward work posture. See Figure 10.1 (a).

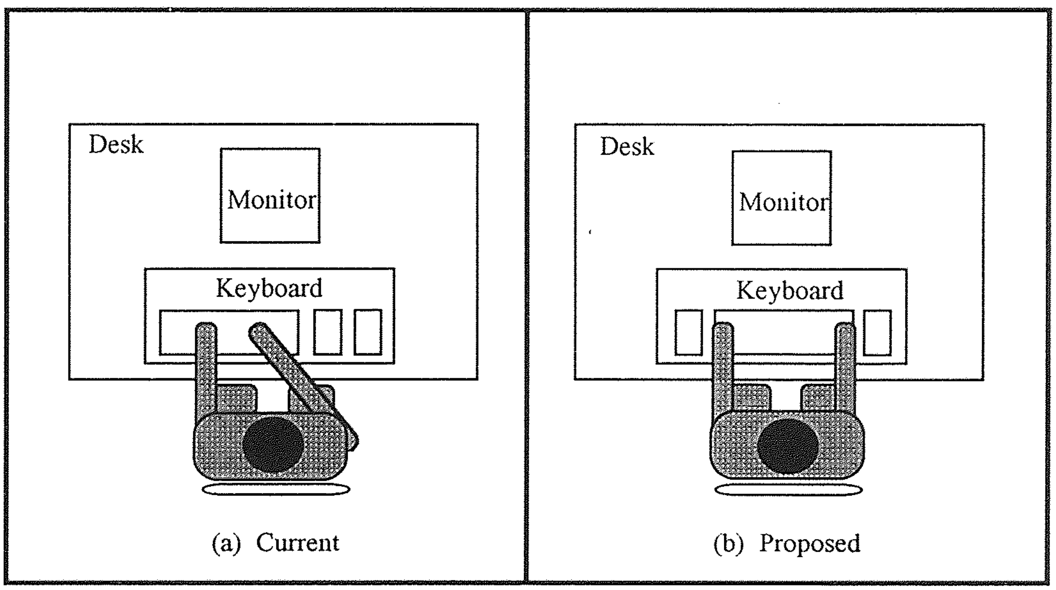


Figure 10.1 Standard 101-Key Keyboard: Current vs. Proposed Grouping of Keys

Many desk designs provide limited surface space for the keyboard. This prevents correcting the skewed key arrangement by shifting the keyboard to the right of center. An improved design would reposition the text keys to the center and then flank them on either side with the other groups. A keyboard incorporating this configuration would afford the computer operator a work posture that is more natural and square to the keyboard. See Figure 10.1 (b).

10.2 Extensions

10.2.1 Checking for a Keyboard-Abdomen Conflict

IntelAd has satisfactorily demonstrated its success in determining the near optimal workstation orientation for a variety of individuals from the general population. However, there are two sub-populations not currently incorporated into the program that require special concerns. These are obese men and women, and pregnant women. For each of these groups, an additional constraint must be imposed on ***IntelAd's*** algorithms: avoiding a keyboard-abdomen conflict. Meeting this challenge could be accomplished by compiling anthropometric data on mid-drift depth for each group and modifying ***IntelAd*** accordingly

10.2.2 Self Adjusting Workstation (SAW)

A more significant extension of this research would be to design a Self Adjusting Workstation (SAW) based on ***IntelAd's*** algorithms and output. The SAW would be an integrated workstation capable of resetting and adjusting its components to the correct orientation for each computer operator based upon his or her individual anthropometrics. Such a device would likely consist of a set of computer controlled mechanical or hydraulic devices that manipulate the workstation components. Data input and control of the SAW could take the form of a magnetic strip card similar to that of a credit card. This feature would enable the device to be used by a member of the general public.

10.3 Conclusions

Carpal tunnel syndrome is a significant concern for safety professionals who deal with computer users. Regard for human health, regulatory emphasis, and the inherent cost of CTS give rise to this point. In an attempt to reduce the risk of injury to computer operators, this body of work provides an easy to use tool which can determine the near optimal workstation orientation for any operator/workstation combination.

While minimizing the human involvement in the adjustment/decision making process, an interactive, user friendly computer program calculates the workstation orientation given the computer user's sex and height, and the adjustment capability of the computer workstation. Field trials confirmed that ***IntelAd*** is an effective tool which meets its design objectives and offers an orientation that requires only minor adjustments to account for differences between the actual and the modeled computer user.

By design ***IntelAd*** is constrained by only two criteria; specifically it must be easy to use and it must advance the "straight wrist" principle. By limiting its data inputs and employing human factors in its development, ***IntelAd*** has evolved into a straight-forward tool intended for the general public. The straight wrist principle is part of the program's algorithms and its application is invisible to the user.

Combining ***IntelAd*** with a comprehensive office safety program which includes administrative controls, worker training, and medical surveillance, allows one to control the four major risk factors associated with CTS (force, repetition, lack of rest, and posture) and thereby reduce the risk of CTS. It must be recognized, however, that incidence of CTS cannot be completely eliminated since there will always be a certain segment of the population predisposed to developing this disorder.

APPENDIX A

INTERPRETING ANSI/HFS-100 TO DETERMINE *INTELAD'S* DEFAULT ADJUSTMENT PARAMETERS

A.1 Introduction

The American National Standard for Human Factors Engineering of Visual Display Terminal Workstations (ANSI/HFS-100) is a technical document written to guide professionals in the design, manufacture, set-up, and use of computer workstations. Despite its title, this document should be used as a guide; it has been promulgated only as a recommendation. Its contents have not been adopted into regulation and are, therefore, not enforceable. Given the near infinite variation in human anthropometrics, one would be ill advised to lock manufacturers and operators of computer workstations into a binding set of regulations. The ANSI/HFS-100 Standard recognizes its own limitations by noting in Section 1, Purpose, and Section 3, Conformance, that the nature of human factors is to tailor each workstation to the intended application and that this may lead to alternates which deviate from the standard.

With the above comments in mind, the remainder of this Appendix will detail how the ANSI/HFS-100 Standard is interpreted to determine ***IntelAd's*** default adjustment parameters.

A.2 Seat Height

Section 8.7.1 of ANSI/HFS-100 states that the minimum range of adjustment for the height of the workstation chair shall be 40.6 to 52 centimeters (16 to 20.5 inches).

A.3 Keyboard Height

Section 8.4.1 of ANSI/HFS-100 states that the minimum range of adjustment for the height of the keyboard support surface shall be 58.5 to 71 centimeters (23.0 to 28.0 inches). ***IntelAd*** uses this range of values, but applies it to the height of the keyboard's home row (the row containing the letters a, s, d, f, g, h, j, k, and l) instead. This apparent discrepancy exists in order to remedy an inherent difference between how ***IntelAd*** models the keyboard's use and what actually occurs in practice.

When ***IntelAd*** calculates a workstation orientation, it places the home row of the computer keyboard level with the extended fingertips of the modeled computer operator. In reality though, individuals performing keying operations will curl their fingers downward from the horizontal plane, effectively lowering the fingertips by approximately 1 to 3 centimeters. This amounts to the same distance that is characteristic of the height difference between the support surface and the home row of a typical computer keyboard and, thus, the range of height for the keyboard support is applied to the keyboard home row.

A.4 Monitor Height

The ANSI/HFS-100 Standard does not directly provide a range of values for acceptable monitor height. To establish maximum and minimum values it is necessary to interpret what is written into the standard with regard to the clearance envelope under the work surfaces. Section 8.1 of ANSI/HFS-100 describes how this envelope is developed from the lower extremity anthropometrics of a fifth percentile female and a ninety-fifth percentile male.

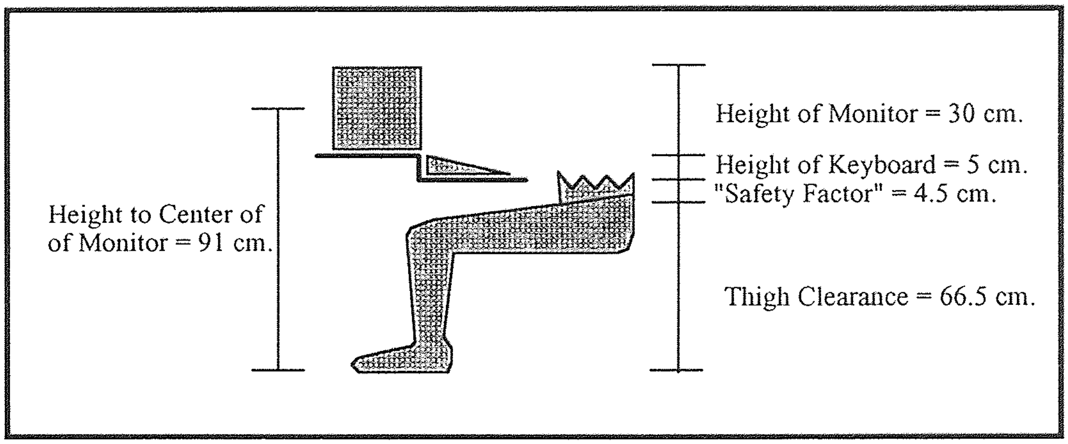


Figure A.1 Determining the Maximum Permissible Monitor Height Based on a 95th Percentile Male

Figure A.1 details how the monitor height upper limit of 91 centimeters (35.8 inches) is established from the thigh clearance height of a 95th percentile male. The 5 centimeter keyboard height and 30 centimeter monitor height are typical measurements for these workstation components. Note the "safety factor" added to the thigh clearance height permitting an individual to adjust his or her position without bumping the underside of the work surface.

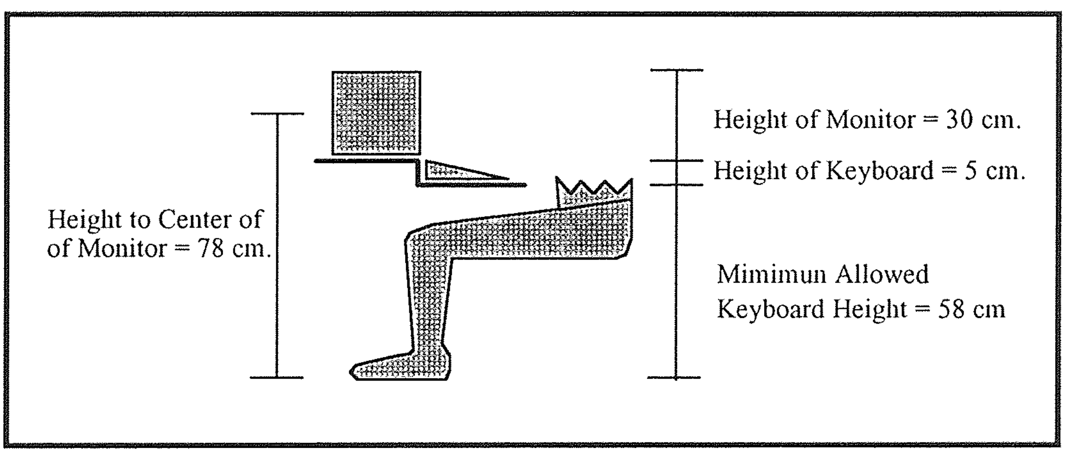


Figure A.2 Determining Minimum Permissible Monitor Height Based on the Minimum Permissible Keyboard Height

The lower limit of 78 centimeters (30.7 inches) is determined by similar calculations. One notable difference is that the keyboard height is set at its lowest permissible value of 58 centimeters. At this height, there is approximately 7 centimeters of clearance between a 5th percentile female's thigh and the keyboard support surface.

A.5 Viewing Distance

Section 6.22 of ANSI/HFS-100 states that the minimum viewing distance shall be 30 centimeters (11.8 inches). However, no upper limit is given.

For an upper limit, ***IntelAd*** borrows from Gross and Hassel (1991) who recommend 71 centimeters (27.9 inches). Their value is based on a review of eight workstation adjustment standards from domestic as well as international sources.

A.6 Viewing Angle

Section 8.5 of ANSI/HFS-100 states that the entire primary viewing area of the display shall be located between zero and 60 degrees below the horizontal. ***IntelAd*** adheres to this recommendation.

A.7 Commentary

ANSI/HFS-100 represents the recommendations of only one institution. As indicated in Table A.1, there is a great deal of variation between the recommendations of many groups and institutions who have studied computer workstation design and orientation. At this time, there is a definite need for additional research to resolve these differences.

Table A.1 A Comparison of Adjustment Ranges for Computer Workstations
(All measurements are given in inches.)

Feature	ANSI/HFS 100 (1988)	AT&T	Grandjean et al. (1982)	ECMA*	Grandjean et al. (1983)	Miller and Suther (1983)
Seat Height	40.6-52.0	31.0-51.0	45.0-49.0	42.0-50.0	42.0-55.0	35.0-52.0
Keyboard Height	58.5-71.0	63.0-78.0	70.0-82.0	60.0-80.0	74.0-97.0	64.0-80.0
Monitor Height	78.0-91.0	84.0-106.0	97.0-122.0	92.0-121.0	92.0-116.0	78.0-106.0
Viewing Distance	33.0-71.0	38.0-76.0	54.0-78.0	45.0-60.0	61.0-93.0	No Data
Viewing Angle	0-60 deg	15-25 deg	0-15 deg	0-20 deg	≤ 26 deg	0-7 deg

*ECMA - European Computer Manufacturers Association

(Adapted from Nanthavanij, 1992)

APPENDIX B

FIELD TRIAL OUTPUT

IntelAd - Computer Workstation Adjustment Software

Personalized workstation adjustment settings for FEMALE #1

Sex: .... FEMALE
Height:................ 58.0

- Height of seat base: .... 16.5 in.
- Height of keyboard home row: .... 24.9 in.
- Height of center of the monitor:. .... 39.0 in.
- Horizontal distance from
  seat back to keyboard home row: .... 15.4 in.
- Horizontal distance from
  seat back to center of monitor: .... 25.5 in.
- Foot rest height: .... 2.1 in.

Workstation constraints:

Seat height adjustment limits: .... 16.5 to 22.0 in.
Keyboard height adjustment limits: .... 23.0 to 28.0 in.
Monitor height adjustment limits: .... 38.0 to 38.0 in. (FIXED)

Viewing distance: .... 24.21 in. (Optimal: 12.99 to 27.95 in.)
Viewing angle: .... 13.29 deg. (Optimal: 0.00 to 60.0 deg.)

Notes:

A foot rest is required to prevent the feet from dangling.

Figure B.1 Field Trial #1

IntelAd - Computer Workstation Adjustment Software

Personalized workstation adjustment settings for FEMALE #2

Sex: .... FEMALE
Height:................. 61.8 in.

- Height of seat base:...19.1 in.
- Height of keyboard home row:... 28.0 in.
- Height of center of the monitor:. .... 40.0 in.
- Horizontal distance from
  seat back to keyboard home row: .... 16.4 in.
- Horizontal distance from
  seat back to center of monitor: .... 24.6 in.
- Foot rest height:... 3.7 in.

Workstation constraints:

Seat height adjustment limits:.. 16.0 to 20.5 in.
Keyboard height adjustment limits:................................ 28.0 to 20.0 in. (FIXED)
Monitor height adjustment limits:.................................. 40.0 to 40.0 in. (FIXED)

Viewing distance:................................... 23.92 in. (Optimal: 12.99 to 27.95 in.)
Viewing angle:....................................... 18.85 deg. (Optimal 0.00 to 60.00 deg.)

Notes:

A foot rest is required to prevent the feet from dangling.

Figure B.2 Field Trial #2

IntelAd - Computer Workstation Adjustment Software

Personalized workstation adjustment settings for FEMALE #3

Sex: .... FEMALE
Height:................. 63.0 in.

- Height of seat base: .... 17.0 in.
- Height of keyboard home row: .... 26.1 in.
- Height of center of the monitor:. .... 42.3 in.
- Horizontal distance from
  seat back to keyboard home row: .... 16.8 in.
- Horizontal distance from
  seat back to center of monitor: .... 25.8 in.
- Foot rest height: .... 1.4 in.

Workstation constraints:

Seat height adjustment limits: .... 17.0 to 19.8 in.
Keyboard height adjustment limits: .... 20.5 to 27.8 in.
Monitor height adjustment limits: .... 42.3 to 42.3 in. (FIXED)

Viewing distance: .... (Optimal: 12.99 to 27.95 in.)
Viewing angle: .... (Optimal 0.00 to 60.00 deg.)

Notes:

A foot rest is required to prevent the feet from dangling.

Figure B.3 Field Trial #3

IntelAd - Computer Workstation Adjustment Software

Personalized workstation adjustment settings for FEMALE #4

Sex: .... FEMALE
Height:................. 65.0 in.

- Height of seat base: .... 17.5 in.
- Height of keyboard home row: .... 26.9 in.
- Height of center of the monitor:. .... 37.0 in.
- Horizontal distance from
  seat back to keyboard home row: .... 17.3 in.
- Horizontal distance from
  seat back to center of monitor: .... 23.9 in.
- Foot rest height: .... 1.4 in.

Workstation constraints:

Seat height adjustment limits: .... 17.5 to 21.5 in.
Keyboard height adjustment limits: .... 20.5 to 28.5 in.
Monitor height adjustment limits: .... 37.0 to 37.0 in. (FIXED)

Viewing distance: .... 24.21 in. (Optimal: 12.99 to 27.95 in.)
Viewing angle: .... 24.94 deg. (Optimal 0.00 to 60.00 deg.)

Notes:

A foot rest is required to prevent the feet from dangling.

Figure B.4 Field Trial #4

IntelAd - Computer Workstation Adjustment Software

Personalized workstation adjustment settings for FEMALE #5

Sex: .... FEMALE
Height:................. 65.0 in.

- Height of seat base: .... 21.1 in.
- Height of keyboard home row: .... 30.5 in.
- Height of center of the monitor:. .... 42.5 in.
- Horizontal distance from
  seat back to keyboard home row: .... 17.3 in.
- Horizontal distance from
  seat back to center of monitor: .... 24.6 in.
- Foot rest height: .... 5.0 in.

Workstation constraints:

Seat height adjustment limits:... 17.5 to 22.0 in.
Keyboard height adjustment limits:................................. 30.5 to 30.5 in. (FIXED)
Monitor height adjustment limits:................................... 42.5 to 42.5 in. (FIXED)

Viewing distance:.................................... 24.21 in. (Optimal: 12.99 to 27.95 in.)
Viewing angle:.. 20.95 deg. (Optimal 0.00 to 60.00 deg.)

Notes:

A foot rest is required to prevent the feet from dangling.

Figure B.5 Field Trial #5

IntelAd - Computer Workstation Adjustment Software

Personalized workstation adjustment settings for FEMALE #6

Sex: .... FEMALE
Height:................ 66.0 in.

- Height of seat base: .... 17.5 in.
- Height of keyboard home row: .... 27.0 in.
- Height of center of the monitor:. .... 43.5 in.
- Horizontal distance from
  seat back to keyboard home row: .... 17.6 in.
- Horizontal distance from
  seat back to center of monitor: .... 25.7 in.
- Foot rest height: .... 1.1 in.

Workstation constraints:

Seat height adjustment limits: .... 17.5 to 21.0 in.
Keyboard height adjustment limits: .... 20.5 to 28.5 in.
Monitor height adjustment limits: .... 43.5 to 43.5 in. (FIXED)

Viewing distance: .... 24.21 in. (Optimal: 12.99 to 27.95 in.)
Viewing angle: .... 11.41 deg. (Optimal 0.00 to 60.00 deg.)

Notes:

A foot rest is required to prevent the feet from dangling.

Figure B.6 Field Trial #6

IntelAd - Computer Workstation Adjustment Software

Personalized workstation adjustment settings for FEMALE #7

Sex: ....FEMALE
Height:.................68.0 in.

- Height of seat base: ....20.7 in.
- Height of keyboard home row: ....30.5 in.
- Height of center of the monitor:. ....43.5 in.
- Horizontal distance from
  seat back to keyboard home row: ....18.1 in.
- Horizontal distance from
  seat back to center of monitor: ....24.6 in.
- Foot rest height: .... 3.8 in.

Workstation constraints:

Seat height adjustment limits: ....17.5 to 22.0 in.
Keyboard height adjustment limits: ....30.5 to 30.5 in. (FIXED)
Monitor height adjustment limits: ....43.5 to 43.5 in. (FIXED)

Viewing distance: ....24.21 in. (Optimal: 12.99 to 27.95 in.)
Viewing angle: ....20.86 deg. (Optimal 0.00 to 60.00 deg.)

Notes:

A foot rest is required to prevent the feet from dangling.

Figure B.7 Field Trial #7

IntelAd - Computer Workstation Adjustment Software

Personalized workstation adjustment settings for MALE #1

Sex: .... MALE
Height:................. 67.0 in.

- Height of seat base:..17.5 in.
- Height of keyboard home row: ....26.8 in.
- Height of center of the monitor:. ....41.5 in.
- Horizontal distance from
  seat back to keyboard home row: ....18.4 in.
- Horizontal distance from
  seat back to center of monitor: ....25.2 in.
- Foot rest height:... 0.5 in.

Workstation constraints:

Seat height adjustment limits:..17.5 to 22.0 in.
Keyboard height adjustment limits:.................................23.8 to 29.8 in.
Monitor height adjustment limits:..................................41.5 to 41.5 in. (FIXED)

Viewing distance:...................................24.21 in. (Optimal: 12.99 to 27.95 in.)
Viewing angle:.......................................16.05 deg. (Optimal 0.00 to 60.00 deg.)

Notes:

A foot rest is required to prevent the feet from dangling.

Figure B.8 Field Trial #8

IntelAd - Computer Workstation Adjustment Software

Personalized workstation adjustment settings for MALE #2

Sex: .... MALE
Height:................ 67.5 in.

- Height of seat base: .... 18.1 in.
- Height of keyboard home row: .... 27.5 in.
- Height of center of the monitor:. .... 37.5 in.
- Horizontal distance from
  seat back to keyboard home row: .... 18.5 in.
- Horizontal distance from
  seat back to center of monitor: .... 23.6 in.
- Foot rest height: .... 1.0 in.

Workstation constraints:

Seat height adjustment limits:....................................... 17.0 to 21.0 in.
Keyboard height adjustment limits:................................ 27.5 to 27.5 in. (FIXED)
Monitor height adjustment limits:.................................. 37.5 to 37.5 in. (FIXED)

Viewing distance:.................................. 24.21 in. (Optimal: 12.99 to 27.95 in.)
Viewing angle:...................................... 26.56 deg. (Optimal 0.00 to 60.00 deg.)

Notes:

A foot rest is required to prevent the feet from dangling.

Figure B.9 Field Trial #9

IntelAd - Computer Workstation Adjustment Software

Personalized workstation adjustment settings for MALE #3

Sex: .... MALE
Height:................ 71.0 in.

- Height of seat base:...20.0 in.
- Height of keyboard home row:...30.5 in.
- Height of center of the monitor:. ....46.5 in.
- Horizontal distance from
  seat back to keyboard home row:..20.0 in.
- Horizontal distance from
  seat back to center of monitor:...25.4 in.
- Foot rest height:... 2.0 in.

Workstation constraints:

Seat height adjustment limits:..17.5 to 20.0 in.
Keyboard height adjustment limits:................................30.5 to 30.5 in. (FIXED)
Monitor height adjustment limits:..................................46.5 to 46.5 in. (FIXED)

Viewing distance:...................................24.21 in. (Optimal: 12.99 to 27.95 in.)
Viewing angle:.......................................14.49 deg. (Optimal 0.00 to 60.00 deg.)

Notes:

A foot rest is required to prevent the feet from dangling.

Figure B.10 Field Trial #10

**IntelAd** - Computer Workstation Adjustment Software

Personalized workstation adjustment settings for MALE #4

Sex: .... MALE
Height:................ 71.0 in.

- Height of seat base: ....20.5 in.
- Height of keyboard home row: ....30.5 in.
- Height of center of the monitor:. ....38.5 in.
- Horizontal distance from
  seat back to keyboard home row: ....38.7 in.
- Horizontal distance from
  seat back to center of monitor: ....28.4 in.
- Foot rest height:... 2.5 in.

Workstation constraints:

Seat height adjustment limits:.......................................16.0 to 20.5 in.
Keyboard height adjustment limits:................................30.5 to 30.5 in. (FIXED)
Monitor height adjustment limits:.................................38.7 to 38.7 in. (FIXED)

Viewing distance:..................................29.82 in. (Optimal: 12.99 to 27.95 in.)
Viewing angle:.......................................27.42 deg. (Optimal 0.00 to 60.00 deg.)

Notes:

A foot rest is required to prevent the feet from dangling.

The optimal viewing distance is exceeded to avoid a conflict between the monitor and the keyboard.

Figure B.11 Field Trial #11

IntelAd - Computer Workstation Adjustment Software

Personalized workstation adjustment settings for MALE #5

Sex: .... MALE
Height:................. 78.0 in.

- Height of seat base: .... 19.8 in.
- Height of keyboard home row: .... 27.9 in.
- Height of center of the monitor:. .... 38.5 in.
- Horizontal distance from
  seat back to keyboard home row: .... 21.3 in.
- Horizontal distance from
  seat back to center of monitor: .... 27.6 in.
- Foot rest height: .... 0.0 in.

Workstation constraints:

Seat height adjustment limits: .... 16.0 to 20.5 in.
Keyboard height adjustment limits:................................ 23.0 to 28.0 in.
Monitor height adjustment limits: .... 38.5 to 40.0 in.

Viewing distance:.................................. 30.22 in. (Optimal: 12.99 to 27.95 in.)
Viewing angle: .... 32.03 deg. (Optimal 0.00 to 60.00 deg.)

Notes:

The optimal viewing distance is exceeded to avoid a conflict between the monitor and the keyboard.

Figure B.12 Field Trial #12

APPENDIX C

USERS MANUAL

INTELLIGENT COMPUTER WORKSTATION ADJUSTMENT SOFTWARE

Version 1.3

Developed and Written by

David W. Venezia

Introduction - What is *IntelAd*?

IntelAd, short for "Intelligent Adjustment", is an interactive software package designed to assist computer operators in the proper adjustment of their computer workstations so as to minimize their risk of developing Carpal Tunnel Syndrome (CTS).

Frequent computer users have been identified as a high risk group in terms of CTS. While typing, the repeated flexing of the computer operator's fingers - often with a bent wrist - causes a series of micro-traumas to the tissue surrounding the median nerve where it passes through the wrist (in the carpal tunnel). Over time, these small injuries can combine to cause a debilitating hand/wrist injury that is costly in terms of human and financial resources.

The correct workstation posture, especially at the wrist, is a key factor in reducing the incidence of CTS in computer operators. ***IntelAd*** has been designed specifically to recommend computer workstation settings for a variety of individuals. Using ***IntelAd*** the "straight wrist" principle and maximum body comfort can be achieved with a minimum of effort.

Getting Started

Installing GWBASIC on your ***IntelAd*** disk:

IntelAd has been written in GWBASIC 3.23 for IBM and IBM compatible computers. GWBASIC is included with the Disk Operating System (DOS) of most personal computers. GWBASIC version 3.23 or higher must be on the same computer disk as ***IntelAd*** (or in the same directory as ***IntelAd*** if you are using a hard drive).

To copy GWBASIC from your DOS disk to your ***IntelAd*** disk place your DOS disk containing the GWBASIC.EXE file in your A: drive. Place the ***IntelAd*** disk in your B: drive and type

COPY GWBASIC.EXE B:

and then press [ENTER]. GWBASIC is now loaded on your ***IntelAd*** disk.

Information that you will need to in order to use ***IntelAd***

- The operator's standing height.
- The operator's sex.
- The range of height adjustment of the operator's chair.
- The range of height adjustment for the computer keyboard.
- The range of height adjustment for the computer monitor. Keep in mind that the monitor can be adjusted upwards by placing an appropriate object underneath it.

Note: keyboard height is measured at the home row (or median row). The home row is that row containing the letters A, S, D, F, G, H, J, K, and L. The monitor height is measured to the center of the screen.

IntelAd uses the American National Standards Institute (ANSI) recommended computer workstation standards as the default values for all adjustment parameters. These values can be referenced in the appendix.

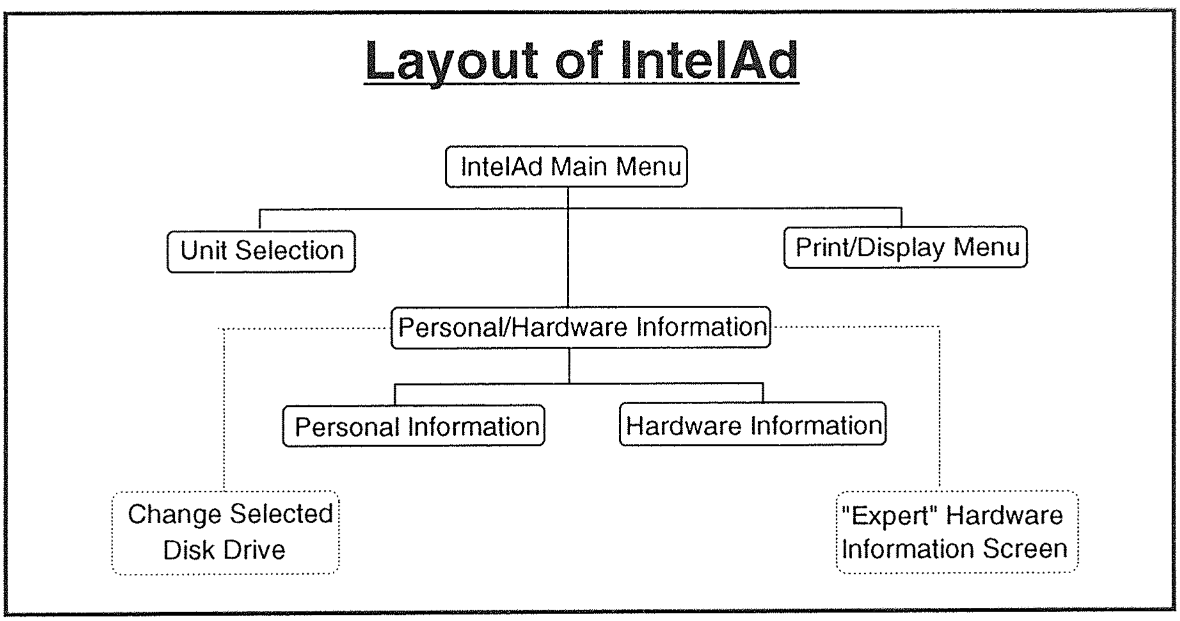
Using *IntelAd*

With the ***IntelAd*** disk in your disk drive, type "***IntelAd***" at the prompt and press [ENTER].

When using ***IntelAd***, you must press [ENTER] after each data entry for the program to continue. Inappropriate responses will not be accepted as input and you will be re-prompted for the correct information.

The first screen allows you to indicate to ***IntelAd*** which disk drive you are operating from. Select the appropriate response and you will move on to the Main Menu.

IntelAd has been designed to be used with little or no introduction; simply follow the commands, menus and the following chart.



NOTE: The areas represented with dotted lines are *hidden* features.

To get to the Expert Hardware Information Screen, type "expert" at the Personal/Hardware Information menu prompt. This screen allows one to quickly change the hardware constraints.

To get to the Change Selected Disk Drive screen, type "disk" at the Personal/Hardware Information menu prompt. This allows one to go back and change the selected disk drive if the wrong drive was initially selected at start-up.

One additional hidden feature allows the user to reset the default workstation constraint settings. To do this, type "reset" at the Personal/Hardware Information menu prompt.

Questions?

If you experience technical difficulty using ***IntelAd***, please call the technical support line at (908) 709-4171 during the hours of 9:00 am and 5:00 PM, Monday through Friday. Our technical support staff will be happy to assist you.

Your comments/suggestions are welcome. Please write to:

IntelAd
c/o David W. Venezia
10 New Street
Cranford, NJ 07016

Appendix

ANSI Recommended Adjustment Ranges		
Parameter	**Centimeters**	**Inches**
Seat Height	40.6 - 52.0	16.0 - 20.5
Keyboard Height	46.0 - 74.0	22.8 - 28.0
Monitor Height	74.0 - 91.0	29.1 - 35.8
Viewing Distance	33.0 - 71.0	13.0 - 28.0

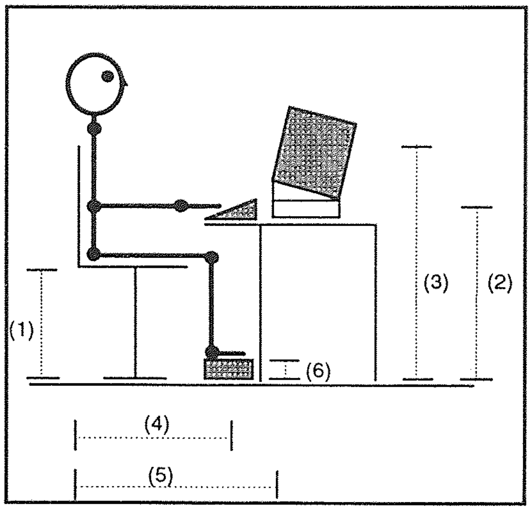
Standard Tables for Workstations having ANSI Recommended Adjustment Capabilities

To facilitate the adjustment of a computer workstation when the ANSI recommended adjustment ranges are present, the following two charts are provided (one for males, one for females). These charts represent the output of ***IntelAd*** using the default adjustment range values.

To use the charts, simply look up the computer user's height in the left most column and then read across the row to find all of the recommended workstation settings that ***IntelAd*** calculated.

Recommended Workstation Adjustment Settings for Males

(All entries are in inches)



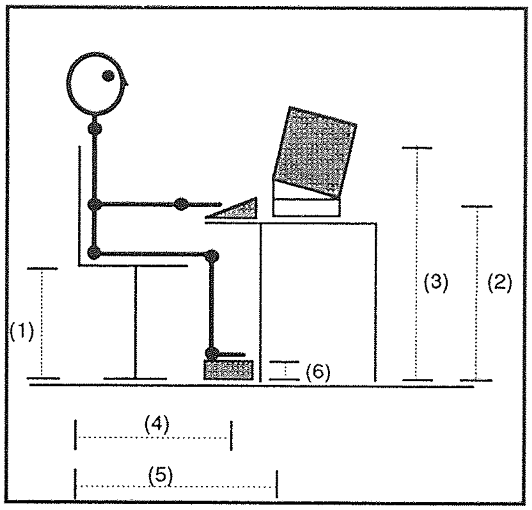
(1) Seat Height
(2) Keyboard Height (to Home Row)
(3) Monitor Height (to Center Screen)
(4) Seatback to Home Row Distance
(5) Seatback to Center Screen Distance
(6) Footrest Height

Standing Height	(1)	(2)	(3)	(4)	(5)	(6)	Notes
58.0	16.0	24.0	31.7	15.9	23.3	1.3	A
59.0	16.0	24.2	31.9	16.2	23.2	1.0	A
60.0	16.0	24.3	32.0	16.5	23.0	0.8	A
61.0	16.0	24.5	32.1	16.8	22.8	0.5	A
62.0	16.0	24.6	32.3	17.0	22.7	0.3	A
63.0	16.0	24.7	32.8	17.3	22.7	0.0	
64.0	16.2	25.1	33.5	17.6	22.7	0.0	
65.0	16.5	25.5	33.8	17.8	23.4	0.0	
66.0	16.7	25.9	34.3	18.1	23.7	0.0	
67.0	17.0	26.3	34.8	18.4	24.0	0.0	
68.0	17.2	26.7	35.8	18.7	24.7	0.0	
69.0	17.5	27.1	35.8	18.9	24.7	0.0	
70.0	17.7	27.4	35.8	19.2	24.7	0.0	
71.0	18.0	27.8	35.6	19.5	25.1	0.0	
72.0	18.2	28.0	35.7	19.8	25.6	0.0	B
73.0	18.5	28.0	35.7	20.0	26.1	0.0	B
74.0	18.7	28.0	35.7	20.3	26.6	0.0	B
75.0	19.0	28.0	35.7	20.5	27.0	0.0	B
76.0	19.3	27.9	35.7	20.8	27.5	0.0	B
77.0	19.5	27.9	35.7	21.0	27.9	0.0	B
78.0	19.8	27.9	35.6	21.3	28.4	0.0	B

NOTES: A = Footrest is required to prevent the feet from dangling.
B = Optimal viewing distance exceeded to avoid conflict of the monitor with the keyboard.

Recommended Workstation Adjustment Settings for Males

(All entries are in inches)



(1) Seat Height
(2) Keyboard Height (to Home Row)
(3) Monitor Height (to Center Screen)
(4) Seatback to Home Row Distance
(5) Seatback to Center Screen Distance
(6) Footrest Height

Standing Height	(1)	(2)	(3)	(4)	(5)	(6)	Notes
58.0	16.0	24.4	32.0	15.4	23.3	1.6	A
59.0	16.0	24.5	32.2	15.7	23.1	1.3	A
60.0	16.0	24.6	32.3	16.0	22.9	1.1	A
61.0	16.0	24.8	32.5	16.2	22.8	0.8	A
62.0	16.0	24.9	32.8	16.5	22.7	0.6	A
63.0	16.0	25.1	33.3	16.8	22.7	0.3	A
64.0	16.0	25.2	33.7	17.0	22.7	0.1	A
65.0	16.1	25.5	34.4	17.3	22.7	0.0	
66.0	16.4	25.9	35.1	17.6	22.7	0.0	
67.0	16.6	26.3	35.4	17.8	23.4	0.0	
68.0	16.9	26.7	35.8	18.1	24.2	0.0	
69.0	17.1	27.1	35.8	18.4	24.2	0.0	
70.0	17.4	27.5	35.8	18.6	24.7	0.0	
71.0	17.6	27.9	35.8	18.9	24.7	0.0	
72.0	17.9	27.9	35.8	19.1	24.7	0.0	
73.0	18.1	28.0	35.7	19.4	25.0	0.0	B
74.0	18.4	28.0	35.7	19.7	25.5	0.0	B
75.0	18.6	28.0	35.7	19.7	25.9	0.0	B
76.0	18.9	28.0	35.7	20.1	26.4	0.0	B
77.0	19.1	28.0	35.7	20.4	26.8	0.0	B
78.0	19.4	28.0	35.7	20.6	27.2	0.0	B

NOTES:
A = Footrest is required to prevent the feet from dangling.
B = Optimal viewing distance exceeded to avoid conflict of the monitor with the keyboard.

APPENDIX D

PROGRAM LISTING

```
50 REM ****************************************************************
100 REM
150 REM   IntelAd - Intelligent Computer Workstation Adjustment Software
200 REM
250 REM             Version 1.2 - Updated 6 November 1993
300 REM   --------------------------------------------------------------
350 REM           Written and developed by David W. Venezia
400 REM
450 REM                   Copyright -- 1993
500 REM                  ALL RIGHTS RESERVED
550 REM
600 REM ****************************************************************
650 DIM X(20),Y(20)
700 CALCULATE$ = "no"
750 DEGTORAD=3.1416/180
800 RADTODEG=180/3.1416
850 REM ****************************************************************
900 REM                  D E F A U L T   V A L U E S
950 REM ****************************************************************
1000 SEATLOWER = 40.6: SEATUPPER = 52:                REM IN CM
1050 ELBOWLOWER = 46: ELBOWUPPER = 74:               REM IN CM 1100
KEYHEIGHTLOWER = 58.5: KEYHEIGHTUPPER = 71:     REM IN CM
1150 KEYANGLELOWER = 0: KEYANGLEUPPER = 25:          REM IN DEGREES 1200
KEYANGLELOWER = 0*DEGTORAD: KEYANGLEUPPER = 25*DEGTORAD: REM IN RAD
1250 MONITORLOWER = 78: MONITORUPPER = 91:           REM IN CM
1300 VIEWDISTLOWER = 30: VIEWDISTUPPER = 71:         REM IN CM
1350 VIEWANGLELOWER = 0: VIEWANGLEUPPER = 60:        REM IN DEGREES
1400 VIEWANGLELOWER = 0*DEGTORAD: VIEWANGLEUPPER = 60*DEGTORAD: REM IN
RAD
1450 UNIT$ = "in.": CONVFACTOR = 1/2.54: REM      Default units are
inches
1500 IF GSUB$ = "yes" THEN GOTO 1600
1550 GOTO 1650
1600 RETURN
1650 REM ************************************************************
1700 REM                       M A I N   M E N U
1750 REM ************************************************************
1800 KEY OFF: SCREEN 0: COLOR 14,1:CLS
1850 COLOR 0,11
1900 LOCATE 3,8:PRINT "
"
1950 LOCATE 4,8:PRINT " IntelAd - Intelligent Computer Workstation
Adjustment Software "
2000 LOCATE 5,8:PRINT "
"
2050 LOCATE 6,8:PRINT "           Version 1.2 - Updated on 6 November
1993           "
2100 LOCATE 7,8:PRINT " ----------------------------------------------
-------------- "
2150 LOCATE 8,8:PRINT "          Developed and Written by David W.
Venezia            "
2200 LOCATE 9,8:PRINT "
"
2250 LOCATE 10,8:PRINT "                        Copyright -- 1993
"
2300 LOCATE 11,8:PRINT "                       ALL RIGHTS RESERVED
"
2350 LOCATE 12,8:PRINT "
"
2400 COLOR 14,1
```

```
2450 LOCATE 14,16:PRINT "Please indicate which disk drive you are
using:"
2500 LOCATE 16,16:PRINT "                (1) A Drive
2550 LOCATE 17,16:PRINT "                (2) B Drive
2600 LOCATE 18,16:PRINT "                (3) C Drive
2650 LOCATE 20,16:INPUT "           Enter 1, 2, or 3: ";DISK$ 2700 IF
DISK$ = "1" OR DISK$ = "2" OR DISK$ = "3" THEN GOTO 2850
2750 LOCATE 20,16:PRINT "
"
2800 BEEP: GOTO 2650
2850 IF DISK$ = "1" THEN DISK$ = "A:"
2900 IF DISK$ = "2" THEN DISK$ = "B:"
2950 IF DISK$ = "3" THEN DISK$ = "C:"
3000 IF GSUB$ = "yes" GOTO 3100
3050 GOTO 3150
3100 RETURN
3150 HILITE=0
3200 SCREEN 0: COLOR 14,1: CLS: COLOR 0,11
3250 LOCATE 4,16: PRINT " +---------------------------------------+ "
3300 LOCATE 5,16: PRINT " | I n t e l A d   M a i n   M e n u | "
3350 LOCATE 6,16: PRINT " +---------------------------------------+ "
3400 COLOR 14,1
3450 IF UNIT$="" THEN CURRENT$="none selected" ELSE CURRENT$=UNIT$
3500 LOCATE 8,17: PRINT "(1) Select units (current = ";CURRENT$;")"
3550 LOCATE 9,17:PRINT "(2) Input personal/hardware information
3600 LOCATE 10,17: PRINT "(3) Calculate suggested workstation settings"
3650 LOCATE 11,17: PRINT "(4) Print information/results
3700 LOCATE 13,17: PRINT "(5) Exit this program"
3750 IF HILITE=0 THEN GOTO 3850
3800 LOCATE 7+HILITE,13:PRINT "-->"
3850 LOCATE 15,17: INPUT "Please enter your selection: ";MAIN$
3900 IF MAIN$ = "1" OR MAIN$ = "2" OR MAIN$ = "3" THEN GOTO 4150
3950 IF MAIN$ = "4" OR MAIN$ = "5" THEN GOTO 4150
4000 LOCATE 17,16: COLOR 4,8: PRINT " PLEASE ENTER 1, 2, 3, 4, OR 5 ONLY
":BEEP
4050 LOCATE 15,45: COLOR 14,1: PRINT "            "
4100 GOTO 3850
4150 CLS: HILITE=0
4200 IF MAIN$="2" THEN GOTO 5150
4250 IF MAIN$="1" THEN GOTO 31550
4300 IF MAIN$="3" THEN GOTO 32750
4350 IF MAIN$="4" THEN GOTO 47400
4400 CLS
4450 COLOR 4,8:LOCATE 10,22:BEEP
4500 PRINT "                                   "
4550 LOCATE 11,22
4600 PRINT "                                   "
4650 LOCATE 12,22
4700 PRINT "              (1) YES              "
4750 LOCATE 13,22
4800 PRINT "              (2) NO               "
4850 LOCATE 14,22: PRINT "                                   "
4900 LOCATE 11,22
4950 INPUT " EXIT IntelAd AND RETURN TO SYSTEM";EXIT$
5000 IF EXIT$ = "1" THEN GOTO 5100
5050 GOTO 3150
5100 SYSTEM:REM ***** END OF PROGRAM *****
5150 REM ******************************************************
5200 REM   P E R S O N A L / H A R D W A R E   I N F O R M A T I O N
5250 REM ******************************************************
```

```
5300 CLS: COLOR 0,11
5350 LOCATE 6,9
5400 PRINT " +------------------------------------------------------------
---+ "
5450 LOCATE 7,9
5500 PRINT " |  P E R S O N A L / H A R D W A R E   I N F O R M A T I O
N  | "
5550 LOCATE 8,9
5600 PRINT " +------------------------------------------------------------
---+ "
5650 COLOR 14,1
5700 LOCATE 10,20: PRINT "(1) Input/change personal information"
5750 LOCATE 11,20: PRINT "(2) Input/change hardware adjustment ranges"
5800 LOCATE 12,20: PRINT "(3) Retrieve data from a file"
5850 LOCATE 13,20: PRINT "(4) Save current information" 5900 LOCATE
15,20: PRINT "(5) Go back to the main menu"
5950 LOCATE 18,20: INPUT "Please enter your selection: ";MAIN$
6000 IF MAIN$ = "RESET" OR MAIN$ = "Reset" OR MAIN$ = "reset" THEN GOTO
6100
6050 GOTO 6300
6100 GSUB$ = "yes"
6150 GOSUB 850
6200 GSUB$ = "no"
6250 GOTO 5300
6300 IF MAIN$ = "Disk" OR MAIN$ = "disk" OR MAIN$ = "DISK" THEN GOTO
6400
6350 GOTO 6650
6400 GSUB$ = "yes"
6450 CLS
6500 GOSUB 2450
6550 GSUB$ = "no"
6600 GOTO 5150
6650 IF MAIN$ = "expert" OR MAIN$ = "Expert" OR MAIN$ = "EXPERT" GOTO
15950
6700 IF MAIN$ = "1" OR MAIN$ = "2" OR MAIN$ = "3" THEN GOTO 6950
6750 IF MAIN$ = "4" OR MAIN$ = "5" THEN GOTO 6950
6800 LOCATE 20,19: COLOR 4,8: PRINT " PLEASE ENTER 1, 2, 3, 4, OR 5 ONLY
":BEEP
6850 LOCATE 18,48: COLOR 14,1: PRINT "              "
6900 GOTO 5950
6950 ON VAL(MAIN$) GOTO 12900,15950,7050,9600,7000
7000 GOTO 3200: REM ***** RETURNS TO MAIN MENU *****
7050 REM ********************* READING DATA FROM DISK ***************
7100 ON ERROR GOTO 7250
7150 IF ERR = 0 GOTO 8250
7200 GOTO 8250
7250 IF ERR=53 THEN GOTO 7350
7300 IF ERR=71 THEN GOTO 7750
7350 CLS:COLOR 4,8:LOCATE 9,25:PRINT "                                  "
7400 LOCATE 10,25:PRINT "                              "
7450 LOCATE 10,25:PRINT " IntelAd cannot find ";DISK$;FILENAME$
7500 LOCATE 11,25:PRINT  "                             "
7550 LOCATE 12,25: PRINT " Is the file name correct?    "
7600 LOCATE 13,25:PRINT  "                             ":BEEP
7650 COLOR 14,1:LOCATE 17,23: INPUT "Please press [ENTER] to try again:
"; GO$
7700 GOTO 8200
7750 CLS:COLOR 4,8:LOCATE 9,25:PRINT "
":BEEP
7800 LOCATE 10,25:PRINT "                                 "
```

```
7850 LOCATE 10,25:PRINT " IntelAd cannot read from drive ";DISK$;" "
7900 LOCATE 11,25:PRINT "                                   "
7950 COLOR 14,1:LOCATE 17,7: INPUT "Please press [ENTER] to try again or
type DISK to change drives: "; GO$
8000 IF GO$ = "" THEN GOTO 8200
8050 GSUB$ = "yes"
8100 CLS:GOSUB 2400
8150 GSUB$ = "no"
8200 RESUME 8250
8250 CLS:LOCATE 4,10:PRINT "Please choose a file to read the data from."
8300 LOCATE 6,10:FILES DISK$+"*.add"
8350 LOCATE 21,10:PRINT "Press [ENTER] to return without retrieving"
8400 LOCATE 19,10:PRINT "Type the filename and then press [ENTER]:
________":LOCATE 19,52:INPUT FILENAME$
8450 IF FILENAME$ = "" THEN GOTO 5150
8500 IF LEN(FILENAME$)<=8 THEN GOTO 8650
8550 LOCATE 19,52:PRINT "             "
8600 BEEP:LOCATE 23,10:COLOR 4,0:PRINT" FILE NAME RESTRICTED TO 8
CHARACTERS MAX. ":COLOR 14,1:GOTO 8350
8650 CLS:LOCATE 10,20:PRINT "Reading information from ";DISK$;FILENAME$
8700 OPEN DISK$+FILENAME$+".add" FOR INPUT AS #1
8750 INPUT#1, EATLOWER, SEATUPPER, ELBOWLOWER, ELBOWUPPER,
KEYHEIGHTLOWER, KEYHEIGHTUPPER, MONITORLOWER, MONITORUPPER,
VIEWDISTLOWER, VIEWDISTUPPER, VIEWANGLELOWER, VIEWANGLEUPPER
8800 INPUT#1,UNIT$,SEX$,FIRSTNAME$,LASTNAME$
8850 INPUT#1,HEIGHT,CONVFACTOR
8900 INPUT#1,CALCULATE$
8950 INPUT#1,
BODY(1),BODY(2),BODY(3),BODY(4),BODY(5),BODY(6),BODY(7),BODY(8),BODY(9)
9000 INPUT#1, XANKLE, YANKLE, XTOE, YTOE, XKNEE, YKNEE, XHIP, YHIP,
XSHOULDER, YSHOULDER, XELBOW, YELBOW, XFINGERTIP, YFINGERTIP, XWRIST,
YWRIST, XEYES, YEYES, XTOPOFHEAD, YTOPOFHEAD, XCHIN, YCHIN
9050 INPUT#1, XMEDIANROW, YMEDIANROW, VIEWDISTANCE, VIEWANGLE,
XCENTERMONITOR, YCENTERMONITOR, XULC, YULC, XURC, YURC, XLLC, YLLC,
XLRC, YLRC, XKEY1, YKEY1, XKEY2, YKEY2, XKEY3, YKEY3, FOOTREST, TOHIGH
9100  INPUT#1, PROBLEM$(1), PROBLEM$(2), PROBLEM$(3), PROBLEM$(4),
PROBLEM$(5), PROBLEM$(6), PROBLEM$(7), PROBLEM$(8), PROBLEM$(9),
PROBLEM$(10)
9150 INPUT#1,FILENAME$
9200 CLOSE#1
9250 ON ERROR GOTO 700
9300 FOR X = 1 TO 10
9350 IF PROBLEM$(X) = "empty" THEN GOTO 9450 9400 GOTO 9500
9450 PROBLEM$(X) = ""
9500 NEXT X
9550 GOTO 3150
9600 REM **************** SAVING INFORMATION TO DISK **************
9650 IF CALCULATE$ = "yes" GOTO 9950
9700 CLS:COLOR 4,0:LOCATE 10,15:
9750 IF CALCULATE$ = "no" THEN PRINT "WORKSTATION SETTINGS HAVE NOT BEEN
CALCULATED YET.":BEEP
9800 IF CALCULATE$ = "changed" THEN PRINT "WORKSTATION SETTINGS HAVE NOT
BEEN RECALCULATED YET.":BEEP
9850 LOCATE 12,15: INPUT "PLEASE PRESS [ENTER] TO RETURN TO THE MAIN
MENU: ";G$
9900 COLOR 14,1:CLS:HILITE = 3:GOTO 3200
9950 ON ERROR GOTO 5150
10000 CLS:LOCATE 10,10:PRINT "Please enter a filename (maximum 8 alpha-
numeric characters):
10050 LOCATE 16,10:PRINT"Press [ENTER] to return without saving
```

```
information"
10100 LOCATE 12,10:PRINT "Filename =    ________"
10150 LOCATE 12,34:PRINT "Current filename = ";
10200 IF FILENAME$ = "" THEN PRINT "FILE HAS NOT BEEN NAMED"
10250 PRINT FILENAME$
10300 LOCATE 12,21:INPUT FILENAME$
10350 IF FILENAME$="" THEN GOTO 5150
10400 IF LEN(FILENAME$)<=8 THEN GOTO 10600
10450 LOCATE 14,10:COLOR 4,0:PRINT" FILE NAME RESTRICTED TO 8 CHARACTERS
MAX. ":COLOR 14,1
10500 LOCATE 12,21:PRINT "                  ":BEEP
10550 GOTO 10100
10600 CLS:LOCATE 10,30:PRINT "Saving as ";DISK$;FILENAME$
10650 ON ERROR GOTO 10750
10700 GOTO 11250
10750 CLS:COLOR 4,8:LOCATE 9,25:PRINT "
":BEEP
10800 LOCATE 10,25:PRINT "                                   "
10850 LOCATE 10,25:PRINT " D I S K    E R R O R --- Drive ";DISK$;" "
10900 LOCATE 11,25:PRINT  "                                   "
10950 COLOR 14,1:LOCATE 17,7: INPUT "Please press [ENTER] to try again
or type DISK to change drives: "; GO$ 11000 IF GO$ = "" THEN GOTO 11200
11050 GSUB$ = "yes"
11100 CLS:GOSUB 2400
11150 GSUB$ = "no"
11200 RESUME 10000
11250 OPEN DISK$+FILENAME$+".add" FOR OUTPUT AS #1
11300 PRINT#1, SEATLOWER; SEATUPPER; ELBOWLOWER; ELBOWUPPER;
KEYHEIGHTLOWER; KEYHEIGHTUPPER; MONITORLOWER; MONITORUPPER;
VIEWDISTLOWER; VIEWDISTUPPER; VIEWANGLELOWER; VIEWANGLEUPPER
11350 PRINT#1,UNIT$
11400 PRINT#1,SEX$
11450 PRINT#1,FIRSTNAME$
11500 PRINT#1,LASTNAME$
11550 PRINT#1,HEIGHT,CONVFACTOR
11600 PRINT#1,CALCULATE$
11650 PRINT#1, BODY(1); BODY(2); BODY(3); BODY(4); BODY(5); BODY(6);
BODY(7); BODY(8); BODY(9)
11700 PRINT#1, XANKLE; YANKLE; XTOE; YTOE; XKNEE; YKNEE; XHIP; YHIP;
XSHOULDER; YSHOULDER; XELBOW; YELBOW; XFINGERTIP; YFINGERTIP; XWRIST;
YWRIST; XEYES; YEYES; XTOPOFHEAD; YTOPOFHEAD; XCHIN; YCHIN
11750 PRINT#1, XMEDIANROW; YMEDIANROW; VIEWDISTANCE; VIEWANGLE;
XCENTERMONITOR; YCENTERMONITOR; XULC; YULC; XURC; YURC; XLLC; YLLC;
XLRC; YLRC; XKEY1; YKEY1; XKEY2; YKEY2; XKEY3; YKEY3; FOOTREST; TOHIGH
11800 FOR X=1 TO 10
11850 IF PROBLEM$(X) <> "" GOTO 11950
11900 PROBLEM$(X) = "empty"
11950 NEXT X
12000 PRINT#1, PROBLEM$(1)
12050 PRINT#1, PROBLEM$(2)
12100 PRINT#1, PROBLEM$(3)
12150 PRINT#1, PROBLEM$(4)
12200 PRINT#1, PROBLEM$(5)
12250 PRINT#1, PROBLEM$(6)
12300 PRINT#1, PROBLEM$(7)
12350 PRINT#1, PROBLEM$(8)
12400 PRINT#1, PROBLEM$(9)
12450 PRINT#1, PROBLEM$(10)
12500 PRINT#1,FILENAME$
12550 CLOSE#1
```

```
12600 FOR X = 1 TO 10
12650 IF PROBLEM$(X) = "empty" THEN PROBLEM$(X) = "" 12700 NEXT X
12750 IF GSUB$="yes" GOTO 12850
12800 GOTO 5150
12850 RETURN
12900 REM ***** PERSONAL INFORMATION *****
12950 CLS
13000 IF UNIT$="" THEN LOCATE 10,8 ELSE GOTO 13350
13050 COLOR 4,0
13100 PRINT "YOU MUST SELECT UNITS BEFORE ENTERING PERSONAL/HARDWARE
INFORMATION"
13150 BEEP
13200 LOCATE 12,17: INPUT "PLEASE PRESS [ENTER] TO RETURN TO THE MAIN
MENU ";GO$
13250 HILITE=1: COLOR 14,1
13300 GOTO 3200: COLOR 0,14
13350 CLS: COLOR 0,11
13400 LOCATE 4,17: PRINT " +------------------------------------------+
"
13450 LOCATE 5,17: PRINT " |  P E R S O N A L   I N F O R M A T I O N  |
"
13500 LOCATE 6,17: PRINT " +------------------------------------------+
"
13550 COLOR 14,1
13600 LOCATE 9, 20: PRINT "(1) Last name:    ";LASTNAME$
13650 LOCATE 10,20: PRINT "(2) First name:   ";FIRSTNAME$
13700 LOCATE 11,20: PRINT "(3) Sex:          ";SEX$
13750 IF HEIGHT=0 GOTO 13850
13800 LOCATE 12,20: PRINT "(4) Height:       ";:PRINT USING
"###.##";HEIGHT*CONVFACTOR;:PRINT" ";UNIT$: GOTO 13900
13850 LOCATE 12,20: PRINT "(4) Height:       "
13900 LOCATE 14,20: PRINT "(5) Return to Personal/Hardware Menu"
13950 LOCATE 16,20: INPUT "Please enter your selection: ";QUES$
14000 LOCATE 18,19: COLOR 14,1: PRINT "
"
14050 IF QUES$="1" OR QUES$="2" OR QUES$="3" THEN GOTO 14350
14100 IF QUES$="4" OR QUES$="5" THEN GOTO 14350
14150 LOCATE 16,48: PRINT"                 ":BEEP
14200 LOCATE 18,19: COLOR 4,8: PRINT " PLEASE ENTER 1, 2, 3, 4, OR 5
ONLY "
14250 COLOR 14,1
14300 GOTO 13950
14350 ON VAL(QUES$) GOTO 14400,14650,14900,15450,15900
14400 LOCATE 9,16: PRINT "-->": LOCATE 9,37: PRINT"
"
14450 LOCATE 16,20: PRINT"
"
14500 LOCATE 9,37: INPUT LASTNAME$
14550 LOCATE 9,16: PRINT "   "
14600 GOTO 13950
14650 LOCATE 10,16: PRINT "-->": LOCATE 10,37: PRINT"
"
14700 LOCATE 16,20: PRINT"
"
14750 LOCATE 10,37: INPUT FIRSTNAME$
14800 LOCATE 10,16: PRINT "   "
14850 GOTO 13950
14900 LOCATE 11,16: PRINT "-->": LOCATE 11,37: PRINT"
"
14950 LOCATE 16,20: PRINT"
```

```
"
15000 LOCATE 11,45: PRINT "(M or F)": LOCATE 11,37: INPUT SEX$
15050 IF SEX$="M" OR SEX$="F" OR SEX$="m" OR SEX$="f" THEN GOTO 15200
15100 LOCATE 11,37: PRINT "                          ":BEEP: GOTO 15000
15150 LOCATE 11,37: PRINT "                          ":BEEP: GOTO 15000
15200 IF SEX$="m" OR SEX$="M" THEN SEX$="Male" ELSE SEX$="Female"
15250 IF CALCULATE$ = "yes" THEN CALCULATE$ = "changed"
15300 LOCATE 11,16: PRINT "   ": LOCATE 11,37: PRINT "            "
15350 LOCATE 11,45: PRINT "         ": LOCATE 11,37: PRINT "? ";SEX$
15400 GOTO 13950
15450 LOCATE 12,16: PRINT "-->": LOCATE 12,37: PRINT"
"
15500 LOCATE 16,20: PRINT"
"
15550 LOCATE 12,47: PRINT "(";UNIT$;")": LOCATE 12,37: INPUT HEIGHT$
15600 IF CALCULATE$ = "yes" THEN CALCULATE$ = "changed"
15650 IF UNIT$="cm." THEN HEIGHT=VAL(HEIGHT$): REM VARIABLES ARE CARRIED
IN CM
5700 IF UNIT$="in." THEN HEIGHT=2.54*VAL(HEIGHT$): REM VARIABLES CARRIED
IN CM
15750 LOCATE 12,47: PRINT "                    "
15800 LOCATE 12,16: PRINT "   ":LOCATE 12,37: PRINT "? ";:PRINT USING
"###.##";HEIGHT*CONVFACTOR;:PRINT " ";UNIT$
15850 GOTO 13950
15900 CLS:FOR X=1 TO 10: PROBLEM$(X)="": NEXT X: GOTO 5150
15950 REM **************** HARDWARE INFORMATION **********************
16000 CLS
16050 IF UNIT$="" THEN LOCATE 10,8 ELSE GOTO 16400
16100 COLOR 4,0
16150 PRINT "YOU MUST SELECT UNITS BEFORE ENTERING PERSONAL/HARDWARE
INFORMATION"
16200 BEEP
16250 LOCATE 12,17: INPUT "PLEASE PRESS [ENTER] TO RETURN TO THE MAIN
MENU ";GO$
16300 HILITE=1: COLOR 14,1
16350 GOTO 3200
16400 CLS: COLOR 0,11
16450 LOCATE 2,17: PRINT " +------------------------------------------
---+ "
16500 LOCATE 3,17: PRINT " |   H A R D W A R E    I N F O R M A T I O N
| "
16550 LOCATE 4,17: PRINT " +------------------------------------------
---+ "
16600 COLOR 14,1
16650 IF MAIN$ = "expert" OR MAIN$ = "Expert" OR MAIN$ = "EXPERT" GOTO
21900
16700 LOCATE 6,36:PRINT "SEAT HEIGHT"
16750 LOCATE 10,19:INPUT "Is your chair adjustable?  (1) Yes  (2) No
";ADJ$
16800 IF ADJ$ = "1" OR ADJ$ = "2" GOTO 17000
16850 LOCATE 11,29:COLOR 4,0:PRINT " PLEASE ENTER 1 OR 2 ONLY
":BEEP:COLOR 14,1
16900 LOCATE 10,6:FOR X= 1 TO 73:PRINT " ";:NEXT X
16950 GOTO 16750
17000 LOCATE 11,29:PRINT "                                "
17050 LOCATE 10,19:PRINT "
"
17100 IF ADJ$ = "1" GOTO 17500
17150 FIXEDSEAT = (SEATUPPER - SEATLOWER)/2 + SEATLOWER
17200 LOCATE 10,17:PRINT "Currently the seat height is fixed at ";:PRINT
```

```
USING "###.##";FIXEDSEAT*CONVFACTOR;:PRINT " ";UNIT$
17250 LOCATE 12,17:PRINT "Please input the height of your chair: ______
("UNIT$;")":LOCATE 13,17:PRINT "or press [ENTER] to use the current
value.":LOCATE 12,55:INPUT MEAS$
17300 IF MEAS$ = "" THEN GOTO 17400
17350 FIXEDSEAT = VAL(MEAS$)/CONVFACTOR
17400 SEATLOWER = FIXEDSEAT:SEATUPPER = FIXEDSEAT
17450 GOTO 18200
17500 LOCATE 10,17:FOR X=1 TO 62:PRINT " ";:NEXT X:LOCATE 12,17:FOR X=1
TO 62:PRINT " ";:NEXT X
17550 LOCATE 10,15:PRINT "Currently the lower seat adjustment limit is
";:PRINT USING "###.##";SEATLOWER*CONVFACTOR;:PRINT " ";UNIT$
17600 LOCATE 12,15:PRINT "Please input the lower seat adjustment limit:
______ ("UNIT$;")"
17650 LOCATE 13,15:PRINT "or press [ENTER] to use the current
value.":LOCATE 12,60:INPUT MEAS$
17700 IF MEAS$ = "" GOTO 17800
17750 SEATLOWER = VAL(MEAS$)/CONVFACTOR
17800 LOCATE 17,15:PRINT "Currently the upper seat adjustment limit is
";:PRINT USING "###.##";SEATUPPER*CONVFACTOR;:PRINT " ";UNIT$
17850 LOCATE 20,15:PRINT "Please input the upper seat adjustment limit:
______ ("UNIT$;")"
17900 LOCATE 21,15:PRINT "or press [ENTER] to use the current
value.":LOCATE 20,60:INPUT MEAS$
17950 IF MEAS$ = "" GOTO 18200
18000 SEATUPPER = VAL(MEAS$)/CONVFACTOR
18050 IF SEATLOWER <= SEATUPPER THEN GOTO 18200
18100 LOCATE 23,20:COLOR 4,0:BEEP:PRINT "LOWER LIMIT MUST BE LESS THAN
UPPER LIMIT":COLOR 14,1
18150 GOTO 17550
18200 CLS: COLOR 0,11
18250 LOCATE 2,17: PRINT " +-----------------------------------------------
---+ "
18300 LOCATE 3,17: PRINT " |   H A R D W A R E    I N F O R M A T I O N
| "
18350 LOCATE 4,17: PRINT " +-----------------------------------------------
---+ "
18400 COLOR 14,1:LOCATE 6,33:PRINT "KEYBOARD HEIGHT"
18450 LOCATE 7,33:PRINT "(to median row)"
18500 LOCATE 10,11:INPUT "Is the height of your keyboard adjustable?
(1) Yes  (2) No ";ADJ$
18550 IF ADJ$ = "1" OR ADJ$ = "2" GOTO 18750
18600 LOCATE 12,29:COLOR 4,0:PRINT " PLEASE ENTER 1 OR 2 ONLY
":BEEP:COLOR 14,1
18650 LOCATE 10,6:FOR X= 1 TO 73:PRINT " ";:NEXT X
18700 GOTO 18500
18750 LOCATE 12,2:FOR X=1 TO 77:PRINT " ";:NEXT X
18800 LOCATE 10,2:FOR X=1 TO 77:PRINT " ";:NEXT X
18850 IF ADJ$ = "1" GOTO 19250
18900 FIXEDKEY = (KEYHEIGHTUPPER - KEYHEIGHTLOWER)/2 + KEYHEIGHTLOWER
18950 LOCATE 10,17:PRINT "Currently the keyboard height is fixed at
";:PRINT USING "###.##";FIXEDKEY*CONVFACTOR;:PRINT " ";UNIT$
19000 LOCATE 12,17:PRINT "Please input the height of your keyboard:
______ ("UNIT$;")":LOCATE 13,17:PRINT "or press [ENTER] to use the
current value.":LOCATE 12,58:INPUT MEAS$
19050 IF MEAS$ = "" THEN GOTO 19150
19100 FIXEDKEY = VAL(MEAS$)/CONVFACTOR
19150 KEYHEIGHTLOWER = FIXEDKEY:KEYHEIGHTUPPER = FIXEDKEY
19200 LOCATE 12,3:FOR X=1 TO 72:PRINT " ";:NEXT X:LOCATE 13,3:FOR X=1 TO
72:PRINT " ";:NEXT X:GOTO 20200
```

```
19250 LOCATE 10,3:FOR X=1 TO 77:PRINT " ";:NEXT X:LOCATE 12,3:FOR X=1 TO
77:PRINT " ";:NEXT X
19300 LOCATE 10,15:PRINT "Currently the lower keyboard adjustment limit
is ";:PRINT USING "###.##";KEYHEIGHTLOWER*CONVFACTOR;:PRINT " ";UNIT$
19350 LOCATE 12,15:PRINT "Please input the lower keyboard adjustment
limit:  ______ ("UNIT$;")"
19400 LOCATE 13,15:PRINT "or press [ENTER] to use the current
value.":LOCATE 12,64:INPUT MEAS$
19450 IF MEAS$ = "" GOTO 19550
19500 KEYHEIGHTLOWER = VAL(MEAS$)/CONVFACTOR
19550 LOCATE 18,15:PRINT "Currently the upper keyboard adjustment limit
is ";:PRINT USING "###.##";KEYHEIGHTUPPER*CONVFACTOR;:PRINT " ";UNIT$
19600 LOCATE 20,15:PRINT "Please input the upper keyboard adjustment
limit:  ______ ("UNIT$;")"
19650 LOCATE 21,15:PRINT "or press [ENTER] to use the current
value.":LOCATE 20,64:INPUT MEAS$
19700 IF MEAS$ = "" GOTO 19950
19750 KEYHEIGHTUPPER = VAL(MEAS$)/CONVFACTOR
19800 IF KEYHEIGHTLOWER <= KEYHEIGHTUPPER THEN GOTO 19950
19850 LOCATE 23,20:COLOR 4,0:BEEP:PRINT "LOWER LIMIT MUST BE LESS THAN
UPPER LIMIT":COLOR 14,1
19900 GOTO 19300
19950 CLS: COLOR 0,11
20000 LOCATE 2,17: PRINT " +--------------------------------------------
---+ "
20050 LOCATE 3,17: PRINT " |   H A R D W A R E    I N F O R M A T I O N
| "
20100 LOCATE 4,17: PRINT " +--------------------------------------------
---+ "
20150 COLOR 14,1
20200 COLOR 14,1:LOCATE 6,33:PRINT "MONITOR HEIGHT      "
20250 LOCATE 7,29:PRINT "(to center of screen)"
20300 LOCATE 10,11:INPUT "Is the height of your monitor adjustable?  (1)
Yes  (2) No ";ADJ$
20350 IF ADJ$ = "1" OR ADJ$ = "2" GOTO 20550
20400 LOCATE 12,29:COLOR 4,0:PRINT " PLEASE ENTER 1 OR 2 ONLY
":BEEP:COLOR 14,1
20450 LOCATE 10,6:FOR X= 1 TO 73:PRINT " ";:NEXT X
20500 GOTO 20300
20550 LOCATE 12,2:FOR X=1 TO 77:PRINT " ";:NEXT X
20600 LOCATE 10,2:FOR X=1 TO 77:PRINT " ";:NEXT X
20650 IF ADJ$ = "1" GOTO 21050
20700 FIXEDMONITOR = (MONITORUPPER - MONITORLOWER)/2 + MONITORLOWER
20750 LOCATE 10,17:PRINT "Currently the monitor height is fixed at
";:PRINT USING "###.##";FIXEDMONITOR*CONVFACTOR;:PRINT " ";UNIT$
20800 LOCATE 12,17:PRINT "Please input the height of your monitor:
______ ("UNIT$;")":LOCATE 13,17:PRINT "or press [ENTER] to use the
current value.":LOCATE 12,57:INPUT MEAS$
20850 IF MEAS$ = "" THEN GOTO 20950
20900 FIXEDMONITOR = VAL(MEAS$)/CONVFACTOR
20950 MONITORLOWER = FIXEDMONITOR:MONITORUPPER = FIXEDMONITOR
21000 GOTO 21800
21050 LOCATE 10,3:FOR X=1 TO 77:PRINT " ";:NEXT X:LOCATE 12,3:FOR X=1 TO
77:PRINT " ";:NEXT X
21100 LOCATE 10,15:PRINT "Currently the lower monitor adjustment limit
is ";:PRINT USING "###.##";MONITORLOWER*CONVFACTOR;:PRINT " ";UNIT$
21150 LOCATE 12,15:PRINT "Please input the lower monitor adjustment
limit:  ______ ("UNIT$;")"
21200 LOCATE 13,15:PRINT "or press [ENTER] to use the current
value.":LOCATE 12,63:INPUT MEAS$
```

```
21250 IF MEAS$ = "" GOTO 21350
21300 MONITORLOWER = VAL(MEAS$)/CONVFACTOR
21350 LOCATE 18,15:PRINT "Currently the upper monitor adjustment limit
is ";:PRINT USING "###.##";MONITORUPPER*CONVFACTOR;:PRINT " ";UNIT$
21400 LOCATE 20,15:PRINT "Please input the upper monitor adjustment
limit: ______ ("UNIT$;")"
21450 LOCATE 21,15:PRINT "or press [ENTER] to use the current
value.":LOCATE 20,63:INPUT MEAS$
21500 IF MEAS$ = "" GOTO 21750
21550 MONITORUPPER = VAL(MEAS$)/CONVFACTOR
21600 IF MONITORLOWER <= MONITORUPPER THEN GOTO 21750
21650 LOCATE 23,20:COLOR 4,0:BEEP:PRINT "LOWER LIMIT MUST BE LESS THAN
UPPER LIMIT":COLOR 14,1
21700 GOTO 21100
21750 GOTO 21800
21800 GOTO 5150
21850 REM ********** EXPERT HARDWARE INFORMATION SCREEN ****************
21900 LOCATE 6,46: PRINT "Lower":LOCATE 6,59: PRINT "Upper"
21950 LOCATE 7,46: PRINT "Limit":LOCATE 7,59: PRINT "Limit"
22000 LOCATE 8,46: PRINT "-----":LOCATE 8,59: PRINT "-----"
22050 LOCATE 10,20: PRINT "(1) Seat Height:"
22100 LOCATE 10,44: PRINT USING "###.##";SEATLOWER*CONVFACTOR;: PRINT "
";UNIT$: LOCATE 10,57: PRINT USING "###.##";SEATUPPER*CONVFACTOR;: PRINT
" ";UNIT$
22150 LOCATE 11,20: PRINT "(2) Elbow Height:"
22200 LOCATE 11,44: PRINT USING "###.##";ELBOWLOWER*CONVFACTOR;: PRINT "
";UNIT$: LOCATE 11,57: PRINT USING "###.##";ELBOWUPPER*CONVFACTOR;:
PRINT " ";UNIT$
22250 LOCATE 12,20: PRINT "(3) Keyboard Height:"
22300 LOCATE 12,44: PRINT USING "###.##";KEYHEIGHTLOWER*CONVFACTOR;:
PRINT " ";UNIT$: LOCATE 12,57: PRINT USING
"###.##";KEYHEIGHTUPPER*CONVFACTOR;: PRINT " ";UNIT$
22350 LOCATE 13,20: PRINT "(4) Keyboard Angle:"
22400 LOCATE 13,44: PRINT USING "###.##";KEYANGLELOWER*RADTODEG;: PRINT
" deg": LOCATE 13,57: PRINT USING "###.##";KEYANGLEUPPER*RADTODEG;:
PRINT " deg"
22450 LOCATE 14,20: PRINT "(5) Monitor Height:"
22500 LOCATE 14,44: PRINT USING "###.##";MONITORLOWER*CONVFACTOR;: PRINT
" ";UNIT$: LOCATE 14,57: PRINT USING "###.##";MONITORUPPER*CONVFACTOR;:
PRINT " ";UNIT$
22550 LOCATE 15,20: PRINT "(6) Viewing Distance:"
22600 LOCATE 15,44: PRINT USING "###.##";VIEWDISTLOWER*CONVFACTOR;:
PRINT " ";UNIT$: LOCATE 15,57: PRINT USING
"###.##";VIEWDISTUPPER*CONVFACTOR;: PRINT " ";UNIT$
22650 LOCATE 16,20: PRINT "(7) Viewing Angle:"
22700 LOCATE 16,44: PRINT USING "###.##";VIEWANGLELOWER*RADTODEG;: PRINT
" deg": LOCATE 16,57: PRINT USING "###.##";VIEWANGLEUPPER*RADTODEG;:
PRINT " deg"
22750 LOCATE 18,20: PRINT "(8) Return to the Personal/Hardware menu."
22800 IF SEATUPPER = SEATLOWER THEN LOCATE 10,70 ELSE GOTO 22900
22850 PRINT "(FIXED)"
22900 IF ELBOWUPPER = ELBOWLOWER THEN LOCATE 11,70 ELSE GOTO 23000
22950 PRINT "(FIXED)"
23000 IF KEYHEIGHTLOWER = KEYHEIGHTUPPER THEN LOCATE 12,70 ELSE GOTO
23100
23050 PRINT "(FIXED)"
23100 IF KEYANGLEUPPER = KEYANGLELOWER THEN LOCATE 13,70 ELSE GOTO 23200
23150 PRINT "(FIXED)"
23200 IF MONITORUPPER = MONITORLOWER THEN LOCATE 14,70 ELSE GOTO 23300
23250 PRINT "(FIXED)"
```

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23300 IF VIEWDISTUPPER = VIEWDISTLOWER THEN LOCATE 15,70 ELSE GOTO 23400
23350 PRINT "(FIXED)"
23400 IF VIEWANGLEUPPER = VIEWANGLELOWER THEN LOCATE 16,70 ELSE GOTO
23500
23450 PRINT "(FIXED)"
23500 LOCATE 20,15: PRINT "Please enter 1 to 7 to change information or
8 to exit: ";
23550 INPUT QUES$
23600 IF QUES$="1" OR QUES$="2" OR QUES$="3" OR QUES$="4" GOTO 23850
23650 IF QUES$="5" OR QUES$="6" OR QUES$="7" OR QUES$="8" GOTO 23850
23700 LOCATE 20,70: PRINT "          ": LOCATE 22,21: COLOR 4,8: PRINT "
PLEASE ENTER 1, 2, 3, 4, 5, 6, 7, OR 8 ONLY ":BEEP: COLOR 14,1
23750 LOCATE 20,65: PRINT "                    "
23800 GOTO 23500
23850 LOCATE 20,15:FOR X=1 TO 65: PRINT " ";:NEXT X
23900 LOCATE 22,15: PRINT "
"
23950 ON VAL(QUES$) GOTO 24000,25100,26200,27300,28300,29400,30500,31500
24000 LOCATE 10,16: PRINT "-->"
24050 CALCULATE$ = "changed"
24100 LOCATE 10,44: PRINT "______ ":LOCATE 10,42:INPUT MEASUREMENT$
24150 IF UNIT$="cm." THEN SEATLOWER = VAL(MEASUREMENT$)
24200 IF UNIT$="in." THEN SEATLOWER = 2.54*VAL(MEASUREMENT$)
24250 LOCATE 10,42: PRINT "         "
24300 LOCATE 10,44: PRINT USING "###.##";SEATLOWER*CONVFACTOR
24350 LOCATE 10,57: PRINT "______ ":LOCATE 10,55:INPUT MEASUREMENT$
24400 IF UNIT$="cm." THEN SEATUPPER = VAL(MEASUREMENT$)
24450 IF UNIT$="in." THEN SEATUPPER = 2.54*VAL(MEASUREMENT$)
24500 LOCATE 10,55: PRINT "         "
24550 LOCATE 10,57: PRINT USING "###.##";SEATUPPER*CONVFACTOR
24600 LOCATE 10,16: PRINT "   "
24650 LOCATE 22,20: FOR X=1 TO 50: PRINT " ";: NEXT X
24700 IF SEATLOWER=SEATUPPER THEN GOTO 25000
24750 IF SEATUPPER > SEATLOWER THEN GOTO 24900
24800 LOCATE 22,20: COLOR 4,8: PRINT "LOWER LIMIT MUST BE LESS THAN
UPPER LIMIT": BEEP: COLOR 14,1
24850 GOTO 24000
24900 LOCATE 10,70: PRINT "         "
24950 GOTO 23500
25000 LOCATE 10,70: PRINT "(FIXED)"
25050 GOTO 23500
25100 LOCATE 11,16: PRINT "-->"
25150 CALCULATE$ = "changed"
25200 LOCATE 11,44: PRINT "______ ":LOCATE 11,42:INPUT MEASUREMENT$
25250 IF UNIT$="cm." THEN ELBOWLOWER = VAL(MEASUREMENT$)
25300 IF UNIT$="in." THEN ELBOWLOWER = 2.54*VAL(MEASUREMENT$)
25350 LOCATE 11,42: PRINT "         "
25400 LOCATE 11,44: PRINT USING "###.##";ELBOWLOWER*CONVFACTOR
25450 LOCATE 11,57: PRINT "______ ":LOCATE 11,55:INPUT MEASUREMENT$
25500 IF UNIT$="cm." THEN ELBOWUPPER = VAL(MEASUREMENT$)
25550 IF UNIT$="in." THEN ELBOWUPPER = 2.54*VAL(MEASUREMENT$)
25600 LOCATE 11,55: PRINT "         "
25650 LOCATE 11,57: PRINT USING "###.##";ELBOWUPPER*CONVFACTOR
25700 LOCATE 11,16: PRINT "   "
25750 LOCATE 22,20: FOR X=1 TO 50: PRINT " ";: NEXT X
25800 IF ELBOWLOWER=ELBOWUPPER THEN GOTO 26100
25850 IF ELBOWUPPER > ELBOWLOWER THEN GOTO 26000
25900 LOCATE 22,20: COLOR 4,8: PRINT "LOWER LIMIT MUST BE LESS THAN
UPPER LIMIT": BEEP: COLOR 14,1
25950 GOTO 25100
```

```
26000 LOCATE 11,70: PRINT "         "
26050 GOTO 23500
26100 LOCATE 11,70: PRINT "(FIXED)"
26150 GOTO 23500
26200 LOCATE 12,16: PRINT "-->"
26250 CALCULATE$ = "changed"
26300 LOCATE 12,44: PRINT "______ ":LOCATE 12,42:INPUT MEASUREMENT$
26350 IF UNIT$="cm." THEN KEYHEIGHTLOWER = VAL(MEASUREMENT$)
26400 IF UNIT$="in." THEN KEYHEIGHTLOWER = 2.54*VAL(MEASUREMENT$)
26450 LOCATE 12,42: PRINT "                 "
26500 LOCATE 12,44: PRINT USING "###.##";KEYHEIGHTLOWER*CONVFACTOR
26550 LOCATE 12,57: PRINT "______ ":LOCATE 12,55:INPUT MEASUREMENT$
26600 IF UNIT$="cm." THEN KEYHEIGHTUPPER = VAL(MEASUREMENT$)
26650 IF UNIT$="in." THEN KEYHEIGHTUPPER = 2.54*VAL(MEASUREMENT$)
26700 LOCATE 12,55: PRINT "                 "
26750 LOCATE 12,57: PRINT USING "###.##";KEYHEIGHTUPPER*CONVFACTOR
26800 LOCATE 12,16: PRINT "   "
26850 LOCATE 22,20: FOR X=1 TO 50: PRINT " ";: NEXT X
26900 IF KEYHEIGHTLOWER=KEYHEIGHTUPPER THEN GOTO 27200
26950 IF KEYHEIGHTUPPER > KEYHEIGHTLOWER THEN GOTO 27100
27000 LOCATE 22,20: COLOR 4,8: PRINT "LOWER LIMIT MUST BE LESS THAN
UPPER LIMIT": BEEP: COLOR 14,1
27050 GOTO 26200
27100 LOCATE 12,70: PRINT "                 "
27150 GOTO 23500
27200 LOCATE 12,70: PRINT "(FIXED)"
27250 GOTO 23500
27300 LOCATE 13,16: PRINT "-->"
27350 CALCULATE$ = "changed"
27400 LOCATE 13,44: PRINT "______ ":LOCATE 13,42:INPUT MEASUREMENT$
27450 KEYANGLELOWER = (VAL(MEASUREMENT$))*DEGTORAD
27500 LOCATE 13,42: PRINT "                 "
27550 LOCATE 13,44: PRINT USING "###.##";KEYANGLELOWER*RADTODEG
27600 LOCATE 13,57: PRINT "______ ":LOCATE 13,55:INPUT MEASUREMENT$
27650 KEYANGLEUPPER = (VAL(MEASUREMENT$))*DEGTORAD
27700 LOCATE 13,55: PRINT "                 "
27750 LOCATE 13,57: PRINT USING "###.##";KEYANGLEUPPER*RADTODEG
27800 LOCATE 13,16: PRINT "   "
27850 LOCATE 22,20: FOR X=1 TO 50: PRINT " ";: NEXT X
27900 IF KEYANGLELOWER=KEYANGLEUPPER THEN GOTO 28200
27950 IF KEYANGLEUPPER > KEYANGLELOWER THEN GOTO 28100
28000 LOCATE 22,20: COLOR 4,8: PRINT "LOWER LIMIT MUST BE LESS THAN
UPPER LIMIT": BEEP: COLOR 14,1
28050 GOTO 27300
28100 LOCATE 13,70: PRINT "                 "
28150 GOTO 23500
28200 LOCATE 13,70: PRINT "(FIXED)"
28250 GOTO 23500
28300 LOCATE 14,16: PRINT "-->"
28350 CALCULATE$ = "changed"
28400 LOCATE 14,44: PRINT "______ ":LOCATE 14,42:INPUT MEASUREMENT$
28450 IF UNIT$="cm." THEN MONITORLOWER = VAL(MEASUREMENT$)
28500 IF UNIT$="in." THEN MONITORLOWER = 2.54*VAL(MEASUREMENT$)
28550 LOCATE 14,42: PRINT "                 "
28600 LOCATE 14,44: PRINT USING "###.##";MONITORLOWER*CONVFACTOR
28650 LOCATE 14,57: PRINT "______ ":LOCATE 14,55:INPUT MEASUREMENT$
28700 IF UNIT$="cm." THEN MONITORUPPER = VAL(MEASUREMENT$)
28750 IF UNIT$="in." THEN MONITORUPPER = 2.54*VAL(MEASUREMENT$)
28800 LOCATE 14,55: PRINT "                 "
28850 LOCATE 14,57: PRINT USING "###.##";MONITORUPPER*CONVFACTOR
```

```
28900 LOCATE 14,16: PRINT "   "
28950 LOCATE 22,20: FOR X=1 TO 50: PRINT " ";: NEXT X
29000 IF MONITORLOWER=MONITORUPPER THEN GOTO 29300
29050 IF MONITORUPPER > MONITORLOWER THEN GOTO 29200
29100 LOCATE 22,20: COLOR 4,8: PRINT "LOWER LIMIT MUST BE LESS THAN
UPPER LIMIT": BEEP: COLOR 14,1
29150 GOTO 28300
29200 LOCATE 14,70: PRINT "                 "
29250 GOTO 23500
29300 LOCATE 14,70: PRINT "(FIXED)"
29350 GOTO 23500
29400 LOCATE 15,16: PRINT "-->"
29450 CALCULATE$ = "changed"
29500 LOCATE 15,44: PRINT "_______ ":LOCATE 15,42:INPUT MEASUREMENT$
29550 IF UNIT$="cm." THEN VIEWDISTLOWER = VAL(MEASUREMENT$)
29600 IF UNIT$="in." THEN VIEWDISTLOWER = 2.54*VAL(MEASUREMENT$)
29650 LOCATE 15,42: PRINT "                "
29700 LOCATE 15,44: PRINT USING "###.##";VIEWDISTLOWER*CONVFACTOR
29750 LOCATE 15,57: PRINT "_______ ":LOCATE 15,55:INPUT MEASUREMENT$
29800 IF UNIT$="cm." THEN VIEWDISTUPPER = VAL(MEASUREMENT$)
29850 IF UNIT$="in." THEN VIEWDISTUPPER = 2.54*VAL(MEASUREMENT$)
29900 LOCATE 15,55: PRINT "         "
29950 LOCATE 15,57: PRINT USING "###.##";VIEWDISTUPPER*CONVFACTOR
30000 LOCATE 15,16: PRINT "   "
30050 LOCATE 22,20: FOR X=1 TO 50: PRINT " ";: NEXT X
30100 IF VIEWDISTLOWER=VIEWDISTUPPER THEN GOTO 30400
30150 IF VIEWDISTUPPER > VIEWDISTLOWER THEN GOTO 30300
30200 LOCATE 22,20: COLOR 4,8: PRINT "LOWER LIMIT MUST BE LESS THAN
UPPER LIMIT": BEEP: COLOR 14,1
30250 GOTO 29400
30300 LOCATE 15,70: PRINT "         "
30350 GOTO 23500
30400 LOCATE 15,70: PRINT "(FIXED)"
30450 GOTO 23500
30500 LOCATE 16,16: PRINT "-->"
30550 CALCULATE$ = "changed"
30600 LOCATE 16,44: PRINT "_______ ":LOCATE 16,42:INPUT MEASUREMENT$
30650 VIEWANGLELOWER = (VAL(MEASUREMENT$))*DEGTORAD
30700 LOCATE 16,42: PRINT "         "
30750 LOCATE 16,44: PRINT USING "###.##";VIEWANGLELOWER*RADTODEG
30800 LOCATE 16,57: PRINT "_______ ":LOCATE 16,55:INPUT MEASUREMENT$
30850 VIEWANGLEUPPER = (VAL(MEASUREMENT$))*DEGTORAD
30900 LOCATE 16,55: PRINT "         "
30950 LOCATE 16,57: PRINT USING "###.##";VIEWANGLEUPPER*RADTODEG
31000 LOCATE 16,16: PRINT "   "
31050 LOCATE 22,20: FOR X=1 TO 50: PRINT " ";: NEXT X
31100 IF VIEWANGLELOWER=VIEWANGLEUPPER THEN GOTO 31400
31150 IF VIEWANGLEUPPER > VIEWANGLELOWER THEN GOTO 31300
31200 LOCATE 22,20: COLOR 4,8: PRINT "LOWER LIMIT MUST BE LESS THAN
UPPER LIMIT": BEEP: COLOR 14,1
31250 GOTO 30500
31300 LOCATE 16,70: PRINT "         "
31350 GOTO 23500
31400 LOCATE 16,70: PRINT "(FIXED)"
31450 GOTO 23500
31500 FOR X=1 TO 10: PROBLEM$(X)="": NEXT X: GOTO 5150
31550 REM *****************************************************
31600 REM                U N I T   S E L E C T I O N
31650 REM *****************************************************
31700 CLS: COLOR 0,11
```

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31750 LOCATE 4,19: PRINT " +---------------------------------+ "
31800 LOCATE 5,19: PRINT " |  U N I T    S E L E C T I O N  | "
31850 LOCATE 6,19: PRINT " +---------------------------------+ "
31900 COLOR 14,1
31950 LOCATE 8,20: PRINT "(1) Use centimeters (cm)"
32000 LOCATE 9,20: PRINT "(2) Use inches (in)
32050 LOCATE 11,20: PRINT "(3) Return to main menu"
32100 LOCATE 13,20: INPUT "Please enter your selection: ";QUES$
32150 IF QUES$="1" OR QUES$="2" OR QUES$="3" THEN GOTO 32350
32200 LOCATE 15,19: COLOR 4,8: PRINT " PLEASE ENTER 1, 2, OR 3 ONLY ":
BEEP
32250 LOCATE 13,48: COLOR 14,1: PRINT "                  "
32300 GOTO 32100
32350 IF QUES$="3" THEN GOTO 3200
32400 IF QUES$="2" THEN GOTO 32600
32450 CONVFACTOR=1: REM ALL DEFAULT VALUES ARE GIVEN IN CENTIMETERS
32500 UNIT$="cm."
32550 GOTO 3200
32600 CONVFACTOR=1/2.54: REM CONVERTS DEFAULT VALUES TO INCHES
32650 UNIT$="in."
32700 GOTO 3200
32750 REM *******************************************************
32800 REM    C A L C U L A T I O N    O F    S E T T I N G S
32850 REM *******************************************************
32900 FOOTREST = 0: RAISEHANDS = 0
32950 FOR X= 1 TO 10
33000 PROBLEM$(X) = ""
33050 NEXT X
33100 CLS
33150 IF SEX$ <> "" AND HEIGHT > 0 THEN GOTO 33550
33200 CLS
33250 COLOR 4,0: LOCATE 10,8
33300 PRINT "YOU MUST INPUT SUBJECT'S STANDING HEIGHT AND SEX BEFORE
CALCULATING."
33350 BEEP
33400 LOCATE 12,23: INPUT " PLEASE PRESS [ENTER] TO CONTINUE"; GO$
33450 COLOR 14,1
33500 HILITE = 2: GOTO 3200
33550 REM BODY(1)=HEIGHT; BODY(2)=SEAT HEIGHT; BODY(3)=SEAT DEPTH
33600 REM BODY(4)=SEATED EYE HEIGHT; BODY(5)=TRUNK; BODY(6)=UPPERARM
33650 REM BODY(7)=ELBOW TO FINGERTIP; BODY(8)=SEATED HEIGHT
33700 REM BODY(10)=HEAD (CHIN TO TOP)
33750 CALCULATE$ = "yes"
33800 DEGTORAD=3.1416/180
33850 RADTODEG=180/3.1416
33900 BACKANGLE=0: REM IN DEGREES
33950 BACKANGLE=BACKANGLE*DEGTORAD: REM IN RADIANS
34000 ARMANGLE=0: REM IN DEGREES
34050 ARMANGLE=ARMANGLE*DEGTORAD: REM IN RADIANS
34100 SEATANGLE=0: REM IN DEGREES
34150 SEATANGLE=SEATANGLE*DEGTORAD: REM IN RADIANS
34200 KEYANGLE = (KEYANGLEUPPER-KEYANGLELOWER)*.8 + KEYANGLELOWER :REM
IN RAD
34250 BODY(1)=HEIGHT
34300 IF SEX$ = "Male" THEN GOTO 35000
34350 REM -----------------------------------------------
34400 REM BODY MEASUREMENTS FOR WOMEN
34450 REM -----------------------------------------------
34500 LOCATE 5,20: PRINT "Calculating body measurements for a female."
34550 BODY(2)=.2484*BODY(1): REM SEAT HIEGHT
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34600 BODY(3)=.2997*BODY(1): REM SEAT DEPTH
34650 BODY(5)=.3388*BODY(1): REM TRUNK (SHOULDER)
34700 BODY(4)=.4641*BODY(1)-BODY(5): REM EYES ABOVE SHOULDER
34750 BODY(6)=(.3388-.1444)*BODY(1): REM UPPER ARM
34800 BODY(7)=.266*BODY(1): REM ELBOW TO FINGERTIP
34850 BODY(8) = .5291*BODY(1)
34900 BODY(9) = .1231*BODY(1)
34950 GOTO 35600
35000 REM -------------------------------------------------
35050 REM BODY MEASUREMENTS FOR MEN
35100 REM -------------------------------------------------
35150 LOCATE 5,20: PRINT "Calculating body measurements for a male."
35200 BODY(2)=.2533*BODY(1): REM SEAT HIEGHT
35250 BODY(3)=.2845*BODY(1): REM SEAT DEPTH
35300 BODY(5)=.3368*BODY(1): REM TRUNK (SHOULDER)
35350 BODY(4)=.4567*BODY(1)-BODY(5): REM EYES ABOVE SHOULDER
35400 BODY(6)=(.3368-.1388)*BODY(1): REM UPPER ARM
35450 BODY(7)=.2746*BODY(1): REM ELBOW TO FINGERTIP
35500 BODY(8) = .5219*BODY(1)
35550 BODY(9) = .1275*BODY(1)
35600 REM ------------------------------------------------
35650 REM PLACING THE INDIVIDUAL IN THE X-Y PLANE
35700 REM ------------------------------------------------
35750 LOCATE 6,20: PRINT "Placing the individual in the X-Y plane."
35800 XANKLE=BODY(5)*SIN(BACKANGLE)+BODY(3)*COS(SEATANGLE)
35850 YANKLE=0
35900 XTOE = .152*BODY(1)+XANKLE
35950 YTOE = 0
36000 XKNEE=XANKLE
36050 YKNEE=YANKLE+BODY(2)
36100 XHIP=BODY(5)*SIN(BACKANGLE)
36150 YHIP=YKNEE-BODY(3)*SIN(SEATANGLE)
36200 XSHOULDER=0
36250 RASISEHANDS = SEATUPPER - YKNEE
36300 YSHOULDER=YHIP+BODY(5)*COS(BACKANGLE)
36350 XELBOW=BODY(6)*SIN(ARMANGLE)
36400 YELBOW=YSHOULDER-BODY(6)*COS(ARMANGLE)
36450 XFINGERTIP=XELBOW + BODY(7)*COS(ARMANGLE)
36500 YFINGERTIP=YELBOW + BODY(7)*SIN(ARMANGLE)
36550 XWRIST = XFINGERTIP - .108*BODY(1)*COS(ARMANGLE)
36600 YWRIST = YFINGERTIP - .108*BODY(1)*SIN(ARMANGLE)
36650 XEYES=5
36700 YEYES=YSHOULDER+BODY(4)
36750 XTOPOFHEAD = 0
36800 YTOPOFHEAD = YSHOULDER+(BODY(8)-BODY(5))
36850 XCHIN = 0
36900 YCHIN = YTOPOFHEAD - BODY(9)
36950 REM ------------------------------------------------
37000 REM PLACING THE HARDWARE IN THE X-Y PLANE
37050 REM ------------------------------------------------
37100 LOCATE 7,20: PRINT "Placing the hardware in the X-Y plane."
37150 XMEDIANROW=XFINGERTIP
37200 YMEDIANROW=YFINGERTIP
37250 VIEWDISTANCE = (VIEWDISTUPPER-VIEWDISTLOWER)*.75 + VIEWDISTLOWER
37300 VIEWANGLE= (VIEWANGLEUPPER - VIEWANGLELOWER)*.5 + VIEWANGLELOWER
37350 XCENTERMONITOR=XEYES+VIEWDISTANCE*COS(VIEWANGLE)
37400 YCENTERMONITOR=YEYES-VIEWDISTANCE*SIN(VIEWANGLE)
37450 IF VIEWANGLE<15*DEGTORAD THEN TILT=VIEWANGLE ELSE TILT=15*DEGTORAD
37500 XULC = XCENTERMONITOR + 15*SIN(TILT)
37550 YULC = YCENTERMONITOR + 15*COS(TILT)
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37600 XURC = XULC + 30*COS(TILT)
37650 YURC = YULC - 30*SIN(TILT)
37700 XLLC = XCENTERMONITOR - 15*SIN(TILT)
37750 YLLC = YCENTERMONITOR - 15*COS(TILT) 37800 XLRC = XLLC +
30*COS(TILT)
37850 YLRC = YLLC - 30*SIN(TILT)
37900 XKEY1 = XFINGERTIP - 8*COS(KEYANGLE)
37950 YKEY1 = YFINGERTIP - 8*SIN(KEYANGLE)
38000 XKEY2 = XFINGERTIP + 8*COS(KEYANGLE) 38050 YKEY2 = YFINGERTIP +
8*SIN(KEYANGLE)
38100 XKEY3 = XKEY1 + 16*COS(KEYANGLE)
38150 YKEY3 = YKEY1
38200 LOCATE 8,20: PRINT "Checking for constraint violations."
38250 REM -------------------------------------------------------------
38300 REM                CHECKING FOR CONSTRAINT VIOLATION
38350 REM -------------------------------------------------------------
38400 IF SEATLOWER <= YKNEE  THEN GOTO 38900
38450 FOOTREST = SEATLOWER - YKNEE
38500 PROBLEM$(7) = "Foot rest is required to prevent feet from
dangling."
38550 YTOE = YTOE+FOOTREST: YANKLE=YANKLE+FOOTREST
38600 YKNEE = YKNEE+FOOTREST: YHIP = YHIP+FOOTREST
38650 YSHOULDER = YSHOULDER+FOOTREST: YELBOW = YELBOW+FOOTREST
38700 YFINGERTIP = YFINGERTIP+FOOTREST: YWRIST = YWRIST + FOOTREST
38750 YEYES = YEYES+FOOTREST: YTOPOFHEAD = YTOPOFHEAD + FOOTREST
38800 YCHIN = YCHIN + FOOTREST
38850 GOTO 36950
38900 TOHIGH = 0
38950 IF SEATUPPER >= YHIP THEN GOTO 39350
39000 TOHIGH = YHIP - SEATUPPER
39050 YHIP = YHIP - TOHIGH
39100 YSHOULDER = YSHOULDER-TOHIGH: YELBOW = YELBOW-TOHIGH
39150 YFINGERTIP = YFINGERTIP-TOHIGH: YWRIST = YWRIST-TOHIGH
39200 YEYES = YEYES-TOHIGH: YTOPOFHEAD = YTOPOFHEAD-TOHIGH
39250 YCHIN = YCHIN-TOHIGH
39300 GOTO 36950
39350 IF YFINGERTIP>=KEYHEIGHTLOWER AND YFINGERTIP<=KEYHEIGHTUPPER GOTO
42150
39400 IF INT(10*(YFINGERTIP+.05)) >= INT(10*(KEYHEIGHTUPPER)) GOTO 41550
39450 IF PROBLEM$(1) <> "" GOTO 41550
39500 ARMANGLE = 0
39550 IF YFINGERTIP >= KEYHEIGHTLOWER THEN GOTO 41500
39600 IF RAISEHANDS > 0 GOTO 40550
39650 RAISEHANDS = KEYHEIGHTLOWER - YFINGERTIP
39700 IF YKNEE + RAISEHANDS < SEATUPPER GOTO 39850
39750 RAISEHANDS = SEATUPPER - YKNEE
39800 IF RAISEHANDS = 0 GOTO 40550
39850 YTOE = YTOE + RAISEHANDS
39900 YANKLE = YANKLE + RAISEHANDS
39950 YKNEE = YKNEE + RAISEHANDS
40000 YHIP = YHIP + RAISEHANDS
40050 YSHOULDER = YSHOULDER + RAISEHANDS
40100 YELBOW = YELBOW + RAISEHANDS
40150 YFINGERTIP = YFINGERTIP + RAISEHANDS
40200 YWRIST = YWRIST + RAISEHANDS
40250 YEYES = YEYES + RAISEHANDS
40300 YTOPOFHEAD = YTOPOFHEAD + RAISEHANDS
40350 YCHIN = YCHIN + RAISEHANDS
40400 FOOTREST = FOOTREST + RAISEHANDS
40450 PROBLEM$(7) = "Foot rest is required to prevent feet from
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dangling."
40500 GOTO 36950
40550 ARMANGLE = ARMANGLE + 1*DEGTORAD
40600 XELBOW = BODY(6)*SIN(ARMANGLE)
40650 YELBOW = YSHOULDER - BODY(6)*COS(ARMANGLE)
40700 XFINGERTIP = XELBOW + BODY(7)
40750 YFINGERTIP = YELBOW
40800 XWRIST = XFINGERTIP - .108*BODY(1)
40850 YWRIST = YFINGERTIP
40900 IF ARMANGLE*RADTODEG < 15 THEN GOTO 39550
40950 ARMANGLE = 0
41000 ARMANGLE = ARMANGLE + 1*DEGTORAD
41050 XELBOW = BODY(6)*SIN(ARMANGLE)
41100 YELBOW = YSHOULDER - BODY(6)*COS(ARMANGLE)
41150 XFINGERTIP = XELBOW + BODY(7)*COS(ARMANGLE)
41200 YFINGERTIP = YELBOW + BODY(7)*SIN(ARMANGLE)
41250 XWRIST = XFINGERTIP - .108*BODY(1)*COS(ARMANGLE)
41300 YWRIST = YFINGERTIP - .108*BODY(1)*SIN(ARMANGLE)
41350 IF YFINGERTIP >= KEYHEIGHTLOWER THEN GOTO 41500
41400 IF ARMANGLE*RADTODEG < 15 THEN GOTO 41000
41450 PROBLEM$(1)= "Optimum keyboard height is lower than constraints
will allow."
41500 GOTO 36950
41550 IF INT(10*(YFINGERTIP+.05)) <= INT(10*(KEYHEIGHTUPPER+.05)) THEN
GOTO 42150
41600 IF INT(10*(YFINGERTIP+.05)) <= INT(10*(KEYHEIGHTUPPER+.05)) THEN
GOTO 42100
41650 IF PROBLEM$(2) <> "" THEN GOTO 42150
41700 IF ARMANGLE*RADTODEG < -15 THEN GOTO 42050
41750 ARMANGLE = ARMANGLE - .1*DEGTORAD
41800 XFINGERTIP = XELBOW + BODY(7)*COS(ARMANGLE)
41850 YFINGERTIP = YELBOW + BODY(7)*SIN(ARMANGLE)
41900 XWRIST = XFINGERTIP - .108*BODY(1)*COS(ARMANGLE)
41950 YWRIST = YFINGERTIP - .108*BODY(1)*SIN(ARMANGLE)
42000 GOTO 41600
42050 PROBLEM(2)$ = "Optimum keyboard height is higher than constraints
will allow"
42100 GOTO 36950
42150 IF YCENTERMONITOR >= MONITORLOWER AND YCENTERMONITOR <=
MONITORUPPER THEN GOTO 43350
42200 IF YCENTERMONITOR <= MONITORLOWER GOTO 42800
42250 IF PROBLEM$(3)<>"" THEN GOTO 42800
42300 YCENTERMONITOR = MONITORUPPER
42350 VIEWANGLE = ATN((YEYES-YCENTERMONITOR)/(XCENTERMONITOR))
42400 IF VIEWANGLE > VIEWANGLEUPPER THEN GOTO 42550
42450 XCENTERMONITOR = XEYES+VIEWDISTANCE*COS(VIEWANGLE)
42500 GOTO 37450
42550 VIEWANGLE=VIEWANGLEUPPER
42600 YCENTERMONITOR = YEYES-VIEWDISTANCE*SIN(VIEWANGLE)
42650 XCENTERMONITOR = XEYES+VIEWDISTANCE*COS(VIEWANGLE)
42700 PROBLEM$(3)="Optimal monitor position is lower than constraints
will allow"
42750 GOTO 37450
42800 IF PROBLEM$(4)<>"" THEN GOTO 43350
42850 YCENTERMONITOR = MONITORLOWER
42900 VIEWANGLE = ATN((YEYES-YCENTERMONITOR)/(XCENTERMONITOR))
42950 IF VIEWANGLE < VIEWANGLELOWER THEN GOTO 43100
43000 XCENTERMONITOR = XEYES+VIEWDISTANCE*COS(VIEWANGLE)
43050 GOTO 37450
43100 VIEWANGLE=VIEWANGLELOWER
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43150 YCENTERMONITOR = YEYES-VIEWDISTANCE*SIN(VIEWANGLE)
43200 XCENTERMONITOR = XEYES+VIEWDISTANCE*COS(VIEWANGLE)
43250 PROBLEM$(4)="Optimal monitor position is higher than constraints
will allow" 43300 GOTO 37450
43350 IF YLRC >= YKEY3 THEN GOTO 44750
43400 IF PROBLEM$(5) <> "" THEN GOTO 44750
43450 VIEWANGLE=VIEWANGLE-.1*DEGTORAD
43500 XCENTERMONITOR=XEYES+VIEWDISTANCE*COS(VIEWANGLE)
43550 YCENTERMONITOR=YEYES-VIEWDISTANCE*SIN(VIEWANGLE)
43600 IF INT(10*(YCENTERMONITOR+.05)) <= INT(10*(MONITORUPPER+.05)) GOTO
43900
43650 PROBLEM$(5) = "Optimal height of monitor is higher than
constraints will allow."
43700 VIEWANGLE = VIEWANGLE + .1*DEGTORAD
43750 XCENTERMONITOR=XEYES+VIEWDISTANCE*COS(VIEWANGLE)
43800 YCENTERMONITOR=YEYES-VIEWDISTANCE*SIN(VIEWANGLE)
43850 GOTO 38250
43900 IF VIEWANGLE<15*DEGTORAD THEN TILT=VIEWANGLE ELSE TILT=15*DEGTORAD
43950 XULC = XCENTERMONITOR + 15*SIN(TILT)
44000 YULC = YCENTERMONITOR + 15*COS(TILT)
44050 XURC = XULC + 30*COS(TILT)
44100 YURC = YULC - 30*SIN(TILT)
44150 XLLC = XCENTERMONITOR - 15*SIN(TILT)
44200 YLLC = YCENTERMONITOR - 15*COS(TILT)
44250 XLRC = XLLC + 30*COS(TILT)
44300 YLRC = YLLC - 30*SIN(TILT)
44350 XKEY1 = XFINGERTIP - 8*COS(KEYANGLE)
44400 YKEY1 = YFINGERTIP - 8*SIN(KEYANGLE)
44450 XKEY2 = XFINGERTIP + 8*COS(KEYANGLE)
44500 YKEY2 = YFINGERTIP + 8*SIN(KEYANGLE)
44550 XKEY3 = XKEY1 + 16*COS(KEYANGLE)
44600 YKEY3 = YKEY1
44650 IF YLRC > YKEY3 THEN GOTO 38250
44700 GOTO 43450
44750 IF XLLC > XKEY3+1 THEN GOTO 45900
44800 VIEWDISTANCE = VIEWDISTANCE + 1
44850 XCENTERMONITOR=XEYES+VIEWDISTANCE*COS(VIEWANGLE)
44900 YCENTERMONITOR=YEYES-VIEWDISTANCE*SIN(VIEWANGLE)
44950 PROBLEM$(5) ="":PROBLEM$(4)=""
45000 IF VIEWANGLE<15*DEGTORAD THEN TILT=VIEWANGLE ELSE TILT=15*DEGTORAD
45050 XULC = XCENTERMONITOR + 15*SIN(TILT)
45100 YULC = YCENTERMONITOR + 15*COS(TILT)
45150 XURC = XULC + 30*COS(TILT)
45200 YURC = YULC - 30*SIN(TILT)
45250 XLLC = XCENTERMONITOR - 15*SIN(TILT)
45300 YLLC = YCENTERMONITOR - 15*COS(TILT)
45350 XLRC = XLLC + 30*COS(TILT)
45400 YLRC = YLLC - 30*SIN(TILT)
45450 XKEY1 = XFINGERTIP - 8*COS(KEYANGLE)
45500 YKEY1 = YFINGERTIP - 8*SIN(KEYANGLE)
45550 XKEY2 = XFINGERTIP + 8*COS(KEYANGLE)
45600 YKEY2 = YFINGERTIP + 8*SIN(KEYANGLE)
45650 XKEY3 = XKEY1 + 16*COS(KEYANGLE)
45700 IF VIEWDISTANCE > VIEWDISTUPPER THEN PROBLEM$(6) = "Optimal
viewing distance exceeded to avoid conflict of monitor with keyboard"
45750 YKEY3 = YKEY1
45800 IF XLLC > XKEY3+2.54 THEN GOTO 38250
45850 GOTO 44800
45900 REM --------------------------------------------------
45950 REM INITIAL OUTPUT
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46000 REM --------------------------------------------------
46050 C = 0
46100 FOR X = 1 TO 10
46150 IF PROBLEM$(X) = "" GOTO 46300
46200 C=C+1
46250 LOCATE 9+C,(40-LEN(PROBLEM$(X))/2): PRINT PROBLEM$(X) 46300 NEXT X
46350 GOTO 47300
46400 PRINT"STANDING HEIGHT:  ";BODY(1);"  SEX:  ";SEX$:PRINT:PRINT
46450 PRINT"SITE                      (X,Y)"
46500 PRINT"----                      -----":PRINT
46550 PRINT"KNEE                :  (";XKNEE;",";YKNEE;")"
46600 PRINT"HIP                 :  (";XHIP;",";YHIP;")"
46650 PRINT"SHOULDER            :  (";XSHOULDER;",";YSHOULDER;")"
46700 PRINT"ELBOW               :  (";XELBOW;",";YELBOW;")"
46750 PRINT"FINGERTIP           :  (";XFINGERTIP;",";YFINGERTIP;")"
46800 PRINT"EYES                :  (";XEYES;",";YEYES;")"
46850 PRINT"MEDIAN ROW          :  (";XMEDIANROW;",";YMEDIANROW;")"
46900 PRINT"CENTER MONITOR :  (";XCENTERMONITOR;","YCENTERMONITOR;")"
46950 PRINT
47000 PRINT"SEAT ANGLE          :  ";SEATANGLE*RADTODEG
47050 PRINT"BACK ANGLE          :  ";BACKANGLE*RADTODEG
47100 PRINT"ARM ANGLE           :  ";ARMANGLE*RADTODEG
47150 PRINT"VIEWING ANGLE  :  ";VIEWANGLE*RADTODEG
47200 PRINT"VIEWING DIST.  :  ";VIEWDISTANCE
47250 FOR X=1 TO 10: PRINT PROBLEM$(X); "  ";:NEXT X
47300 LOCATE 9+C+2,20: INPUT "Press [ENTER] to continue: ";GO$
47350 REM ***** Send to display menue after calculation ****
47400 REM *******************************************************
47450 REM                 P R I N T    R O U T I N E S
47500 REM *******************************************************
47550 CLS: COLOR 14,1
47600 COLOR 0,11
47650 LOCATE 4,19: PRINT " +----------------------------------------+ "
47700 LOCATE 5,19: PRINT " |  P R I N T / D I S P L A Y    M E N U  | "
47750 LOCATE 6,19: PRINT " +----------------------------------------+ "
47800 COLOR 14,1: LOCATE 8,23: PRINT "(1) Adjust your monitor for
correct "
47850 LOCATE 9,23: PRINT "          vertical height (Aspect Ratio)"
47900 LOCATE 10,23: PRINT "(2) See results displayed on screen"
47950 LOCATE 11,23: PRINT "(3) Print results (Hard Copy)"
48000 LOCATE 12,23: PRINT "(4) Save results to disk"
48050 LOCATE 14,23: PRINT "(5) Return to Main Menu"
48100 LOCATE 16,23: INPUT "Please enter your selection: ";QUES$
48150 IF QUES$ = "1" OR QUES$ = "2" OR QUES$ = "3" OR QUES$ = "4" OR
QUES$ = "5" GOTO 48350
48200 LOCATE 18,22:COLOR 4,8: PRINT " PLEASE ENTER 1, 2, 3, 4, OR 5 ONLY
": BEEP
48250 LOCATE 16,48: COLOR 14,1: PRINT "                  "
48300 GOTO 48100
48350 CLS: ON VAL(QUES$) GOTO 51650,52800,48600,48400,3200
48400 GSUB$ ="yes"
48450 GOSUB 9600
48500 GSUB$ ="no"
48550 GOTO 47400
48600 IF CALCULATE$ = "yes" GOTO 48900
48650 CLS:COLOR 4,0:LOCATE 10,15:
48700 IF CALCULATE$ = "no" THEN PRINT "WORKSTATION SETTINGS HAVE NOT
BEEN CALCULATED YET.":BEEP
48750 IF CALCULATE$ = "changed" THEN PRINT "WORKSTATION SETTINGS HAVE
NOT BEEN RECALCULATED YET.":BEEP
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48800 LOCATE 12,15: INPUT "PLEASE PRESS [ENTER] TO RETURN TO THE MAIN
MENU: ";G$
48850 COLOR 14,1:CLS:HILITE = 3:GOTO 3200
48900 COLOR 14,1:CLS:COLOR 0,11
48950 ON ERROR GOTO 49050
49000 GOTO 49100
49050 BEEP: RESUME 47400
49100 LOCATE 8,18:PRINT "
"
49150 LOCATE 9,18:PRINT " Your printer MUST be [ON-LINE] at this point.
"
49200 LOCATE 10,18:PRINT " If you attempt to print without your printer
"
49250 LOCATE 11,18:PRINT " selected [ON-LINE], information may be lost.
"
49300 LOCATE 12,18:PRINT "
"
49350 COLOR 14,1
49400 LOCATE 15,23:INPUT "Please press [ENTER] to continue: ";GO$
49450 FOR X=1 TO 3:LPRINT:NEXT X
49500 LPRINT TAB(10) "IntelAd - Computer Workstation Adjustment
Software"
49550 LPRINT TAB(10) "-------------------------------------------------
":FOR X=1 TO 3:LPRINT:NEXT X 49600 LPRINT TAB(10) "Personalized
workstation settings for ";FIRSTNAME$;" ";LASTNAME$;":":LPRINT:LPRINT
49650 LPRINT TAB(10) "Sex..........: ";SEX$
49700 LPRINT TAB(10) "Height........:";:LPRINT USING
"###.#";HEIGHT*CONVFACTOR;:LPRINT " ";UNIT$:LPRINT:LPRINT
49750 LPRINT TAB(10) "* Height of seat base..................:";:LPRINT
USING "###.#";YHIP*CONVFACTOR;:LPRINT " ";UNIT$
49800 LPRINT TAB(10) "* Height of keyboard home row..........:";:LPRINT
USING "###.#";YMEDIANROW*CONVFACTOR;:LPRINT " ";UNIT$
49850 LPRINT TAB(10) "* Height of center of monitor..........:";:LPRINT
USING "###.#";YCENTERMONITOR*CONVFACTOR;:LPRINT " ";UNIT$
49900 LPRINT TAB(10) "* Horizontal distance from"
49950 LPRINT TAB(10) "  seat back to keyboard home row.......:";:LPRINT
USING "###.#";(XMEDIANROW-XHIP)*CONVFACTOR;:LPRINT " ";UNIT$
50000 LPRINT TAB(10) "* Horizontal distance from"
50050 LPRINT TAB(10) "  seat back to center of monitor.......:";:LPRINT
USING "###.#";(XCENTERMONITOR-XHIP)*CONVFACTOR;:LPRINT " ";UNIT$
50100 IF FOOTREST = 0 THEN GOTO 50200
50150 LPRINT TAB(10) "* Footrest height.....................:";:LPRINT
USING "###.#";FOOTREST*CONVFACTOR;:LPRINT " ";UNIT$
50200 LPRINT:LPRINT:LPRINT
50250 LPRINT TAB(10) "Workstation constraints:"
50300 LPRINT
50350 LPRINT TAB(10) "* Seat height adjustment limits......:";:LPRINT
USING "###.#";SEATLOWER*CONVFACTOR;:LPRINT " to ";:LPRINT USING
"###.#";SEATUPPER*CONVFACTOR;:LPRINT " ";UNIT$;
50400 IF SEATLOWER = SEATUPPER THEN LPRINT " (FIXED)" ELSE LPRINT
50450 LPRINT TAB(10) "* Keyboard height adjustment limits..:";:LPRINT
USING "###.#";KEYHEIGHTLOWER*CONVFACTOR;:LPRINT " to ";:LPRINT USING
"###.#";KEYHEIGHTUPPER*CONVFACTOR;:LPRINT " ";UNIT$;
50500 IF KEYHEIGHTLOWER = KEYHEIGHTUPPER THEN LPRINT " (FIXED)" ELSE
LPRINT
50550 LPRINT TAB(10) "* Monitor height adjustment limits...:";:LPRINT
USING "###.#";MONITORLOWER*CONVFACTOR;:LPRINT " to ";:LPRINT USING
"###.#";MONITORUPPER*CONVFACTOR;:LPRINT " ";UNIT$;
50600 IF MONITORLOWER = MONITORUPPER THEN LPRINT " (FIXED)" ELSE LPRINT
50650 LPRINT:LPRINT:LPRINT
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50700 LPRINT TAB(10) "Viewing distance..: ";:LPRINT USING
"##.##";VIEWDISTANCE*CONVFACTOR;:LPRINT " ";UNIT$;"  (Optimal: ";:LPRINT
USING "##.##";VIEWDISTLOWER*CONVFACTOR;:LPRINT " to ";:LPRINT USING
"##.##";VIEWDISTUPPER*CONVFACTOR;
50750 LPRINT " ";UNIT$;")"
50800 LPRINT TAB(10) "Viewing angle.....: ";:LPRINT USING
"##.##";VIEWANGLE*RADTODEG;:LPRINT " deg.  (Optimal: ";:LPRINT USING
"##.##";VIEWANGLELOWER;:LPRINT " to ";:LPRINT USING
"##.##";VIEWANGLEUPPER*RADTODEG;:LPRINT " deg.)"
50850 PROB$ = "no"
50900 FOR X = 1 TO 10
50950 IF PROBLEM$(X) = "empty" THEN GOTO 51100 51000 IF PROBLEM$(X) = ""
THEN GOTO 51100 51050 PROB$ = "yes"
51100 NEXT X
51150 IF PROB$ = "no" GOTO 51600
51200 LPRINT:LPRINT:LPRINT
51250 LPRINT TAB(10) "Notes:":LPRINT
51300 FOR X=1 TO 10
51350 IF PROBLEM$(X) = "" GOTO 51500
51400 IF PROBLEM$(X) = "empty" THEN GOTO 51500
51450 LPRINT TAB(10) PROBLEM$(X)
51500 NEXT X
51550 ON ERROR GOTO 50
51600 GOTO 47400
51650 REM **************** ASPECT RATIO ADJUSTMENT ***************
51700 AR=1/1.25
51750 X=200:Y=100
51800 CLS:SCREEN 9:COLOR 14,1
51850 LINE (X,Y)-(X,(Y+200)*AR)
51900 LINE (X+1,Y)-(X+1,(Y+200)*AR)
51950 LINE (X,(Y+200)*AR)-(X+200,(Y+200)*AR)
52000 LINE (X+200,(Y+200)*AR)-(X+200,Y)
52050 LINE (X+199,(Y+200)*AR)-(X+199,Y)
52100 LINE (X+200,Y)-(X,Y)
52150 LOCATE 11,27:PRINT "   Please adjust the"
52200 LOCATE 12,27:PRINT "vertical height control"
52250 LOCATE 13,27:PRINT " on your monitor until"
52300 LOCATE 14,27: PRINT "   this is a perfect"
52350 LOCATE 15,27: PRINT "        SQUARE."
52400 COLOR 3,8
52450 LOCATE 2,22: PRINT "+-------------------------------+"
52500 LOCATE 3,22: PRINT "| ASPECT RATIO ADJUSTMENT SCREEN |"
52550 LOCATE 4,22: PRINT "+-------------------------------+"
52600 COLOR 14,1
52650 LOCATE 22,26: INPUT "Press ENTER to continue: ",CNT$
52700 CLS: SCREEN 0: COLOR 14,1
52750 GOTO 47550
52800 REM *********************** VIDEO DISPLAY ******************
52850 IF CALCULATE$ = "yes" GOTO 53150 52900 CLS:COLOR 4,0:LOCATE 10,15:
52950 IF CALCULATE$ = "no" THEN PRINT "WORKSTATION SETTINGS HAVE NOT
BEEN CALCULATED YET.":BEEP
53000 IF CALCULATE$ = "changed" THEN PRINT "WORKSTATION SETTINGS HAVE
NOT BEEN RECALCULATED YET.":BEEP
53050 LOCATE 12,15: INPUT "PLEASE PRESS [ENTER] TO RETURN TO THE MAIN
MENU: ";G$
53100 COLOR 14,1:CLS:HILITE = 3:GOTO 3200
53150 CLS: SCREEN 9: COLOR 11,56
53200 X(1) = XTOE: Y(1) = YTOE
53250 X(2) = XANKLE: Y(2) = YANKLE
53300 X(3) = XKNEE: Y(3) = YKNEE
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53350 X(4) = XHIP: Y(4) = YHIP
53400 X(5) = XSHOULDER: Y(5) = YSHOULDER
53450 X(6) = XELBOW: Y(6) = YELBOW
53500 X(7) = XWRIST: Y(7) = YWRIST
53550 X(8) = XFINGERTIP: Y(8) = YFINGERTIP
53600 X(9) = XEYES: Y(9) = YEYES
53650 X(10) = XMEDIANROW: Y(10) = YMEDIANROW
53700 X(11) = XCENTERMONITOR: Y(11)= YCENTERMONITOR
53750 X(12) = XTOPOFHEAD: Y(12) = YTOPOFHEAD
53800 X(13) = XCHIN: Y(13) = YCHIN
53850 X(0) = 250:Y(0) = 350
53900 AR=1/1.25
53950 REM **************** DRAW STICK FIGURE ********************
54000 FOR A = 1 TO 7
54050 LINE (X(0)+X(A),(Y(0)-Y(A))*AR)-(X(0)+X(A+1),(Y(0)-Y(A+1))*AR)
54100 NEXT A
54150 LINE (X(0)+X(5),(Y(0)-Y(5))*AR)-(X(0)+X(13),(Y(0)-Y(13))*AR)
54200 FOR A = 1 TO 6
54250 CIRCLE (X(0)+X(A+1),(Y(0)-Y(A+1))*AR),1.5
54300 NEXT A
54350 CIRCLE (X(0)+X(9),(Y(0)-Y(9))*AR),1
54400 MIDDLEOFHEAD=Y(13)+(Y(12)-Y(13))/2
54450 CIRCLE (X(0)+X(5),(Y(0)-MIDDLEOFHEAD)*AR),MIDDLEOFHEAD-Y(13)
54500 LINE (X(0)-50,(Y(0)+3)*AR)-(X(0)+150,(Y(0)+3)*AR): REM  FLOOR
54550 REM ********************* DRAW CHAIR **********************
54600 COLOR 13,56
54650 LINE (X(0)+X(4)-4,(Y(0)-Y(4)+3)*AR)-(X(0)+40,(Y(0)-Y(4)+3)*AR):
REM SEAT
54700 REM  (X(0)+X(4)-4,(Y(0)-Y(4)+2)*AR)-(X(0)+40,(Y(0)-Y(4)+2)*AR):
REM SEAT
54750 LINE (X(0)+X(4)-4,(Y(0)-Y(4)+3)*AR)-(X(0)+X(4)-4,(Y(0)-Y(4)-
40)*AR): 'BACK
54800 REM  (X(0)+X(4)-5,(Y(0)-Y(4)+3)*AR)-(X(0)+X(4)-5,(Y(0)-Y(4)-
40)*AR): 'BACK
54850 LINE (X(0)+(40-(X(4)-4))/2,(Y(0)-Y(4)+3)*AR)-(X(0)+(40-(X(4)-
4))/2,Y(0)*AR)
54900 LINE (X(0)+(40-(X(4)-4))/2+15,(Y(0))*AR)-(X(0)-15+(40-(X(4)-
4))/2,(Y(0))*AR)
54950 REM ************************ DRAW MONITOR *******************
55000 COLOR 14,56
55050 LINE (X(0)+XULC,(Y(0)-YULC)*AR)-(X(0)+XURC,(Y(0)-YURC)*AR)
55100 LINE (X(0)+XURC,(Y(0)-YURC)*AR)-(X(0)+XLRC,(Y(0)-YLRC)*AR)
55150 LINE (X(0)+XLRC,(Y(0)-YLRC)*AR)-(X(0)+XLLC,(Y(0)-YLLC)*AR)
55200 LINE (X(0)+XLLC,(Y(0)-YLLC)*AR)-(X(0)+XULC,(Y(0)-YULC)*AR)
55250 REM ******************** DRAW KEY BOARD ********************
55300 LINE (X(0)+XKEY1,(Y(0)-YKEY1)*AR)-(X(0)+XKEY2,(Y(0)-YKEY2)*AR)
55350 LINE (X(0)+XKEY2,(Y(0)-YKEY2)*AR)-(X(0)+XKEY3,(Y(0)-YKEY3)*AR)
55400 LINE (X(0)+XKEY3,(Y(0)-YKEY3)*AR)-(X(0)+XKEY1,(Y(0)-YKEY1)*AR)
55450 REM ****************** DRAW TABLE ***************************
55500 COLOR 13,56
55550 IF YLRC > YKEY3 THEN GOTO 55850
55600 LINE (X(0)+XKEY1,(Y(0)-YKEY1+2)*AR)-(X(0)+XKEY3,(Y(0)-YKEY3+2)*AR)
55650 LINE (X(0)+XKEY3,(Y(0)-YKEY3+2)*AR)-(X(0)+XKEY3,(Y(0)*AR))
55700 LINE (X(0)+XKEY3,(Y(0)-YLRC+2)*AR)-(X(0)+XURC+5,(Y(0)-YLRC+2)*AR)
55750 LINE (X(0)+XURC+5,(Y(0)-YLRC+2)*AR)-(X(0)+XURC+5,(Y(0)*AR))
55800 GOTO 56000
55850 LINE (X(0)+XKEY1,(Y(0)-YKEY1+2)*AR)-(X(0)+XURC+5,(Y(0)-
YKEY1+2)*AR)
55900 LINE (X(0)+XURC+5,(Y(0)-YKEY1+2)*AR)-(X(0)+XURC+5,Y(0)*AR)
55950 LINE (X(0)+XKEY1+.25*(XURC+5-XKEY1),(Y(0)-YKEY1+2)*AR)-
```

```
(X(0)+XKEY1+.25*(XURC+5-XKEY1),Y(0)*AR)
56000 REM ***************** DRAW MONITOR STAND *******************
56050 IF YLRC > YKEY3 THEN GOTO 56250
56100 LINE (X(0)+XLLC,(Y(0)-YLLC)*AR)-(X(0)+XLLC,(Y(0)-YLRC)*AR)
56150 LINE(X(0)+XLLC,(Y(0)-YLRC)*AR)-(X(0)+XLRC,(Y(0)-YLRC)*AR)
56200 GOTO 56400
56250 LINE (X(0)+XLLC,(Y(0)-YLLC)*AR)-(X(0)+XLLC,(Y(0)-YKEY1)*AR)
56300 LINE (X(0)+XLRC,(Y(0)-YLRC)*AR)-(X(0)+XLRC,(Y(0)-YKEY1)*AR)
56350 LINE (X(0)+XLLC,(Y(0)-YLRC)*AR)-(X(0)+XLRC,(Y(0)-YLRC)*AR)
56400 IF FOOTREST = 0 THEN GOTO 56600
56450 LINE (X(0)+X(1),(Y(0)-Y(1)+2)*AR)-(X(0)+X(1),(Y(0)*AR))
56500 LINE (X(0)+X(1),(Y(0)-Y(1)+2)*AR)-(X(0)+X(2),(Y(0)-Y(1)+2)*AR)
56550 LINE (X(0)+X(2),(Y(0)-Y(1)+2)*AR)-(X(0)+X(2),(Y(0)*AR))
56600 COLOR 14,56
56650 LOCATE 2,2: PRINT FIRSTNAME$;" ";LASTNAME$
56700 LOCATE 3,2:PRINT "* ";:PRINT USING
"###.#";HEIGHT*CONVFACTOR;:PRINT" ";UNIT$;" tall ";SEX$;"."
56750 LOCATE 2,35:PRINT "* Height of seat base: ":LOCATE 2,70:PRINT
USING "###.#";YHIP*CONVFACTOR;:PRINT " ";UNIT$
56800 LOCATE 3,35:PRINT "* Height of keyboard home row: ":LOCATE
3,70:PRINT USING "###.#";YMEDIANROW*CONVFACTOR;:PRINT " ";UNIT$
56850 LOCATE 4,35:PRINT "* Height of center of monitor: ":LOCATE
4,70:PRINT USING "###.#";YCENTERMONITOR*CONVFACTOR;:PRINT " ";UNIT$
56900 LOCATE 5,35:PRINT "* Horizontal distance from"
56950 LOCATE 6,35:PRINT "  seat back to keyboard home row: ":LOCATE
6,70:PRINT USING "###.#";(XMEDIANROW-XHIP)*CONVFACTOR;:PRINT " ";UNIT$
57000 LOCATE 7,35:PRINT "* Horizontal distance from"
57050 LOCATE 8,35:PRINT "  seat back to center of monitor: ":LOCATE
8,70:PRINT USING "###.#";(XCENTERMONITOR-XHIP)*CONVFACTOR;:PRINT "
";UNIT$
57100 IF FOOTREST = 0 GOTO 57200
57150 LOCATE 9,35:PRINT "* Footrest height: ":LOCATE 9,70:PRINT USING
"###.#";FOOTREST*CONVFACTOR;:PRINT " ";UNIT$
57200 LOCATE 24,25: INPUT "Press ENTER to continue ";CNT$
57250 CLS: SCREEN 0: COLOR 14,1: GOTO 47550
```

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