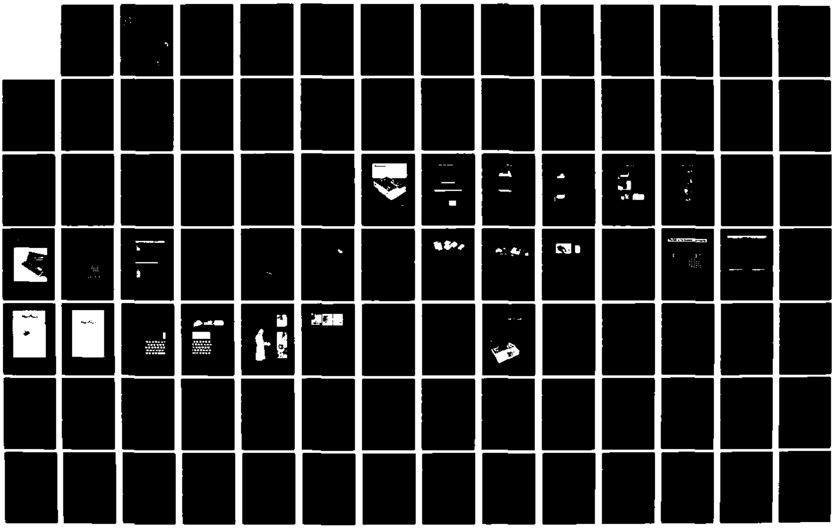
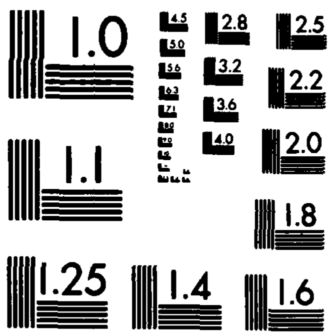
AD-A120 973 AN EVALUATION OF THE FEASIBILITY OF USING HAND-HELD COMPUTERS FOR TRAINING(U) BATTELLE COLUMBUS LABS OH L D FRANCIS ET AL. 30 MAY 82 TDI-TR-82-2 1/1

UNCLASSIFIED DAAG29-81-D-0100 F/G 5/9 NL





MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

REPORT TDI-TR-82-2

AN EVALUATION OF THE FEASIBILITY OF USING HAND HELD COMPUTERS FOR TRAINING

FINAL REPORT

BY: LARRY D. FRANCIS, Ph.D.
GIRARD W. LEVY, Ph.D.

30 MAY 1982

Approved for public release:
Distribution unlimited

PREPARED FOR: *US Army Training and Doctrine Command*
Fort Monroe, VA 23651

ADDERE FLAMMAM

NOTICES

This report has been reviewed and is approved.

Frank E Giunti

FRANK E. GIUNTI
Chief, Instructuinal
Development Division

F. A. NERONE
Colonel, Infantry
Director, Training Developments
Institute

DISCLAIMER

The contents of this report are not to be construed as an official Department of the Army position unless so designated by other authorized documents.

DISPOSITION

Destroy this report when it is no longer needed. Do not return it to the originator.

Accession For
NTIS GRA&I ☑
DTIC TAB ☐
Unannounced ☐
Justification

By
Distribution/
Availability Codes

Dist	Avail and/or Special
A	

SECURITY CLASSIFICATION OF THIS PAGE (*When Data Entered*)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER TDI-TR-82-2	2. GOVT ACCESSION NO. AD-A120973	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (*and Subtitle*) An Evaluation of the Feasibility of Using Hand-Held Computers for Training		5. TYPE OF REPORT & PERIOD COVERED Special Report November 81-April 1982
		6. PERFORMING ORG. REPORT NUMBER TDI-TR-82-2
7. AUTHOR(s) Larry D. Francis Girard W. Levy		8. CONTRACT OR GRANT NUMBER(s) Battelle Columbus Laboratories Delivery Order No. 0102
9. PERFORMING ORGANIZATION NAME AND ADDRESS Battelle Memorial Institute Columbus Laboratories 500 King Avenue Columbus, Ohio 43201		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS Scientific Services Program
11. CONTROLLING OFFICE NAME AND ADDRESS Director US Army Training Developments Institute ATTN: ATTG-DID Ft. Monroe, VA 23651		12. REPORT DATE 30 May 1982
		13. NUMBER OF PAGES
14. MONITORING AGENCY NAME & ADDRESS (*if different from Controlling Office*) Commander US Army Ordnance Center & School ATTN: ATSL-TD Aberdeen Proving Ground, MD 21005		15. SECURITY CLASS. (*of this report*) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (*of this Report*)

Approved for Public Release: Distribution Unlimited

17. DISTRIBUTION STATEMENT (*of the abstract entered in Block 20, if different from Report*)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (*Continue on reverse side if necessary and identify by block number*)

20. ABSTRACT (*Continue on reverse side if necessary and identify by block number*)

In 1981 a training research team was contracted to conduct a two task survey to determine the potential of utilizing the Hand-Held Computer for training purposes as a job training aid in the school environment. The purpose of Task 1 was to survey the relatively new market of available HHC and assess their capability to serve as a generic delivery system for training purpose. Task II of the study was to survey selected Army MOS and report specific training segments which could be more effectively taught using the HHC.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (*When Data Entered*)

PREFACE

This report contains the results of the survey of the HHC market and the MOS survey report conducted at the Ordnance School, Aberdeen Proving Ground, Maryland.

The work was performed by Larry D. Francis and Girard W. Levy of Battelle Memorial Institute Columbus Laboratories. The work was performed under a Scientific Services Agreement administered through Battelle Columbus Laboritories, Durham Operations, Research Triangle Park, North Carolina, for the US Army Training and Doctrine Command (TRADOC). Marianne Weirich, US Army Training Developments Institute, Fort Monroe, Virginia, was the Contracting Officer's Technical Representative.

The sponsor of the work was the Ordnance School, USAOC&S, Aberdeen Proving Ground, Maryland. Mr. Jim Dees served as Ordnance School point of contact.

The outcome of Phase I of this project is presented in two reports. The first report describes the available HHC and their training application. The second report details possible course application and makes recommendations concerning specific HHC for each application. The follow-on test evaluation will be based on the findings of these two reports.

FINAL REPORT

on

TASK I

AN EVALUATION OF THE FEASIBILITY OF USING HAND-HELD COMPUTERS FOR TRAINING

to

U.S. ARMY TRAINING DEVELOPMENTS INSTITUTE

January, 1982

by

Larry D. Francis
and
Girard W. Levy

The views, opinions, and/or findings contained in this report are those of the authors and should not be construed as an official Department of the Army position, policy, or decision, unless so designated by other documentation.

BATTELLE
Columbus Laboratories
505 King Avenue
Columbus, Ohio 43201

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

INTRODUCTION

Background

Hand-held calculators, a product of technology only about a decade old, have now become standard fixtures in many classroom and field situations. This is especially true in certain disciplines such as engineering, navigation, etc., where extensive calculations need to be performed with a mobile unit. More recently at Ft. Sill, Oklahoma, it was found that a large fraction of the calculations performed by the FADAC Fire Control unit could be programmed into a Texas Instruments TI-59 programmable calculator.

During 1981 several manufacturers marketed or announced they would market hand-held computers. These devices have as much or more power than some existing microcomputers, yet retain the size and portability advantages of the hand-held calculators. This study was undertaken to examine the potential of these new, more powerful devices.

Purpose

The purpose of Task I of this study was to survey available hand-held computers (HHCs) and compare their capability to serve as a generic delivery system for training purposes. Task II of the study will survey selected Army courses taught at the U.S. Army Ordnance Center and School (USAOC&S), and suggest specific areas which could be more effectively taught using HHCs. This HHC study is focused on the "mainframe" of the HHC rather than on the peripherals. The guideline for the study was that the machines of greatest interest were those that would function without additional components, peripherals, wires, and connections when the actual training use was taking place, although additional components and connections for transferring programs and data were expected.

Device Definitions

The distinction between a calculator, a hand-held computer, and a microcomputer is not clear. Theoretically, to be a computer by the von Neuman definition, the device's memory must be capable of being divided dynamically into either program or data storage. That is, the device cannot have a fixed partition which limits the number of variables to a certain number and reserves the rest of the memory for programming. This fixed partitioning is evidenced by machines at the "calculator" end of the spectrum; they frequently specify the number of "program steps" permitted. Some devices also have a fixed area for variables, but "excess" variables needed may spill over to the program storage area; according to the von Neuman definition, these just qualify as a computer.

Other views of the calculator vs. computer distinction argue that calculators do all calculations in floating point arithmetic, handle no alphanumeric string processing, and have no alphabetic display capabilities. All of these definitions tend to clarify the typical characteristics of these machines, but this study nevertheless made some examination of even those machines that fall into the "powerful calculator" classifications by most definitions.

Distinguishing an HHC from a microcomputer on the basis of computing power is difficult because the Apple and PET computers use the same microprocessor that the Quasar/Panasonic HHC uses. A fundamental difference, however, is the display requirements and capabilities. Microcomputers require ac line current to power their relatively large cathode ray tube (CRT) displays. HHCs have small displays and use only battery power.

Scope

This study examined the uses of the Hand Held Computer (HHC) as a job aid in an enlisted MOS and officer speciality resident training environment. Potential unit training was a consideration that was also addressed. Because resident training was the main thrust of this study, those applications which were non-training related were de-emphasized. Care was taken to avoid developing a reliance on the HHC that would handicap the student when he was in the unit at his job site.

DISCUSSION

Conduct of the Study

The statement of work for this task included a list of questions to be asked about each HHC. After doing some preliminary reading and trying out several HHCs, Battelle expanded the list of questions; the final list of HHC features is found in Appendix A.

To fill in the "features" table, Battelle performed a literature search to identify manufacturers and machines, and obtain partial and preliminary data. To obtain specific information, Battelle contacted the information sources noted in Appendix C in person, by telephone, by mail and via electronic mail. Sample issues of newsletters were obtained, discussions on electronic networks (PLATO) were initiated, and HHCs were borrowed and programmed. A number of Battelle experts were also consulted.

Devices Noted

This investigation found quite a number of devices which were candidates for initial study. Upon examination many were found not to warrant further study because they fell outside the guidelines and definitions presented above or because they had inadequate resources to be useful. A summary of all devices noted and their reason for rejection from further investigation (in some cases) is presented below.

Panasonic RL-H 1000 & 1400/Quasar. These two machines are identical, but are being marketed differently by the two organizations. This HHC is the "cream-of-the-crop" from nearly every point of view. It is accompanied by a relatively vast assortment of peripherals, but little software at this time. The superiority of this HHC is based on a fast microprocessor connected to large amounts of RAM and ROM storage (see Appendix D). The modular construction makes a wide number of applications possible; this broad market should insure a relatively long life for the hardware and a large user group from whom software might be acquired. Panasonic plans to market only to large buyers who will need custom-designed software; Quasar will concentrate on the retail and will encourage and probably help market software written by many independent vendors.

Sharp PC 1211/Radio Shack TRS-80PC. These are dually-marketed, essentially identical machines with parallels to the Panasonic/Quasar pair. Sharp is selling only hardware; Radio Shack is retailing with relatively heavy software support. This device is much more limited in capacity, speed, and peripherals compared to the Panasonic/Quasar HHC (see Appendix E). It is not expandable, but as a calculator, it has more built-in features (trig functions, calculator memory locations, etc.) than the Panasonic/Quasar. Sharp is designing a successor to this model; no improvements or additional peripherals will be developed for the current model. Of all the devices examined, this was the most compact.

Hewlett-Packard HP-41C(V). For a device that looks like a calculator, this machine includes a comparatively large memory and numerous peripherals. Having been on the market for a while, there is a selection of programmed application ROMs, a user's library, and a newsletter. Though marketed as a calculator, internally this device resembles a computer more than does the Sharp/Radio Shack machine. The 41-CV is a 41C with more memory (see Appendix F).

Texas Instruments TI-59. The TI-59 is somewhat like the HP-41C in terms of age and abundance of supporting software and use experience, but lacks alpha capabilities.

Pinetree 2002. The Pinetree device is designed more as an intelligent hand-held data terminal than as a calculator or a computer. In contrast to all the devices noted above which have a few optional peripherals built around them, the Pinetree is designed to be used in connection with a central data receiver. Although the hand-held unit might function similarly to the other devices discussed, no other machine is integrated so thoroughly with a centralized receiver/transmitter.

Casio FX-702P. This device has the appearance of a Panasonic/Quasar and the most comprehensive BASIC language of any HHC, but is generally programmed with function keys rather than alpha commands. It resembles a programmable calculator that handles alphanumerics (see Appendix G).

Transterm 1. Though this device has a much larger display than usual (64 5x7 characters), there is no available storage in the 128 byte ROM which could be used for training. The firm said they have plans for expanding the memory to 5-6K in the future; for now the device is only a data terminal. It was not investigated further.

Sinclair ZX81. This new microcomputer is the least expensive ($150) microcomputer available. It requires ac power for the TV monitor; a battery-powered TV could be used, but would hardly make the device pocket sized. In the future, a tiny flat TV screen to be marketed by Sinclair (discussed later) could make a convenient hand-held device, but no spokesperson at Sinclair would give details about forthcoming products. Accordingly, this device was not investigated further.

Newbury New Brain MDB. This is a large device with a full-sized keyboard. It has many capabilities, but is well over pocket-sized (see Appendix H) and has a short battery life.

Nixdorf. Popular press reports that Nixdorf is producing hand-held computers are apprently based on conjecture that because Nixdorf produced a hand-held language translator with Friends Amis (who are producing software for Panasonic/Quasar), they would also follow with a computer. No further investigation was made.

Table of Features

Appendix A presents the important features of the various calculators and HHCs which were investigated further. In several cases, Battelle did not feel confident that the answers supplied were accurate; in other cases, vendors promised to search for the answers to questions, but those answers have not yet been received. In both cases, a blank spot has been left pending further information. The most regularly missing data are those related to ruggedness and environmental requirements. Those measurements have not, in general, been made, and when made, are considered proprietary.

The following subsections discuss aspects of the six more-thoroughly investigated devices which are not adequately portrayed by the table data. The data reported in the table are focused more strongly on features of interest to the user and less strongly on features helpful to a programmer.

Panasonic/Quasar Overview

Even if this HHC did not have such a powerful processor or if it required ac power to operate, the Panasonic/Quasar would be worth mentioning as a valuable new microcomputer. This rather significant assertion is based upon the excellent man-machine interface design and the well-prompted software in this HHC. For example, when first turned on, a menu of available options is presented, one item at a time labeled with the key to access the option. If application or language ROMs have been attached anywhere in the system, they automatically appear in the menu. Selection of an option gives further similar sub-menus until the program or function desired has been reached. Hitting the CLEAR key moves one up the menu one level. When Battelle staff showed this device to people unfamiliar with this HHC, they could immediately figure out how to use the menu features with no instructions. The speed with which menu items are changed is controllable by the user at 10 speeds. A HELP key explains the purpose of any key.

Because of the large array of peripherals, Panasonic/Quasar provides three sizes of "trays" which make the HHC package rigid. The largest tray holds six peripherals and is 12"x17". This is really larger than "handheld" or "pocket sized", but many of the peripherals important for this study would add only 4" to the length of the HHC mainframe. These peripherals include extra RAM, the printer, or the RS-232C port. Any of these devices can be attached easily and tightly to the HHC mainframe and be supported by a plastic "tray". If the 44-pin connector is not properly seated, the HHC beeps. All connects and disconnects can be made with the power on.

Another example of the excellent engineering is the battery system. When batteries run low, a message appears. The device can continue to be used, but each keystroke causes a protesting beep (though the keys are processed). If use is continued, the machine will finally shut itself down to retain its memory. If the NiCd batteries have worn out and need to be replaced, capacitors maintain voltage levels for a time while the change is made. The RAM peripherals have batteries to keep their memory from becoming volatile: the batteries are not used for power, but only to maintain a voltage. Thus, instead of putting a low battery indicator on the external RAM, a label is used to indicate when the shelf life of the battery will expire. The capacitors protecting this memory are sufficient that Dennis Reer of Panasonic could connect and disconnect the RAM without losing the memory contents even though the RAM lacked the usual batteries. This is not a recommended procedure; however, it does demonstrate how forgiving the system is. No other device had such a carefully designed power/battery protection system.

Many of the most powerful features of this HHC are available only using the SNAP language (a compact, threaded language). This is normally written on an Apple computer and downloaded. Within the constraints of this study, a detailed examination of SNAP's capabilities was not possible; however, the following items were determined. Using SNAP a programmer can selectively turn on/off any of the 159x8 LCD matrix points effectively creating crude graphics, iconic representations, or special alphabets. This was the only HHC that could do this on its display. In this mode the LCD can be split-screened and can have animation. Dennis Reer reported that a demonstration of these features had been given at the press release meeting, but the demonstration was not available for the Battelle visit.

One important peripheral change from the January 1981 Byte Magazine announcement of this product is the replacement of the cassette tape recorder with a tiny 5.25" floppy disk (not yet available). This change was made to improve speed and reliability.

Software expertise from Friends Amis, Inc., has provided some clever text storage compression advantages, claimed to be a savings of nearly 50%. Many features such as the modified Huffman coding, the Mapping Algorithm, and alphabetized list techniques (all described in the January 1981 Byte article) could save considerably in the preparation of certain drill-and-practice or information retrieval tasks; however, proprietary programming licenses from Friends Amis would be needed.

Based on addressing limitations, the maximum RAM or ROM possible is 4 Megabytes. More practically, however, the current I/O bus expander has only six ports. Each RAM peripheral will add 8K (16K in 1982) and each ROM peripheral will add up to 64K (four interchangeable modules of 16K).

Because this device has a RS-232C serial interface, it can easily be connected to non-HHC peripherals or other computers. Data rates vary from 50-9600 baud in 11 steps. For remote use an acoustic coupler at 110 or 300 baud is available.

Despite the fact that the keyboard is as good or better than other HHCs which were studied, few programmers would want to enter large amounts of programming or data via the keyboard. It is more appropriate to develop and debug programming on a large computer, then download it to this HHC for delivery. Additional flexibility may be forthcoming: a Wall Street Journal article reported ROMs for COBOL, PASCAL, and FORTRAN were being planned. With minor difficulty one can touch type, but for most training uses, this does not seem important. The only keyboard feature the Battelle study found problematic was that deletion of lines of code was too easy: the "delete" function should require two keys. Again, this is not a problem for students.

The BASIC language available (8K) has fairly powerful string manipulation capabilities, but many commonly found features (for example, trignometric functions) must be supplied by the user, if needed.

If one were teaching topics that required strictly numerical inputs and calculations, the BASIC available on other machines would be more desirable. The BASIC provided seems appropriate, however, given the other alpha capabilities.

Summary. Overall the Quasar/Panasonic HHC is the top of the line among the HHCs investigated. Its price is higher, but the performance, peripherals available, thoughtful design, and flexibility give this device the widest range of potential uses of any of the HHCs. One can imagine that student data could be stored in an internal RAM, the HHC could periodically be connected to an external RAM to have its student data dumped. The instructor could use his HHC to sort and print the data from the external RAM and then use a modem to send it to a large central computer. Alternatively, if desired, a student external RAM could collect large amounts of data and the RAMs could be collected from time to time so that their contents could be transmitted elsewhere. In either case a central computer could download software based on the student performance: new topics, remediation, or enrichment material.

Radio Shack/Sharp Overview

The Radio Shack/Sharp HHC is unique in that it utilizes two microprocessors. Also in contrast to most of the other HHCs, it is not expandable via application modules or memory extendors. All preprogrammed material must be entered via the cassette.

For a HHC with a full QWERTY keyboard, this device is very lightweight and thin. Its display consists of character areas, not a continuous matrix; graphics and special characters cannot be made. Like the Panasonic/Quasar, this HHC will store a BASIC programming statement that is 80 characters long, even though the number of characters that can be viewed in the display is only about one-third that many. The version of BASIC is fairly complete for arithmetic calculations, but it has no powerful string parsing commands. The size of BASIC program that can be stored is confusing: the figures of 30-40 lines and 250 lines of BASIC have been printed and quoted for both the Sharp and Radio Shack version. In either case the device suffers from low RAM storage capacity and lack of interchangeable ROM capability. When the low battery indicator appears, all programming and data need to be moved to the cassette because the batteries are not rechargeable, no ac adaptor is available, and no capacitors protect memory during battery changing.

A tray holds the printer and HHC firmly together so that they could be used as a single hand-held unit (total size 1-1/2" x 11-1/8" x 3-3/4"). Radio Shack is selling and developing software for this device. Very few of the announced titles appear useful to the Army.

Summary. This is a low cost, low performance device. If one didn't need an alpha keyboard and BASIC, the TI-59 or HP-41C would probably be preferred for speed, storage capacity, and interchangeable ROMs. If these trade-offs cannot be made, the Radio Shack/Sharp is the cheapest HHC available. Sharp representatives indicated they didn't expect to add accessories to their device, but rather are working on a new, more powerful HHC.

Pinetree

This HHC is unlike any of the other devices investigated for this study. It is sold as standard product, but is customized; it is assembled by a small U.S. organization, not a multi-national; and, most importantly, it is designed to be regularly connected to a central receiver/transmitter (as a data terminal might be) rather than being essentially a free-standing unit. It closely resembles a data terminal, and was probably designed as one, but it may have potential for Army training applications.

Though its keys are few (16), two keystrokes per letter provide alpha input, and three sockets for 8K RAM or ROM potentially provide room for some training programs. An unusual feature (for an HHC) is the built-in telephone modem that also lets two 2002s communicate with each other. When normal speed transmission (300 baud) causes errors, the unit automatically slips to 100 baud. The receiver can communicate with four 2002s simultaneously. It has built-in intelligence, but is designed to be connected to a computer (at up to 9600 baud).

Summary. This device clearly has some strong limitations and cannot have broad applications, but its unusual architecture suggests that there may be applications where its communications capabilities can be used to advantage. However terminals with less cumbersome input should be found if this type of device is found useful.

HP-41C(V)

This HHC looks like a calculator on the outside, and like a computer on the inside. For example, it has a full alphabet, but not in QWERTY layout. It is programmed in Reverse Polish Notation (RPN) logic, not a language. It has keys for many functions, but these functions can also be spelled. Inside it can do moderate string manipulation and can even print user-designated characters on its printer. The peripherals available include a printer, magnetic card reader/writer, and a wand for reading bar codes. Four ports let the user connect ROM, RAM, or peripherals. Since earlier calculator's magnetic cards are compatible, a large library of routines and a considerable user group is available. Unfortunately, the magnetic cards are comparatively fragile for field use; the bar code reader provides a reasonable input device, however.

Summary. The reported speed and storage capacity of this device make it a strong competitor against the Sharp/Radio Shack. Input (other than the HP ROMs) is slow for either machine, but the two big "advantages" of the Sharp/ Radio Shack (the BASIC language and a QWERTY keyboard) are not of particular advantage for the Army training need.

TI-59

The TI-59 might not have been included had not the Fort Sill experience with hand-held devices used it. The TI-59 is much more clearly at the calculator end of the spectrum. It has limited alpha capability, no programming language, and a single and small display. As a programmable calculator it is fast, efficient, and (with overlays) simple to use.

Summary. For a task that requires no prompting, short usage periods (3-hour battery life), and high numerical accuracy, the TI is very appropriate.

Casio FX-702P

Casio makes two HHCs which might be considered for inclusion in this study: the FX-602P and FX-702P. Despite the similarity in designations, the devices are quite different. The 702 is formatted horizontally like the Panasonic or Sharp, and the 602 is formatted vertically like the HP or TI. The 702 seems like the device with the most potential for Army training. Unfortunately Casio maintains only sales and repair staff in the U.S. and available information is limited.

The important features of the 702, as gleaned from the September 16, 1981 EDN magazine are: a 65-key ABCDE format keyboard, the greatest math power of any of the HHCs listed, an extra-powerful and compact BASIC, interchangeable ROMs, single-use Li batteries, and a $200 list price.

Summary. Its limited peripherals and non-expandable memory are its chief limitations compared to the HP-41C. On the surface this device seems to compete most directly with the HP-41C.

HHC-Related Devices

Because HHCs are still relatively new, there are many devices that might be expected to be used as peripherals for them in the near future. This section looks at new technologies which would expand the use of the present HHC for Army training purposes.

Sinclair Microvision Flat TV. The lack of graphics is a considerable constraint on myriad teaching applications. Printer graphics are sometimes helpful, but cannot be animated. Even though a battery-powered TV could be connected to the Panasonic/Quasar (or could make the Sinclair ZX81 a more viable portable computer), few if any hand-held TVs have the proper size and configuration to make a device one could call hand-held. However, Appendix I shows an inexpensive flatscreen TV which is a possible entrant for this role.

Data Terminals. Though not investigated in this study, there may be uses for low-cost, handheld data terminals in Army training. These devices simply hold the user input until "dumped" at some central site. Often used industrially for inventory control, these could potentially be used for student management tasks of some kind.

Smart Cards. Smart cards are microprocessors and storage which are embedded in a credit card-sized piece of plastic. They can store and process data when inserted into a reader. The familiarity and durability of this type of packaging suggests it as an alternative to plug-in modules of RAM for the purposes of transferring data.

Voice Output. Voice synthesis would allow soldiers working at night and without light to use HHCs, it would free the user from watching the display while performing some action or making an observation, and would compensate to some extent for the small display space available on HHCs. The high density storage techniques developed by Friends Amis could be adapted to feed a phoneme generator like the Votrax. Panasonic spokesman Reer noted that Panasonic was marketing talking calculators and microwave ovens; though no HHC synthesizer was currently being readied for marketing, any customer needing a synthesizer could expect quick development on such a device.

Potential Applications

Appendix B presents a discussion of potential applications for HHCs. It is very preliminary and the examples will be expanded as part of Task II of this study. The examples were devised by examining the capabilities of existing HHCs and imagining how they could be used for training. An array of needs was examined: both "types of computer tasks":

- direct instruction (CAI)
- training management (CMI)
- job aid or tool uses

and "types and sites of training":

- MOS
  - classroom
  - field
- basic
- officer
- exported
- self-training.

After discarding uses where another medium was more cost-effective (for example, flash cards) and cases where HHC held no advantage (for example, when portability adds nothing), Battelle estimated the computer resources needed. The survivors of that selection process are found in Appendix B.

Findings

The overall conclusion is that there are HHCs available that have the capabilities to perform important training tasks. All of the commercially available HHCs have extra features (e.g., perpetual calendar, programming keys, etc.) that may not be needed for training applications. Although additional memory and peripherals would enhance any existing HHC, several of the current devices could handle a reasonable subset of the training applications identified. As stated previously, the Panasonic/Quasar is clearly the most versatile, powerful HHC.

Until the training applications are more fully defined and compared with the capabilities of the various available devices, firm conclusions about the most appropriate and cost-effective HHC cannot be made. However, for the conduct of a test and evaluation to determine the feasibility of using HHCs for training, it is not advisable to buy the minimum capacity or lowest cost device, since only a limited number of devices will be procured. It may turn out that additional features are required for some unforeseen reason. Therefore, it is recommended that a single type of HHC with maximum capability (or two qualitatively different HHCs with high capabilities) be selected for use in feasibility studies.

General Issues

Three important issues surfaced as the data collection process was taking place. First, few manufacturers have considered field conditions other than an office in designing and testing their HHC. Environmental and ruggedness data, when known, are typically proprietary. This area of the study was consistently lacking in data and will require Army field testing and evaluation of various resident training and unit applications for this type of data to be collected.

Second, the data gathered are imperfect for measuring, except in a crude way, the differences between storage capacity, speed of execution, and ease of use. For example, some HHCs used elaborate encoding to save space or increase speed. (For example, the Panasonic/Quasar uses the same processor as an APPLE, but is reportedly faster.) Furthermore, the calculator-like devices counted storage in terms of steps and registers, not bytes. Finding an equivalence between these measures is not a mathematical calculation. The only true measure of storage, speed, and ease of use (as a programmer or a student) would be to write several programs of several types and benchmark the devices of interest against these tasks.

The third issue concerns storage in RAM versus ROM. Some HHCs use only RAM for application programs. RAM is often physically larger and more expensive than ROM; in other ways RAM can do anything ROM can do. Because RAM can be erased and written by the user (or his program), it is more flexible. This means, however, that (in contrast to ROM) it can be accidentally or deliberately erased. RAM is particularly important to have in large quantities for uses which involve large quantities of data or user-written programs. However, the only obvious cases where substantial amounts of RAM are needed for training purposes are those involving computer managed instruction (CMI) or "tailored" programs which would be selected for individual students, specially defined and assembled by a central computer, and hooked into student's HHCs. For disseminating more typical programs, it would be easier, possibly cheaper, and more reliable (with respect to erasure) to store application programs in ROM and distribute the "standard" ROM or a HHC with the appropriate ROM already in place.

General Problems

During the conduct of this study, Battelle was reminded of several problems that can be expected to occur in the programming and use of HHCs.

Pilferage. The value-to-volume ratio of HHCs makes them an ideal target. In addition to the normal control mechanisms used to avoid theft problems, it is desirable to build into the system as many safeguards and obstacles as possible. Dennis Reer of Panasonic had the most innovative suggestions -- some of which apply to other devices as well. He suggested that the value of the device would be much lower if user-supplied ROMs were not easily inserted. Therefore, he said Panasonic could manufacture an HHC with a solid back. The street value for a device that had to be dissembled to change application packages would be low. The master on/off switch could also be eliminated to avoid accidental or deliberate data loss. Minor customizing of the internal ROM software would be needed to require a password before deleting RAM files.

Security. Panasonic offered to help Battelle make contacts with the creator of several encrypting algorithms (non-trap-door) which would be easily implemented on their HHC. Such a security mechanism would be valuable if classified information were included in a training program.

Guard Digits. All computers suffer from round-off errors. As a result, an answer which should be "2" may appear as 1.99999999 or 2.00000001, for example. Occasionally the lack of accuracy may be a real shortcoming technically; more often high accuracy is not needed, but the unexpected answers can cause confusion. To avoid this problem some manufacturers use "guard digits", i.e., additional digits which are used to calculate the answer, but are not displayed. For example, the answer may be calculated to the nearest billionth, but displayed only to the nearest millionth. Although the round-off errors still occur, when the answer is displayed with fewer significant digits, no round-off error can be discerned.

Subtle Programming. In some cases, programming and optimizing the execution of software on an HHC is not as simple and straightforward as is programming a larger computer. Many versions of BASIC have unusual definitions: the integer portion of -2.54 is often calculated as "-3". Also, many user groups find unreported features. One user found 83 plotable characters on the HP-41C instead of the 59 advertised. Another found a way to make the TI-59 run twice as fast. Contact with user groups can often point up these curious, but helpful, bits of data.

Pocketing HHCs. The pocket sizes on the new fatigue uniforms are as follows: trouser thigh pockets (2) - 9" long x 9" wide x 3" deep (expandable on only one side); jacket chest pockets (2) - 6" long x 5" wide x 2" deep (expandable on only one side); jacket bottom pockets (2) - 6" long x 6-1/2" wide x

2-1/2" deep. Several manufacturers of HHCs have recommended they not be carried in back pockets to avoid stress on the cases. Our observation is that the HHC should not be carried in the thigh pocket as the computer is too susceptible to damage in that location. Most HHCs studied would extend over the top of the jacket pockets, but could be carried there, if desired.

Handling HHCs. As previously noted, most manufacturers have not considered environmental conditions other than an office environment in designing their HHCs. Use of an HHC by students in a field, classroom, barracks or shop setting, where the device can be dropped or have liquids spilled on it, etc., will shorten the life of the typical HHC. The ruggedness and reliability of the various HHCs may limit the environments in which they can be effectively used.

APPENDIX A

TABLE OF HHC FEATURES

TABLE OF HHC FEATURES

	Panasonic/Quasar	Sharp/Radio Shack	Pinetree	HP-41C (V)	TI-59
Height	8-15/16"	6-7/8"	5-15/16"	5.7"	6-3/8"
Width	3-3/4"	2-3/4"	3-3/16"	3.1"	3-1/4"
Depth	1-3/16"	11/16"	1-9/16"	1.3"	1-1/2"
Weight	14 oz.	6 oz.	11 oz.		8.5 oz.
Microprocessor	6502	2 4-bit custom	Z80A		components
Clock frequency	1.048 MH_z	256KH_z			
Internal clock	yes	no	no	no	no
Physical keys	65	55	16	35	45
Keys and shifts	140	72	42	130	92
Display	LCD matrix (5x8)	LCD matrix (5x7)	LED segment	LCD segment	LED 7 segment
Internal characters/line	80	80		24	12
No. characters displayed	26	24	12	12	12
Flags displayed	8	8	0	yes	no
Redefineable keys	nearly all	18		nearly all	10
User's characters	dot-by-dot	no	no	printer only	no
No. different characters	96	58		59*	20
Upper/lowercase	full, plus inverse	upper	upper	upper plus 5 l.c.	printer only
Internal RAM	2K or 4K	1.9K	24K total RAM & ROM	41C: .4K 41CV: 2.3K	.1K variables plus 1K program steps
Internal ROM	16K	11K			
Interchangeable ROM	64K or 48K	Not available	not available	32K	5K steps
Selective dot erase	yes	no	N/A	N/A	N/A
Animation	yes	apparently		limited	no
Overlays available	yes	yes	N/A	yes	yes
Significant digits	10	10		10 0 guard	10 plus 3 guard
Languages	SNAP & BASIC	BASIC	Assembly	RPN including alpha	algebraic logic
Memory retained while off	yes	yes	yes	yes	yes
Battery type	5 NiCd	4 Mercury #675	4 NiCd AA	4 N cells, optional NiCd	BP-1A pack
Battery life	100 hour	300 hour			3 hour

* Users have found 83, however.

TABLE OF HHC FEATURES (Continued)

	Panasonic/Quasar	Sharp/Radio Shack	Pinetree	HP-41C (V)	TI-59
Battery warning	2 levels*	yes			yes
Timed off	yes	yes	yes	yes	yes
12 VDC adapter	Built, not marketed	no			yes
No. sounds	4 octaves	1		10	0
Duration control	full	2 lengths			N/A
Operating temperature	<120° F	32°-104° F	50°- 120° F		
Storage temperature			0°-150° F		
Waterproof					
Dustproof					
Shock resistant					
Pressure resistant					
Vibration resistant					
Humidity			up to 99%		
Touch typable	barely	no	N/A	N/A	N/A
Interference rejection					
Price	2K: $500 4K: $600	$170	$600 - 950	C: $250 CV: $325	$200
Print matrix	7x9	5x7	not available	5x7	5x7
No. different characters	116 plus user's	58	N/A	127 plus user's	64 (including alpha)
No. characters/line	15	16	N/A	24	20
No. lines/second	1.5	1.0	N/A		~2
Power	4 AA NiCd	NiCd	N/A	battery	ac only
Peripherals	applications ROM	cassette	central receiver	application ROM	application ROM
	16K RAM			magnetic card reader	magnetic card reader
	Acoustic modem				
	Color TV adapter			bar code wand	12V dc adapter
	RS-232 serial interface				
	Disk (in 1982)				

* Memory is protected when batteries are down.

APPENDIX B

POTENTIAL APPLICATIONS

POTENTIAL APPLICATIONS

This section identifies and defines 8 generic applications of computer devices to training. These applications are generic in the sense that they do not consider the content of the application, but rather, its form. These possible applications may not be useful in every training situation, and have to be examined in light of specific training needs and computer capabilities.

In general, the HHC's small size and self-contained power source make it useful in a field situation, for on-site unit training, or wherever micros are not available or easily assessable. The HHC can also be used as a personal training aid in the school environment (classroom, laboratory or learning center). Special programs, lessons, games, etc., can be loaded on the HHC and student data can be off-loaded periodically. Further, the HHC can be used for exported continuing education.

1. Job Performance Aids

In this application, the HHC is used as a dynamic information storage and retrieval device, or as a special-purpose calculator. Job performance aids can be used for review prior to practical exercises, and can provide OJT through their use on the job. The focus of this study is on application of HHC's to training rather than their use as a job performance aid.

Examples of this application are:

1. Storage of parts lists and identification numbers
2. Storage of diagnostic check lists
3. Use as a special-purpose calculator for training engineers, field artillery officers, supply officers, chemical technicians, etc., in the use of less powerful calculators and tables.

2. Tutorials

In this application the HHC presents instructional information (text or graphics), followed by questions. Student answers are given immediate feedback; then more information is presented. The instructional information can be original or remedial material. The sequence of presentation can be linear or branching. The HHC can also store reference information and provide it upon request.

Programmed instruction (as commonly provided by a microcomputer or central computer) best illustrates this application.

3. Drill and Practice

The purpose of drill is to consolidate learning that has already occurred. In this application the HHC generates or selects problems, and presents them to the student. Student answers are given immediate feedback; then additional problems are presented. Problems can be generated randomly or selected from lists. Feedback can be diagnostic or non-diagnostic. Problem difficulty can be adaptive or non-adaptive.

Examples of this application are:

1. Drill on technical terms or symbols
2. A timed drill on arithmetic facts or foreign languages
3. Drill on hardware identification
4. Drill in cross-referencing technical manuals
5. Adaptive speed semaphore or Morse code signal practice.

4. Problem Solving

In this application the student enters a problem (e.g., assigned practice problems), and works toward its solution on the HHC. As the student works the problem, the computer checks the equations used, the procedural steps, and the final solution. Guidance and feedback can be provided by the computer throughout the process. This application can be used with mathematical, scientific/engineering, or procedural problems.

5. Inquiry

In this application, the student poses questions to solve a problem (hence its name "inquiry"). The computer answers the question or provides the requested information. The student interprets the information, then asks additional questions. The student must ask the right questions to get the information to solve the problem. The student's score is the number of questions asked before solving the problem. Different costs may be associated with different questions, analogous to the real-world costs of acquiring the information. This application emphasizes decision-making, as the student must pose effective questions, interpret the information presented, generate hypotheses or possible solutions, and test these solutions.

Examples of this application are:

1. Twenty-questions or varieties thereof
2. Standardized problem exercises to teach principles
3. Non-proceduralized diagnostic problems.

6. Games

Games possess an intrinsic motivation or challenge that in some cases may become addictive. Learning games provide motivation for new learning or practice. Computerized learning games can be played against a personal standard (the student's previous best score), a chance factor, the computer, or another person (inter-terminal game). Games are scored as won or lost, or the computer can provide a score indicating how well the student did. Computer games can be timed, and can be adaptive or non-adaptive in difficulty. Often, games require some randomization to change the starting conditions or sequence.

In this application the HHC stores the rules or equations which constitute the game. The computer may select moves or change the sequence at random. The computer scores the outcome and retains the previous best score. If scores from other students are loaded, the computer can further motivate the student by showing the best scores of other students or the student's percentile rank. The computer may adapt the level of difficulty to the skill level of the student.

Examples of this application are:

1. A troubleshooting game to teach diagnostic strategies
2. A game to teach recruiters the recruiting process
3. A game to teach principles of base security and defense
4. A game to teach Army organization and logistics.

7. Simulations

Simulations resemble learning games, but are more realistic. Computerized learning simulations involve mathematical models or physical representations of real systems. Computer simulations can be run in real time or in simulated time (slow or fast). Simulations often provide realistic inputs and/or require realistic responses from the student. Like games, simulations can be scored qualitatively (successful or unsuccessful) or quantitatively. Learning simulations can be used for initial skill acquisition or for practice.

Examples of this application are:

1. An abstract model of a real piece of equipment is used to teach troubleshooting
2. A realistic model of the post is used to practice security procedures
3. A war game simulation is used to teach the application of a new weapon system

4. A model of battalion maintenance is used to teach maintenance management
5. Part-task training of psychomotor tracking skills.

8. Training Management

In this application, the HHC is used to generate, maintain and update student data. This application would probably be used in conjunction with other instructional uses. The HHC can provide students with tests (pretesting, criterion testing, and diagnostic self-testing) and records of their achievement scores. Student data can also be periodically off-loaded to centralized files. Finally, the HHC can provide assistance to students or instructors by alerting them to student learning problems, diagnosing the nature of the problem, and suggesting lessons or resources to be used. Thus, the HHC can provide a variety of computer managed instruction (CMI) functions.

APPENDIX C

LISTS OF REFERENCES

This appendix is organized into three types of resources:

- Magazine Articles
- Newsletters and Regular Columns
- Manufacturers

MAGAZINE ARTICLES

"Market for Pocket Computers Is Expected To Take Off Soon" by Richard A. Shaffer, Wall Street Journal, November 6, 1981, p. 21.

"Personal Scientific Calculators" by Jim McDermott, EDN, September 16, 1981, p. 71ff.

"Programmable Calculator Features Accessory Parts", Popular Science, February, 1980, p. 125.

"Pocket-Size Computers", Popular Mechanics, October, 1980, p. 119.

"Handheld Computers" by V. Elaine Smay, Popular Science, November, 1980, p. 102.

"A Revolution In Your Hand", The Futurist, December, 1980, p. 59ff.

"Report From Chicago CES", Interface Age, September, 1981, p. 6ff.

"Requiem For The Programmable Calculator" by Paul Snigier, Digital Design, September, 1981, p. 4.

"The HP-41C: A Literate Calculator?", Byte, January, 1981, p. 124ff.

NEWSLETTERS AND REGULAR COLUMNS

"Compunotes" from XCEL, 13763 Polk Street, Sylvia, California 91342, (213) 367-4366.

"Micronotes" file on PLATO computer assisted instruction systems.

Pocket Computer Newsletter, P. O. Box 232, Seymour, Connecticut 06483, (203) 888-1946.

"Power In Your Pocket" by Bob McElwain, Interface Age.

PPC Calculator Journal, 2545 Camden Place, Santa Ana, California 92704, (714) 754-6226.

TRS-80 Microcomputer News.

"The Micro Mathematician", Dr. John C. Nash, Interface Age.

HP Key Notes.

TI PPC Notes, Box 710, Lanham, Maryland 20706, (301) 459-5458.

MANUFACTURERS

Mr. Hal Ohashi, Chief Engineer of Systems, Sharp Electronics, 10 Sharp Place, Paramus, New Jersey 07652, (201) 265-5600 ext. 4192.

Mr. Dick Brayden, General Manager, Systems Division

Mr. Dick Grogan, Manager for Planning

Mr. Dennis Reer, Panasonic Electronics, One Panasonic Way, Syracuse, New Jersey 07094, (201) 348-7792/7818.

Sinclair Research Limited, 6 Kings Parade, Cambridge CB2 15N, England.

Hewlett-Packard, 1000 N.E. Circle Boulevard, Corvallis, Oregon 93770 (503) 757-2000.

Ranell Durgan, Friends Amis, San Francisco, California, (415) 928-2800.

Mr. George Brandt, Quasar Electronics, 9401 W. Grand Avenue, Franklin Park, Illinois 60131, (312) 451-1200.

Mr. Rufus Coomer, President, Pinetree Computer Systems, 734 Greenview Drive, Grand Prairie, Texas 75051, (214) 641-7500.

Commodore International, Santa Clara, California, (408) 727-1130
Pennsylvania, (215) 666-7950.

Newbury Laboratories Ltd., 68 Regent Street, Cambridge CB21DP, England 44 (223) 64862.

Tandy Corporation (Radio Shack), 1800 One Tandy Center, Ft. Worth, Texas 76102 (Local stores were more helpful).

Computerwise (Transterm 1), 4006 E. 137th Terrace, Grandview, Missouri 64030, (816) 765-3330.

Casio, Inc., 15 Gardner Road, Fairfield, New Jersey 07006, (201) 575-7400.
Mr. Sal Morabito, (914) 928-7267.

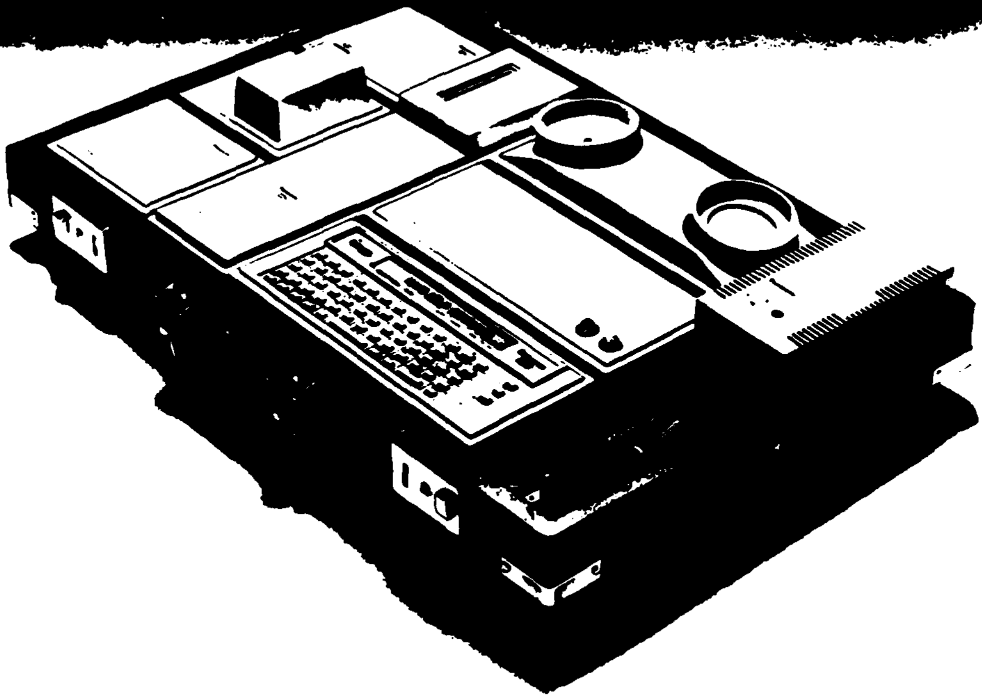
Andrew Surtees, Marketing Director, Grundy Business Systems, Ltd., (Newbury New Brain), Cambridge Sciences Park, Milton Road, Cambridge DB4 4BH, England 44 (223) 350355.

APPENDIX D

PANASONIC/QUASAR SPECIFICATIONS

Panasonic

RL-H1000
RL-H1400
Hand Held Computer
and Peripherals



HHC

HHC Hand Held Computer

1. The business computer has become portable
The range of uses for the business computer has been greatly increased with the adoption of an AC/DC 2-power source system. Full use of all functions is now possible anytime, anyplace.

2. Utilizing a modular system
By combining the various "modules", a program which meets the needs of particular business activities can be selected, remarkably increasing the range of application.

3. Function and efficiency improved by capsulated software
Software can be exchanged quickly and easily, resulting in more flexible application of each program, and greater efficiency in operation.

4. Operation is simplified by use of the "menu" system
Because the software is designed basically in dialogue form, operation is easy enough for virtually anybody to perform.

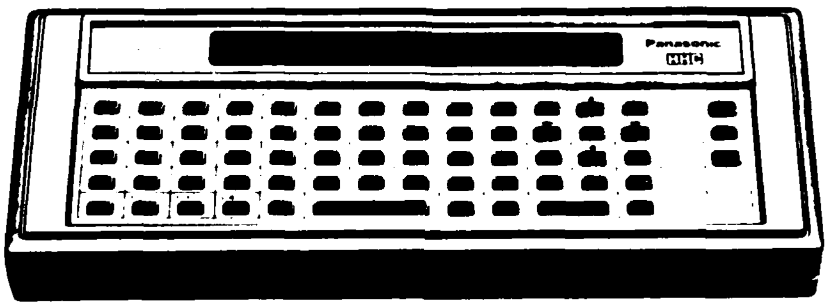
5. Power-saving design
Numerous developments, such as the CPU auto-power-saving function, and the extensive use of CMOS construction designed to make battery operation possible, have resulted in an extremely successful power-saving design.

6. Compact and lightweight
Its small size and light weight make it possible to take the unit where it's needed.

Primary Unit

Model No: RL-H1000 (Built-in 2 K bytes RAM)
RL-H1400 (Built-in 4 K bytes RAM)

Utilization of the ROM capsule system enables use in a wide variety of applications...
8 × 159-dot continuous display capability



Display Section:	Continuous liquid-crystal display (LCD) with an 8 by 159 dot matrix excluding 8 "Blip" dots above corresponding Attention Indicators. Approx. 26 digit columns. Graphic display capability (HHC Capsule provides)
Character Displayed:	Alphabet A~Z, a~z Numerous 0~9 Various symbols
Keyboard:	65 keys, redefinable with overlays, interrupt driven, with 2-key rollover
Capsule Socket:	3
Microprocessor:	6502 running at 1 MHz (8-bit)
ROM Capability:	Internal ROM 16 K bytes 3 sockets for ROM capsule, each containing up to 16 K bytes
RAM Capability:	Internal RAM 2 K bytes (RL-H1000) or 4 K bytes (RL-H1400)
Peripheral Connectors:	• 44-pin edge connector with address and data, busses, control lines, bias lines, bank select lines, busprotect, and power supply lines • Only one peripheral unit can be connected directly to the Primary Unit • In order to connect 2 or more peripheral units to the Primary Unit they must be connected via an I/O Adaptor
Power Source:	Built-in 5 nickel-cadmium "AA" rechargeable battery pack with external AC Adaptor/Recharger
Charging Time:	Approx. 12 hours
Dimensions: (W × H × D)	$8^{15}/_{16}$" × $1^{3}/_{16}$" × $3^{3}/_{4}$" (227 × 30.5 × 95mm)
Weight:	1 lb 5.87oz (620g)

HHC Capsule
Read-only memory (ROM) capsules contain various application software. They can be easily inserted into the capsule socket of the Primary Unit.

HHC Peripherals

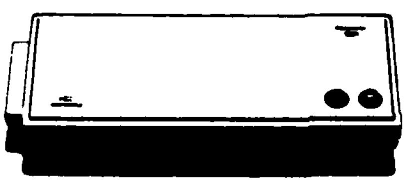
Acoustic Modem Model No: RL-P4001

Bilateral communication capability via public telephone line

Transmission System:	Asynchronous serial transmission
Transmission Mode:	Full or half duplex
Transmission Speed:	110 or 300 bps
Transmission Code:	1 start bit 5, 6, 7 or 8 data bit 1 or 2 stop bit
Parity Check:	Odd, even, or no parity check
Transmission Level:	Originate Mode — −15dBm ±3dBm Answer Mode — −19dBm ±3dBm (on line level)
Receive Sensitivity:	−40dBm (lower limit) for both low and high group (at 80 horn noise level of environment and Bias Distortion ±10%)
Carrier Detection:	Carrier detection level: −40dBm (lower limit) Non-carrier detection level: less than −46dBm
Normal/Test Switch:	On the bottom of the unit Normal position: receive/transmit mode Test position: self test (testable on both full and half duplex mode)
Control application Capsule Slot:	1 slot
Power Source:	+5V supplied from the HHC Primary Unit
Power Consumption:	130mW
Dimensions (W × H × D):	8 15/16" × 2 7/32" × 3 3/4" (227 × 56.5 × 95mm)
Weight:	1 lb 3.4oz (550g)

TV Adaptor Model No: RL-P2001

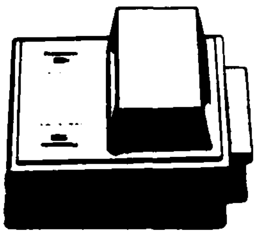
TV Adaptor with semigraphic function



Number of Characters Displayed:	32 characters × 16 lines (512 characters)
Character Configuration:	5 × 7 dot STD, 8 × 12 dot max
Character Type:	Upper case-letters A~Z Lower case-letters a~z Numerals 0~9 Symbols Totals of 116 characters
Semigraphic Mode:	The Capsule program provides this mode
(1) Semigraphic 4 Mode:	Character box (8 × 12 dot) divided into four elements (4 × 6 dot) No. of elements—64 graphic elements × 32 lines No. of colors—8 [green, yellow, blue, red, light yellow (buff), dark blue (cyan), magenta, and orange] Production of two or more colors at the same time is not possible for one character box
(2) Semigraphic 6 Mode:	Character box (8 × 12 dot) divided into six elements (4 × 4 dot) No. of elements—64 graphic elements × 48 lines No. of colors—8 [green, yellow, blue, red, light yellow (buff), dark blue (cyan), magenta and orange] Production of two or more colors at the same time is not possible for one character box
TV-RF Signal Output:	Channel 3 or channel 4 Selection by manual switch residing on bottom of the unit RF Output: Max. 3mV (rms) Frequency Stability Channel 3: 61.25 MHz ±500kHz (32°F~104°F/0°C~40°C) Channel 4: 67.25MHz ±500kHz (32°F~104°F/0°C~40°C) Terminal: F-type connector
Video Signal Output:	Output: 1 Vpp max Terminal: RCA pin type connector
RF and Antenna Cable:	3C-2V coaxial cable Connector: one touch F-type connector Cable length: 4.92 ft (1.5m)
Video Cable:	1.5C coaxial cable connector: RCA pin type connector Cable length: 4.92 ft (1.5m)
Power Consumption:	1.5W (AC Adaptor is necessary)
Operating Temperature:	32°F~104°F (0°C~40°C)
Dimensions (W × H × D):	8 15/16" × 1 3/16" × 3 3/4" (227 × 30.5 × 95mm)
Weight:	1 lb 1.64oz (500g)

RS-232C Serial Interface **Model No: RL-P3001**

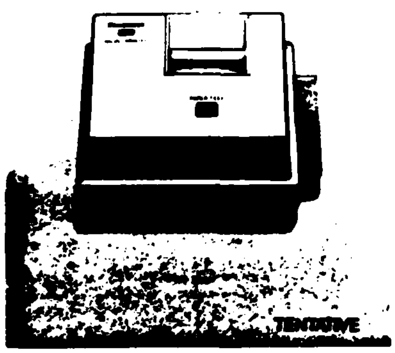
Used to interface HHC to an external device



Transmission Speed:	50, 75, 110, 150, 200, 300, 600, 1200, 2400, 4800, 9600 bps selectable accuracy 0.5% or less
How to set Transmission Speed:	Set manually by dip switches in the bottom of the unit
Output Level of Line Driver:	±(10.3V±0.5V)
Input Level of Line Receiver:	Rated input level within ±20V
Line Driver:	Output termination current within ±12mA Output impedance 300Ω or more (measured by applying ±12V at output terminal when power off)
Input/Output/ Connector for Transmission:	25-pin (CCITT-V24)
Control/Application Capsule Slot:	1 slot (in the bottom of the unit)
Power Source:	+5V (Supplied from the HHC Primary Unit)
Power Consumption:	650mW
Operating Temperature:	32°F~104°F (0°C~40°C)
Dimensions. (W × H × D)	4$^{7}/_{16}$" × 2$^{13}/_{32}$" × 3$^{3}/_{4}$" (113.5 × 61 × 95mm)
Weight:	12.35oz (350g)

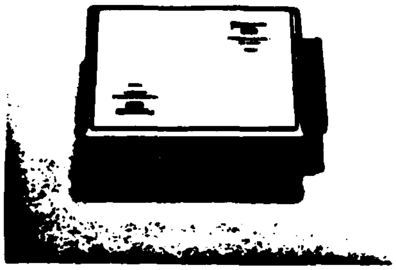
Micro Printer **Model No: RL-P1003**

15 characters/line thermal printer with alphanumeric and symbol printing capability



Printing system:	Thermal, dot matrix printing
Character Configuration:	5 × 7 dots
Maximum No. of Digit Columns:	15 characters/line
Printing Speed:	1.5 lines/sec
Character Type:	Alphabet, upper case-letters A~Z lower case-letters a~z Numerals 0~9 Various Symbols
Character Spacing:	13 characters/inch
Line Feed Spacing:	7 lines/inch
Paper Feed System:	Friction-type (no reverse feeding)
Printer Paper:	Roll type Width. 38mm, Length. 8m (No. of lines printed, approx. 2,200 lines/roll)
Life Time of Thermal Head:	500,000 lines (printing capability of 220 rolls)
Printer Power Source:	4.8V supplied from built-in battery "AA" size Ni-Cd battery × 4 which are charged through the HHC Primary Unit
Printer Controller Power Source:	Supplied from the HHC Primary Unit
Operating Temperature:	32°F~104°F (10°C~40°C)
Dimensions: (W × H × D)	4$^{7}/_{16}$" × 2$^{13}/_{32}$" × 3$^{3}/_{4}$" (113.5 × 61 × 95mm)
Weight:	1 lb (450kg)

HHC Peripherals and Accessories

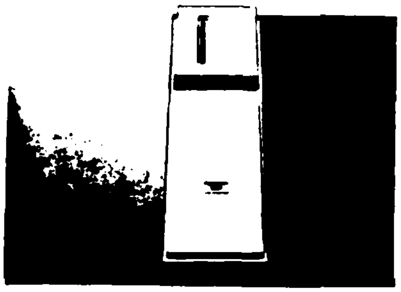


Programmable Memory (RAM)

Model No: RL-P9001 (4 K bytes)
RL-P9002 (8 K bytes)

Memory protected by back-up battery

Memory Capacity:	4 K bytes (two 2 K bytes CMOS RAM)—RL-P9001 8 K bytes (four 2 K bytes CMOS RAM)—RL-P9002
Memory Protection Back-up Battery:	3 "AAA" manganese batteries as back-up
Life Time:	About 1 year
Power Source:	+5V supplied from the HHC Primary Unit
Power Consumption:	10mW
Operating Temperature:	32°F~104°F (0°C~40°C)
Dimensions: (W × H × D)	$4\frac{1}{2}'' \times 1\frac{3}{16}'' \times 3\frac{3}{4}''$ (113 5 × 30 5 × 95mm)
Weight:	9 2oz (260g) with battery

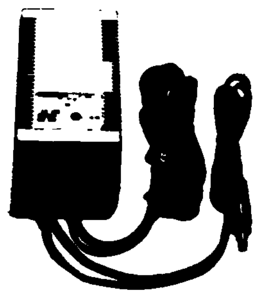


I/O Adaptor **Model No: RL-P6001**

Maximum connection capability of six peripheral units (One via I/O cable)

Peripheral: Connection Slots:	5 + 1 slot (total 6 slots) (When the slot on the top of the I/O Adaptor is used, the I/O Cable must be used) peripherals can be attached to any slot
HHC Primary Unit Connection Slot:	44-terminal edge connector
Power Source:	Supplied from the HHC primary Unit
Power Consumption:	7 5mW
Operating Temperature:	32°F~104°F (0°C~40°C)
Dimensions: (W × H × D)	$16\frac{3}{4}'' \times 2'' \times 12\frac{7}{32}''$ (425 5 × 51 × 318mm)
Weight:	2 lb 6 8oz (1 1kg)

AC Adaptor **Model No: RD-9498**



Primary Side: Input Voltage:	AC 120V ±10%/AC 220V ±10% Switchable
Secondary Side:	At no load DC 9V ±2 5%
Temperature Rise:	Max +55°C over air temperature at 1 1A load applied
Operating Temperature:	32°F~104°F (0°C~40°C)
Dimensions: (W × H × D)	$3\frac{1}{32}'' \times 2\frac{17}{32}'' \times 5\frac{3}{4}''$ (77 × 64.5 × 146mm)
Weight:	2 lb 6.8oz (1 1kg)

Attache Case **Model No: RL-9808**

This fine vinyl attache case with its distinctive dimensions can hold all of the following Primary Unit, I/O Adaptor, 2 large size peripherals (like TV Adaptor and Acoustic Modem), 3 small size peripherals (RS-232C Serial Interface, Programmable Memory (RAM), Micro Printer, etc), AC Adaptor, Antenna Selector Box, TV Cables, owners manual, and others

HHC Examples of main use

1. A "business tool" to be used for data entry

Applicable businesses
Gas, Electric companies, Stock-brokerages, Banks, Beverage stores, Bakeries, etc

2. A valuable aid for sales representatives in the field

Applicable businesses
Life insurance, Casualty insurance, Pharmaceutical companies, Stockbrokerages, etc

3. A data input/output terminal for use with the telephone, or with an exclusive communication line

Applicable businesses
Real estate agencies, Automobile sales agencies, Credit companies, Construction companies, etc

4. Scientific, financial or other special calculation

Applicable businesses
Construction companies, Real estate agencies, Banks, Scientific researchers, Technicians, etc.

Panasonic.
just slightly ahead of our time

Panasonic Company
Division of Matsushita Electric
Corporation of America
One Panasonic Way, Secaucus, New Jersey 07094
(201) 348-7000

Panasonic NEWS
ONE PANASONIC WAY • SECAUCUS, NEW JERSEY 07094

FOR IMMEDIATE RELEASE

PANASONIC HHC SUGGESTED RETAIL PRICES

CPU

RL-H1000	2K Main Unit	$500.00
RL-H1400	4K Main Unit	$600.00
RD-9498	AC Adaptor/Recharger	$ 58.00

PERIPHERALS

RL-P2001	Video/RF Adaptor	$349.00
RL-P3001	RS-232c Serial Interface	$254.00
RL-P4001	Programmable Accoustic Modem	$286.00
RL-P6001	I/O Adaptor for Multi-Peripherals	$158.00
RL-P9001	4K RAM Block	$221.00
RL-P9002	8K RAM Block	$330.00

ACCESSORIES

RL-P6006	I/O Cable for 6th Peripheral	$ 86.00
RD-9808	Attache Case	$163.00
RD-9145	RS 232c Cable	$ 35.00

APPENDIX E

SHARP/RADIO SHACK SPECIFICATIONS

SHARP PC-1211

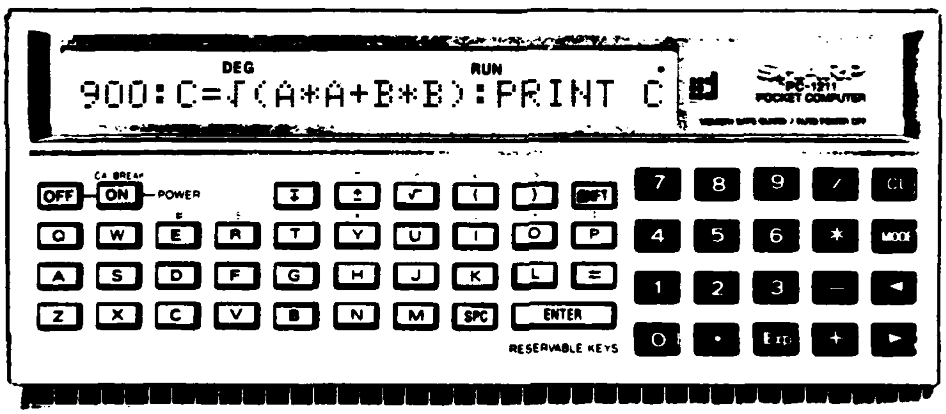
Pocket Computer

The pocket computer which has a whole new range of potential

The compact "Giant" that handles a wide range of applications

Handy pocket computer employing BASIC language

Computers are no longer for professional use only
Sharp's advanced electronics technology presents
the new pocket computer PC-1211.
High-performance functions are packed into a slim,
compact body. The PC-1211 is designed as an "interactive type"
computer to meet your personal needs by employing the
easy-to-understand BASIC language.
Make full use of it with your originality.



(The PC-1211 with template attached)

Pocket Computer

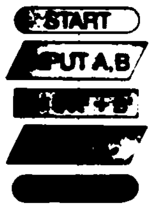
PC-1211

[illegible] convenience of BASIC language

Programming can be performed easily by following the flow chart. Furthermore formulas can be put in as they are written. For program calculation just put in the variables. It's so easy!

The Pythagorean theorem $C = \sqrt{A^2 + B^2}$

Flow chart



Key operation (PRO mode)	Display
1 0 I N P U T A SHFT , B ENTER	10:INP[illegible] A,B
2 0 C = √ (A × A + B × B) ENTER	20:C=[illegible] A*A+B*B
3 0 P R I N T C ENTER	30:PRINT C
4 0 E N D ENTER	40:END

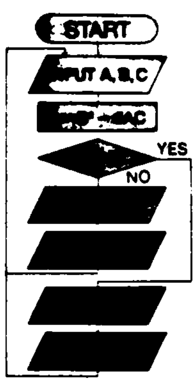
Key operation (RUN mode)	Display
R U N ENTER	?
3 ENTER	?
4 ENTER	5.

PC-1211 [illegible] high [illegible] calcula[illegible] wit[illegible] simple op[illegible]

D[illegible] panel — the window fo[illegible] "in[illegible]raction". Even complicated calc[illegible] can be done easily.

A quadratic equation $AX^2 + BX + C = 0$

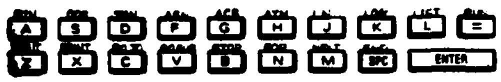
Flow chart



Programming (PRO mode) (Display)	Key operation (RUN mode)	Display
[illegible]	R U N ENTER	[illegible]
[illegible]	4 ENTER	[illegible]
[illegible]	−1 ENTER	[illegible]
[illegible]	−1 ENTER	[illegible]
[illegible]	ENTER	[illegible]
[illegible]	R U N ENTER	[illegible]
[illegible]	5 ENTER	[illegible]
[illegible]	4 ENTER	[illegible]
[illegible]	1 ENTER	[illegible]
[illegible]	ENTER	[illegible]

Speedy operation with unique key system.

Reservable key system



(Template)

Key operation (RUN mode)	Display
SHIFT A	
30	
+ SHIFT S	
30	
ENTER	[illegible]

▲Convenience is increased if you reserve keys for certain functions or commands which are used frequently, and write them on the template for reference.

◀Calculations such as SIN 30° + COS 30° can be quickly done by incorporating the Reservable key system.

Definable key system

(Template)

Key operation (DEF mode)	Display
11 SHIFT A	
5 SHIFT S	
1000 SHIFT D	
SHIFT F	

▲Define frequently used programs with the definable mode. For example, you can define a program for compound interest calculation. i: interest rate, n: period, FV: future value, PV: present value.

◀Simply input the variables to solve. What is the amount with interest added after 5 years at 11% of interest rate on a principal of $1,000?
The PC-1211 handles the calculation quickly and simply.

handles
level
ation
h
eration.

Let's calculate a statistical values.

(Using the Definable key system, program calculation of linear regression can be done.)

[Calculation]

Get the coefficient a, b and correlation function r by applying two couples of data x_i and y_i to the index curve $y = ab^x$.

$\bar{x} = \sum x_i / n$, $\bar{Y} = \sum \ln y_i / n$

$S_{xx} = \sum x_i^2 - n\bar{x}^2$

$S_{xY} = \sum x_i \ln y_i - n\bar{x}\bar{Y}$

$S_{YY} = \sum (\ln y_i)^2 - n\bar{Y}^2$

$r = \dfrac{S_{xY}}{\sqrt{S_{xx} S_{YY}}}$, $b' = \dfrac{S_{xY}}{S_{xx}}$,

$a = e^{\bar{Y} - b'\bar{x}}$, $b = e^{b'}$

[Example]

x	0.5	1.2	3.1	7.4
y	7.01	11.72	44.54	938.71

Apply this data to $y = ab^x$ and presume the case of $x = 8.3, -1.2$

Programming (PRO mode)

(Display)

Program calculation

Key operation (DEF mode)	Display
SHIFT A	[illegible]
5 ENTER	
7.01 ENTER	[illegible]
1.2 ENTER	
11.72 ENTER	
3.1 ENTER	
44.54 ENTER	
7.4 ENTER	
938.71 ENTER	
SHIFT B	[illegible]
ENTER	[illegible]
ENTER	[illegible]
ENTER	
ENTER	[illegible]
8.3 ENTER	
ENTER	[illegible]
-1.2 ENTER	[illegible]

Adoption of BASIC language

For programming the PC-1211 employs the BASIC language used widely from beginners to professionals. This simple programming method can easily be carried out by referring to the flow chart. Moreover formulas can be entered as they are normally written. These innovative functions are designed with ease of operation in mind.
The PC-1211 also serves as an ideal stepping stone to professional computers.

Dot matrix display — up to 24 digits with rolling writer

```
A= 3. B= 4. ANSWER C= 5.
```

(Output display)

Characters as well as numerals are displayed with the dot matrix display enabling the operator in a sense to communicate with the unit. The BASIC language can be used to its full potential. The display panel makes it possible to display portions of the program line by line, visual instructions asking for data and showing calculation results.

Program capacity 1424 steps · 26 memories with memory safe guard

The PC-1211 has a large memory capacity in spite of its slim compact body. Due to the memory safe guard circuit information in memory is maintained even after the power is turned off.
Programming is by an efficient one command one step system. According to your needs steps can also be used as a memory.
(8 steps is equivalent to 1 memory.)

Reservable key and definable key systems

- The reservable key system makes it possible to reserve a key for a function or command which is used frequently. It can easily be recalled by the touch of a key when putting in a formula either during manual calculation or programming.
- The definable key system defines 18 programs for each key. Whenever you need a certain program you can recall and run it with the touch of the proper key.

Smooth key operation with typewriter key arrangement

The PC-1211 employs a key arrangement similar to that of a typewriter. Thus the neat clean appearing keyboard can be operated easily and quickly.

Programs and data can be saved in and loaded from a tape recorder

The cassette tape recorder can be used as an external memory device.
(Cassette interface CE 121 is optional.)
By saving programs or data on a cassette tape the information can be loaded whenever necessary. It is also possible to search the saved program data automatically by file name or load it for use during the program calculation.

Other features

- Long-life operation. Auto power-off function
- Playback function enables correction by displaying the formula with a single touch of a key
- Effective tone function is designed to identify the program. (A beep sound can be input during programming.)

Applications

(Mathematics)
- Simultaneous equations
- Inverse matrix
- Determinant
- Product of matrices
- Mutual conversion and addition and subtraction between decimal notation and other notation
- Mutual conversion between rectangular coordinates and polar coordinates
- Root determining calculation according to Newton's method
- Quadratic equation
- Equation of third degree etc

(Statistics)
- n Σ x σ
- Poisson distribution and binomial distribution
- Normal distribution and percentile
- Estimation of interval of population mean and population variance
- Test of mean and variance
- Test of difference in means ratio of variances
- Rejection test test of correlation coefficient test of goodness of fit
- 2 × 2 contingency table 2 × n contingency table
- m × n contingency table
- Correction moving average
- Random numbers
- Sum of products correlation coefficient linear regression (y = ax + b)
- Exponential regression
- Correction exponential curve
- Logistic curve
- 1 Way layout
- 2 Way layout
- 2 Way layout (with repetitions) etc

(Measurement)
- Angle calculations
- Open and radiate traverse
- Closed and fixed traverse (Compass rule
- Inverse calculations of open and radiate traverse
- Coordinate area calculation
- Diagonal and perpendicular area calculation
- Triangle calculations
- Point on straight line and parallel moving point
- Stadia calculation
- Single curve calculations
- Clothoid curve
- Coordinates conversion
- Chamfer calculation
- Intersecting point and perpendicular calculation
- A point at a certain distance from two points (intersecting points of two circles)
- City block vertex calculation
- Division into specified area by specifying a point in a polygon
- Parallel specified area division
- Vertical specified area division
- Longitudinal curve (quadratic parabola) etc

(Construction)
- Girder load terms calculation program for reinforced concrete construction
- Force of section of simple beam (uniformly varying load trapezoidal
- Correction coefficient of distribution shearing force due to torsion
- Stress calculation of three hinged point gabled roof frame etc

(Electrical)
- Impedance in a series circuit
- Impedance in a parallel circuit
- Self inductance on a straight line
- Δ → Y Translation
- Y → Δ Translation
- Capacitance across two parallel electrodes

(Civil engineering)
- Section dead load and centroid of a polygon
- Coulomb's coefficient of earth pressure
- Stability of a slope (method of slices)
- Bending stress of simple girder
- Internal force of a simple girder (uniform load)
- Internal force of a simple girder (uniformly varying load) etc

(Mechanical)
- Graphic calculation
- Distance between two points and angle
- Involute inverse involute
- The point of intersection of two straight lines P = L/L
- A tangent line from one point P = P/C
- Points of intersection of two circles P = C/C
- A circle tangent to two lines C = L/L
- Intersection of a circle and a line P = L/C
- A line tangent to two circles
- A circle tangent to both a circle and a line C = L/C etc

(Office work)
- Days between dates
- Calculation of past and future dates
- Calculation of interest rate on loan
- Calculation of interest on deposites
- Calculation of present value of compound interest annuity
- Calculation of future & present value (by compound interest)
- Installment calculation
- Calculation of depreciation etc

Applications manual is supplied

Specifications

Model	PC-1211
Number of calculation digits	10 digits (mantissa) + 2 digits (exponent)
Calculation system	According to mathematical formula (with priority judging function)
Program system	Stored system
Program language	BASIC
Capacity	Program memory, Max 1424 steps Data memory: Fixed memory 26 pcs; Flexible memory (common with program memory) Max 178 pcs Reserve memory: Max 48 steps (reserve program Max 18 kinds) Input buffer: 80 characters
Stack	For data: 8 stacks For function: 16 stacks (in parentheses 15 levels) For subroutine: 4 stacks For FOR-NEXT statement: 4 stacks
Calculations	Four arithmetic calculations power calculation, trigonometric and inverse trigonometric functions, logarithmic and exponential functions, angular conversion, extraction of square root, sign function, absolutes, integers, and logical calculations
Editing function	Cursor shifting (▶ ◀) Insertion (INS) Deletion (DEL) Line up and down (↑ ↓)
External memory function	By using the optionally available cassette interface (CE-121), program, reserve program and data memory can be saved or loaded to or from cassette tape recorder
Memory protection	CMOS battery back up
Display	24-digit alphanumeric dot matrix liquid crystal display
Component	CMOS LSI etc
Power supply	Mercury battery (MR44) × 4 Approx. 300 hours
Power consumption	5.4V⎓(DC) 0.011W 5.4V⎓(DC) 0.013W (with CE-121)
Operating temperature	0°C ~ 40°C (32°F ~ 104°F)
Dimensions	175(W) × 70(D) × 15(H)mm 6-7/8"(W) × 2-3/4"(D) × 19/32"(H)
Weight	Approx 170g (0.37 lbs.)
Accessories	Hard case, battery × 4 (built-in), applications manual, beginner's textbook for "BASIC", template × 2

BASIC language specifications

Command	RUN NEW MEM DEBUG LIST CONT CLEAR
Statement	INPUT PRINT PAUSE USING LET STOP REM BEEP FOR TO STEP NEXT GOTO GOSUB RETURN IF THEN END AREAD
Operation	+, −, *, /, ( ), >, <, >=, <=, <>, =
Function	SIN COS TAN ASN ACS ATN EXP LN LOG INT ABS √ DEG DMS SGN DEGREE RADIAN GRAD π ^
Variable	A ~ Z, A( ), A$ ~ Z$, A$( )
Cassette control	CSAVE CLOAD CLOAD? PRINT# INPUT# CHAIN
Other	, ; : "

* Command Statement Function and Cassette control can be used with an abbreviated form (ex) PRINT → P

* Design and specifications subject to change without notice

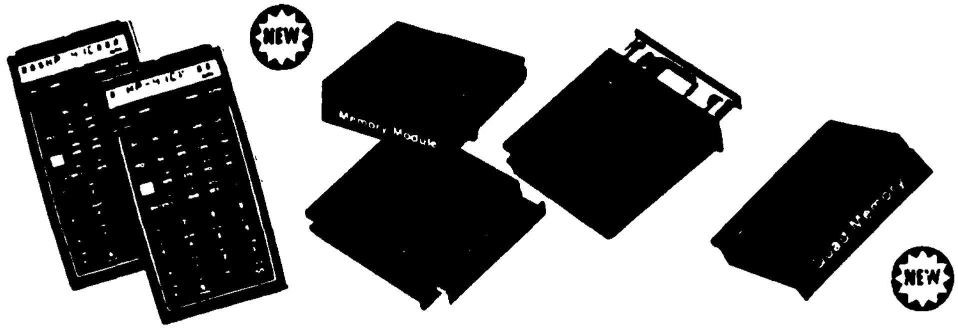
SHARP

SHARP ELECTRONICS CORPORATION
10 Keystone Place Paramus, New Jersey 07652

Distributed by

APPENDIX F

HP-41C SPECIFICATIONS



HP-41C or HP-41CV Alphanumeric Full Performance Programmable with Continuous Memory

The HP-41 is the most powerful handheld, programmable calculator ever made by HP. You now have two calculators to choose from: the HP-41C with 441 bytes of program memory built in (expandable to 2,233 bytes) or the HP-41CV with 2,233 bytes built in.

The HP-41 communicates with words as well as numbers. You can key in any combination of letters and numbers up to 24 characters wide and display 12 characters at a time. A complete system of status annunciators also helps to keep you firmly in control. Error messages are displayed in plain, understandable English. For aural feedback, you can use the HP-41 "beeper." Ten different tones will let you signal the end of a program or data entry point. Continuous Memory saves your programs and data even when the calculator is turned off. Over 130 separate operations comprise the total HP-41 function catalog. You can assign a function or program to almost any key. The HP-41 comes with keyboard overlays and a set of user labels to help facilitate customization of your HP-41. With a few keystrokes, you can actually create a "personalized" custom calculator for special applications.

You can store more and longer programs in the HP-41 than you ever thought possible. Each program is autonomous. Call it up by name, edit it, even clear it without affecting other programs. And each program can have up to 99 local plus 15 local alpha labels for addresses or subroutines. However, these independent programs can also be interactive. Using global labels, you can summon one program or branch to a subroutine (up to 6 levels) from another program.

Both the HP-41C and HP-41CV come complete with Owner's Handbook and Programming Guide, quick reference guide, application book, 4 N-cell batteries, 2 keyboard overlays, 1 module or overlay holder, 1 set of function labels, and a soft carrying case.

HP-41C and HP-41CV Specifications

Mathematical Functions: SIN, COS, TAN, and inverses, DEG, RAD, GRAD, R⇄P, DEG⇄RAD, H⇄H.MS, octal/decimal conversions, sign, modulo, INT, FRAC, ABS, round, log, 10^x, e^x, ln $(1 + x)$, $e^x - 1$, y^x, $\sqrt{x}$, $1/x$, π, +, −, ×, ÷, LN, H.MS±, CHS.

Statistical Functions: %, Δ%, $\bar{x}$, s, summations (n, Σx, Σx^2, Σy, Σy^2, Σxy), summation corrections, select summation registers, factorials.

Stack Functions: ENTER↑, R↑, R↓, x⇄y, X⇄REGISTER, LAST-X.

Alpha Symbols: upper-case alpha A through Z, lower-case alpha a through e, Σ, %, ≠, <, >, ↑, ∢, $, +, −, /, °, :, ., ,, ?, =, space.

User-Definition: alpha mode on and off, alpha store and recall, alpha shift left, alpha view, append alpha.

Programming Features: 100 numeric labels, unlimited global alpha labels, user-definable keys, indirect addressing of labels, data storage and recall, storage register arithmetic, alpha storage and recall, viewing register contents, display formats, looping, audible tone pitch, definition of accumulation registers, flag setting and clearing, catalog list, 6 levels of subroutines, controlled looping, 30 user flags, 26 system flags, 4 flag test functions in addition to set flag and clear flag, 10 conditional tests, 2 of which may be used with alpha strings ($x = y$, $x \neq y$).

Editing: singlestep execution, single- and backstep inspection of a program, delete program memory lines, position the calculator at any line in program memory, pause to review intermediate results, correction key to delete keystroke while entering data or alpha character, change size of data storage register allocation, catalog positioning.

General: label program, alpha prompt, aural prompt, pack program memory, stop, end, programmable OFF, go to end of program memory and prepare calculator for new program, advance paper, prompt, catalog list, copy program from ROM to user memory.

Clearing Options: DISPLAY, X REGISTER DATA, REGISTERS, ALPHA, PROGRAM, FLAG, STACK, STATISTICS REGISTERS.

Display: fixed decimal, scientific, and engineering notation.

Memory: last-x register, 4-register stack, alpha register, data storage registers.

HP-41C: 63 registers and 0 program bytes or 0 registers and 441 bytes (expandable to 2,233 bytes).

HP-41CV: 319 registers and 0 program bytes, or 0 registers and 2,233 bytes.

Power Requirements: 4 size N batteries, not rechargeable. Optional nickel cadmium battery pack.

Size: 33 × 79 × 144 mm (1.3 × 3.1 × 5.7 in).

Alone, the HP-41 is a powerful, programmable, problem-solving calculator. But, by adding optional plug-in peripherals and modules, you can expand the capabilities of the HP-41 to keep pace with your growing computational needs. Four input/output (I/O) ports at the top of the HP-41 accept peripherals, plug-in application modules, or Memory Modules. Each quick-connect peripheral and module is self-contained, with its own set of functions that is added to the calculator's existing function catalog. And each peripheral and module is fully portable.

HP 82106A Memory Module

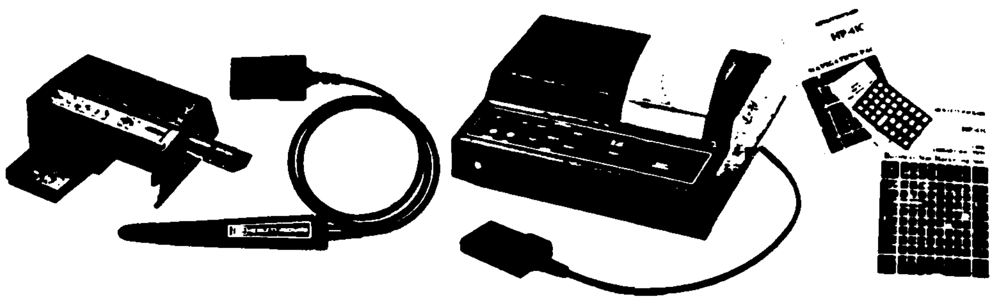
These Memory Modules can quintuple the HP-41C's memory. Each module contains an additional 64 registers that can be allocated as program memory or storage registers, or any combination. You can add four Memory Modules to your HP-41C for a total of 319 storage registers or 2,233 bytes. The Memory Modules, like the HP-41C have Continuous Memory. However, memory loss will occur when the module is removed from the calculator. (Use only with the HP-41C.)

HP 82170A Quad Memory Module

The equivalent of four Memory Modules, the Quad Memory Module contains 256 data storage registers or 1,792 program bytes and expands the HP-41C's memory to full HP-41CV capacity using only one port. The Quad Memory Module, like the HP-41C, has Continuous Memory. However, memory loss will occur when the module is removed from the calculator. (Use only with the HP-41C.)

COMPUTERS, PERIPHERALS & CALCULATORS

HP-41 Peripherals, Software, Accessories



HP 82104A Card Reader

Reads and writes programs and data onto magnetic cards with 32 registers per card. Adds over 30 card reader control functions to your calculator, including prompts and program security. Also reads HP-67/97 program cards.

HP 82143A Thermal Printer/Plotter

Portable, quiet, thermal operation, and battery operable, the HP 82143A prints upper- and lower-case alpha characters, including special characters you can create. The Printer/Plotter also does high-resolution plotting routines.

HP 82153A Optical Wand

Inputs data by reading programs in the form of bar code. Most HP-41 software is available in bar code, including Users' Library programs and solutions books.

HP-41 Application Pacs

Whether you're an engineer or technician, student or scientist, business person or other professional, you'll find an application pac or solutions book to solve many of the most common and difficult problems in your area.

Every application pac comes with a comprehensive manual, and, when applicable, a keyboard overlay. Choose from:

- Aviation
- Clinical Lab & Nuclear Medicine
- Circuit Analysis
- Financial Decisions
- Mathematics
- Games
- Home Management
- Real Estate
- Thermal & Transport Science
- Petroleum Fluids
- Securities
- Statistics
- Stress Analysis—Mechanical Engineers
- Structural Analysis—Civil Engineers
- Surveying
- Machine Design
- Navigation

HP-41 Solutions Books

Business:
- Business Statistics/Marketing/Sales
- Home Construction Estimating
- Lending, Savings, & Leasing
- Real Estate
- Small Business

Engineering:
- Antennas
- Chemical Engineering
- Civil Engineering
- Control Systems
- Electrical Engineering
- Fluid Dynamics & Hydraulics
- Heating, Ventilating, & Air Conditioning
- Mechanical Engineering
- Solar Engineering

Computation:
- Geometry
- High-Level Math
- Test Statistics

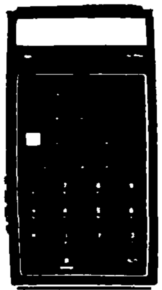
Other:
- Calendars
- Cardiac/Pulmonary
- Chemistry
- Games
- Optometry I (General)
- Optometry II (Contact Lenses)
- Physics
- Surveying
- Taxes

Ordering Information

	Price
HP-41C	\$250 00
HP-41CV	\$325 00
HP 82106A Memory Module	\$30 00
HP 82170A Quad Memory Module	\$95 00
HP 82104A Card Reader	\$215 00
HP 82143A Thermal Printer/Plotter	\$385 00
HP 82153A Optical Wand	\$125 00
HP-41 Application Pacs	\$30 00 to \$75 00
HP-41 Solutions Books	\$12 50

Calculator Accessories

A Hewlett-Packard calculator purchase is a smart decision. Power, convenience, and quality from a company you can depend on. But HP calculators also have a versatility unequaled in the industry. There's a complete accessory line engineered to provide the support you need. No matter what type of Hewlett-Packard calculator you choose, you'll find it supported by a full line of replacement accessories and supplies to keep it operational.



HP Users' Library

The Users' Library is dedicated to making programs contributed by HP-67, HP-97 and HP-41 users available to others. You'll discover a wide variety of programs written for specific applications areas. The solutions you need may already exist! As a subscriber to the Library, you will receive the *Catalog of Contributed Programs* and the *Contributor's Guide*, periodic supplements, and coupons for four programs of your choice complete with pre-recorded magnetic cards. You will also receive the HP *Key Notes* newsletter, which keeps you abreast of programming techniques, Library activities, and notes of interest.

Ordering Information	Price
First Year Subscription	$20 00
Annual Renewal	$10 00
HP-67, HP-97 Programs (Includes program descriptions/listings, and magnetic cards.)	$6 00
HP-41C, HP-41CV Programs (Includes program descriptions/listings, magnetic cards, and bar code.)	$6 00

Custom Services

HP Custom Services satisfies the growing need for specialization in portable computing products. Through customization, the powerful HP-41C and HP-41CV calculators can be tailored to do your dedicated complex or repetitious calculations when and where you need them.

Using customer or third party written programs, the HP-41 or an HP-41 with blank keys (Option 001), can be customized using one of three options: custom ROM's, custom magnetic cards or custom bar code. Each option is designed to suit particular information and problem-solving requirements. When selecting one of these alternatives, consideration is given to: frequency of code alterations, desired program capacity, updating of variables in your data, required level of privacy and initial investment. For assistance, consult your local HP Field Engineer.

HP 82500A or B Custom Modules (ROM's)
4K or 8K bytes of memory with each module. Nearly 21,000 program lines with up to four 8K modules.

HP 82502A Custom Magnetic Cards
Used with the HP-41C, HP-41CV, HP-67, and HP-97. Each card can be customized to load 175 to 200 instructions.

Custom Bar Code
Inexpensive way to load custom programs or data. Available from an independent vendor.

The HP-41 saves time, lowers cost, and ensures accuracy for both the technical and non-technical user. The standard HP-41 allows you to retain access to the full programmable capabilities and scientific functions of the calculator even after it has been customized.

A custom HP-41C or HP-41CV Option 001 with a blank keyboard, is made as friendly as possible. This special calculator limits use to those keys you have designated, minimizing potential user error. Custom overlays, (HP 82501A), label keys for either calculator and provide the final, professional touch.

Already many companies have improved their productivity with customized HP-41's. Proven applications, from banking to fuel savings, from media buying to heavy equipment sales and service, from circuit design to diamond sales, give the same result, increased performance and improved productivity.

Ordering Information

Quantity	Custom Modules 8K	Custom Modules 4K	Custom Mag Card 4K (10 cards/set)	Custom Bar Code 4K (6 cards/prog) (3 prog)
100	NA	NA	$99/set	$3 51/set
250	$102	$ 63	$46/set	$3 02/set
500	$ 52	$ 39	$28/set	$2 86/set
1000	$ 42	$ 27	$19/set	$2 78/set
5000	$ 26	$ 17	$12/set	$2 72/set

APPENDIX G

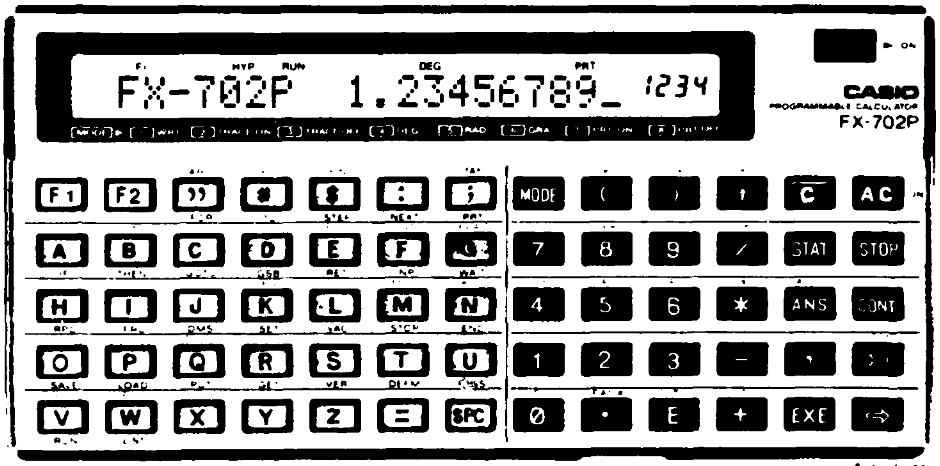
CASIO FX-702P SPECIFICATIONS

FROM THE WORLDS LEADING MANUFACTURER OF QUALITY CALCULATORS

The Talk of the Business Community

400 FOR K=1 TO 1000

Casio's new hand-held programmable calculator solves problems with alpha-numeric clarity, uses BASIC language.



Actual size

- Display capacity for 20 alpha-numeric characters.
- High utility variation of program steps and data memories (with power backup).

1680 steps 26 memories	⟷	880 steps 126 memories	⟷	80 steps 226 memories

- 55 widely applicable functions – incorporating programming.
- In-depth statistical management information, including standard deviation, regression analysis and correlation coefficient, which can be dealt with by a single command.
- Rapid computation speed by high grade C-MOS-LSI.
- Straightforward program debugging by an easy-use tracing system. Also, extremely smooth program editing.

Optional equipment (on sale in the near future):
FA-2 – adaptor for programs and data storage in cassette tape.
FP-10 – mini-printer for print-out of programs and data.

CASIO FX-702P

QUALITY · DEPENDABILITY · DURABILITY
CASIO®

TAKE ADVANTAGE OF CASIO'S EXTENSIVE CAPABILITIES AND UNIQUE TECHNOLOGY

CASIO FX-702P

Speed Completion of Programming!

Eg.) FOR·NEXT looping (counting from 1 to 1000)

Programming

```
 10 WAIT 0
300 PRT "START"
400 FOR K=1 TO 1000
500 NEXT K
700 PRT "END"
800 END
```

Program write-in

```
[MODE] [1] [F1] [P0] [C] [L] [R] [EXE] [D] [E] [F] [M] [0] [EXE]
 10 WAIT 0 [EXE]
300 PRT ["] START ["] [EXE]
400 FOR K [=] 1 TO 1000 [EXE]
500 NEXT K [EXE]
700 PRT ["] END ["] [EXE]
800 END [EXE]
```

Execution

[MODE] [0] [F1] [P0] → START

⋮ (Approx. 20 seconds)

END

Enter a Trial Program, It's Easy!

Eg.) Remainder calculation

Formula

Integer part of quotient = INT (A B)
Remainder = A − INT (A B) x B

Programming

```
10 INP "A=",A,"B=",B
20 C=INT(A B)
30 D=A-B*C
40 PRT A;"/";B;"=";C;"...";D
50 GOTO 10
```

Program write-in

```
[MODE] [1] [F1] [P0] [C] [L] [R] [EXE] [D] [E] [F] [M] [0] [EXE]
10 INP ["] A [=] ["] [,] A [,] ["] B [=] ["] [,] B [EXE]
20 C [=] INT [(] A [/] B [)] [EXE]
30 D [=] A [-] B [*] C [EXE]
40 PRT A [;] ["] [/] ["] [;] B [;] ["] [=] ["]
        [;] C [;] ["] [.] [.] [.] ["] [;] D [EXE]
50 GOTO 10 [EXE]
```

Execution

Eg.) 100 ÷ 7, 1234 ÷ 99

Key operation	Display
[MODE] [0] [F2] [P0] [EXE]	A=?
100 [EXE]	B=?
7 [EXE]	100 7=14. . .2
[CONT]	A=?
1234 [EXE]	B=?
99 [EXE]	1234 99=12. . .46

SPECIFICATIONS

Type: FX-702P

Basic Calculation Functions:
Four fundamental arithmetic operations including negative numbers exponent numbers and parenthesis calculations (with automatic recognition of calculation priority − true algebraic logic)

Built-in Functions:
Trigonometric and inverse trigonometric functions (with angle in degrees radians or gradients) hyperbolic and inverse hyperbolic functions logarithmic and exponential functions square roots powers factorials conversions into integer removal of integer part decimal places specification significant digits specification sexagesimal ↔ decimal conversions rectangular ↔ polar co-ordinates conversions absolute values, rounding random numbers and Pi

Statistical Functions:
Standard deviations: Number of data items, sum, square sum, mean and standard deviations (two kinds)
Linear regression: Number of data items, sum of x, sum of y, square sum of x, square sum of y, data product sum, mean of x, mean of y, standard deviations of x, standard deviations of y, constant term, regression coefficient, correlation coefficient and estimate values ($\hat{x}$ $\hat{y}$)

Character Functions: LEN MID

Calculating Range: From ±1 × 10^{-99} to ±9.999999999 × 10^{99} and 0. Calculations are performed internally with 12 calculation digits (mantissa) in the calculator

Program System: Stored system

Program Language: BASIC

Programming Capacity: 1680 steps/26 memories through 80 steps/226 memories (variable) with power back-up

Subroutine: Nested up to 10 levels

FOR · NEXT Looping: Nested up to 8 levels

Number of Programs storable: Up to 10 (P0 to P9)

Checking Function: Debug by tracing

Editing Functions: Correction, deletion and addition (by moving cursor)

Display: Liquid crystal display [20 characters (1 character: 5 × 7 dot matrix)]

Main Component: C-MOS LSI

Power Consumption: 0.01W

Power Source: Two lithium batteries (type: CR2032) give approximately 200 hours continuous operation

Ambient Temperature range: 0°C – 40°C (32°F – 104°F)

Dimensions: 17H × 165W × 82mmD (5/8"H × 6 1/2"W × 3 1/4"D)

Weight: 180g (6.3 oz) including batteries

** Design and specifications are subject to change without notice*

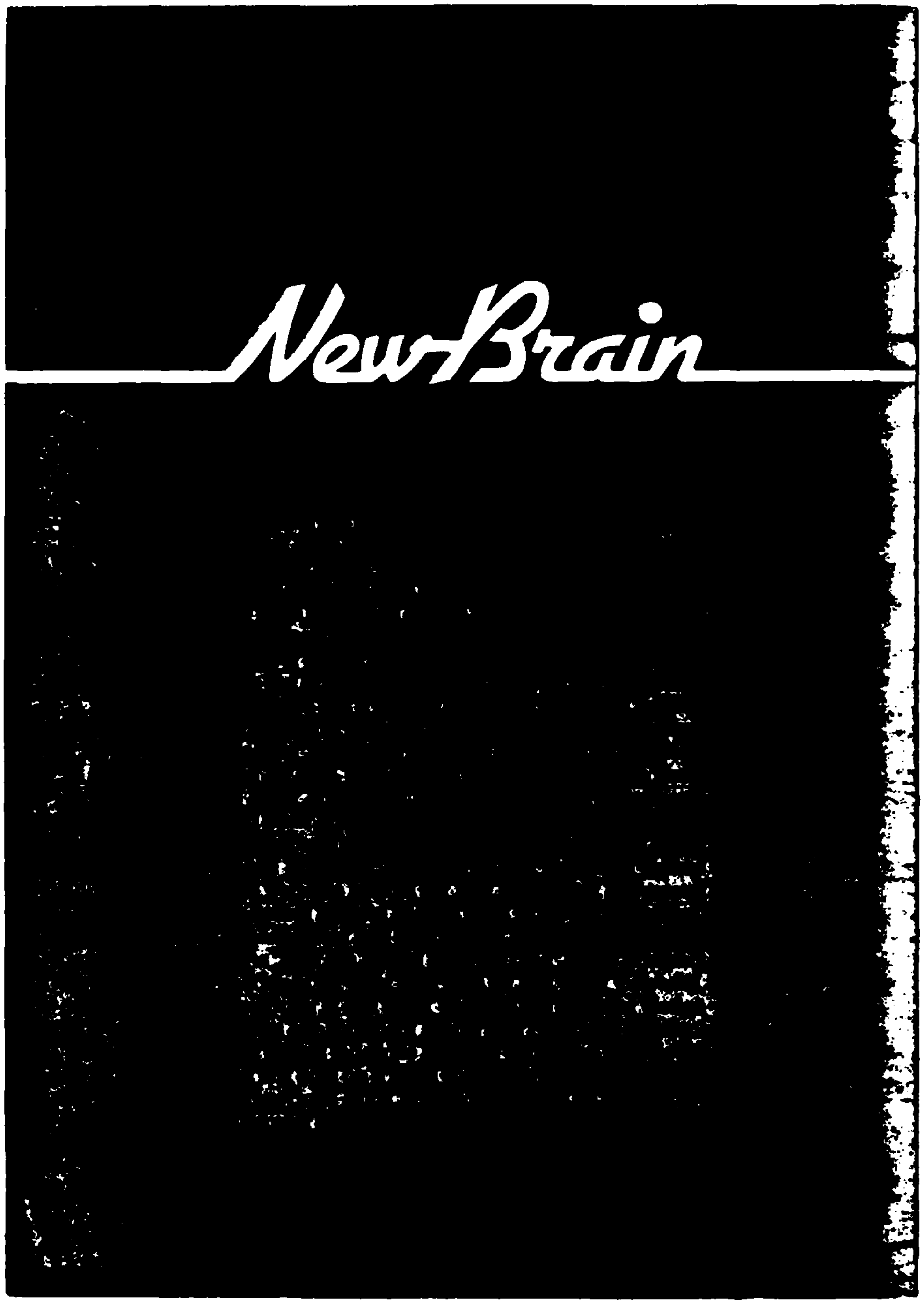
CASIO

FX-702P. 05 1981

APPENDIX H

NEWBURY NEW BRAIN MDB SPECIFICATIONS

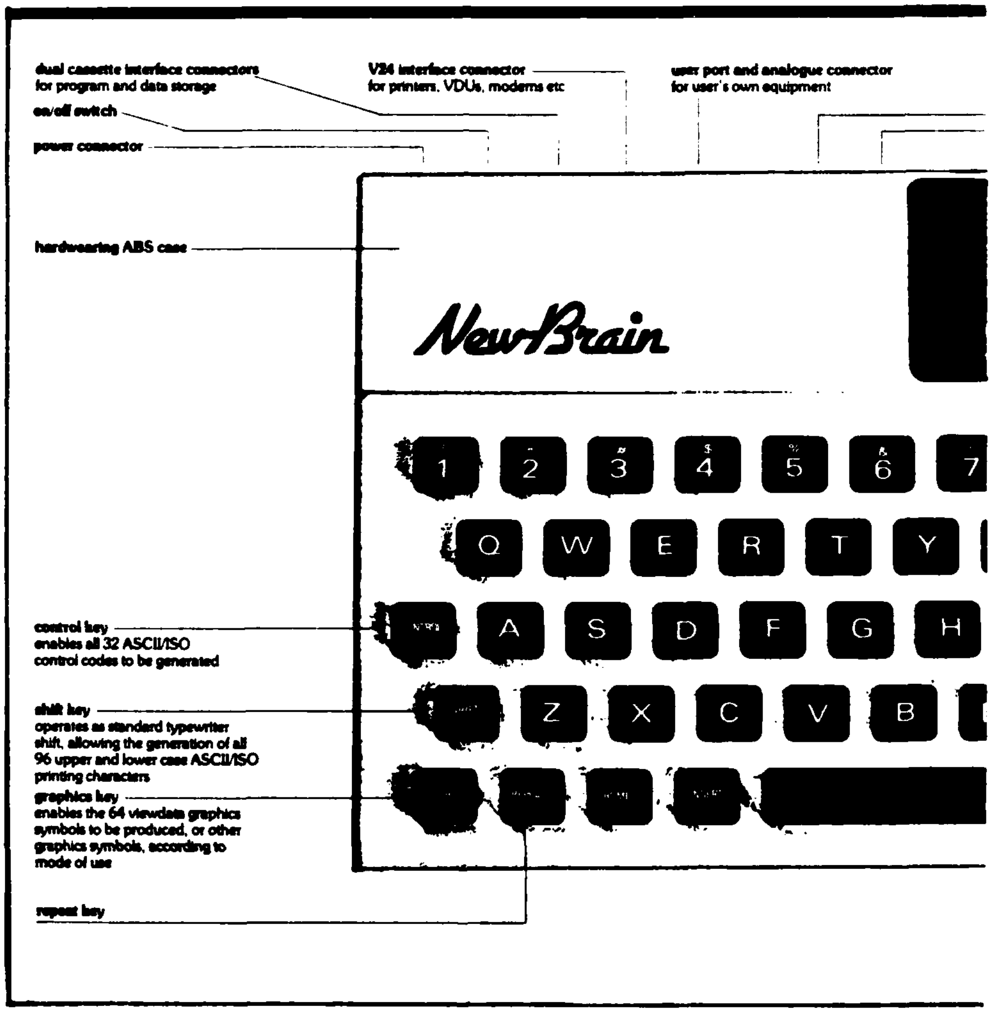

NewBrain


NewBrain

NewBrain is a professional machine.
The keyboard has been carefully designed for use by all categories of typists. It is laid out as a standard electric typewriter and the keys used have optimal profile and feel. Clear lettering aids easy location while the colouring is neutral to avoid eyestrain or distraction. The keyboard software includes a special rollover algorithm which accepts the high burst rate of keying of the professional touch typist and at the same time allows for the inexperienced beginner, avoiding such problems as double keying. The NewBrain keyboard generates 256 different characters. These include the 96 upper and lower case ASCII/ISO printing characters and the 32 control codes. The graphics key can be used to produce the 64 viewdata graphics symbols for TV or video monitor display. Suitable software enables the keys to be user-defined.

As well as providing all the standard keyboard functions of a typewriter, NewBrain provides cursor control for screen and line formatting and editing. The cursor control keys enable any part of a line to be brought into view on the built-in display and for characters to be inserted or deleted. On the TV or video monitor screen the cursor can be moved to any position for full editing and more sophisticated word-processing applications.

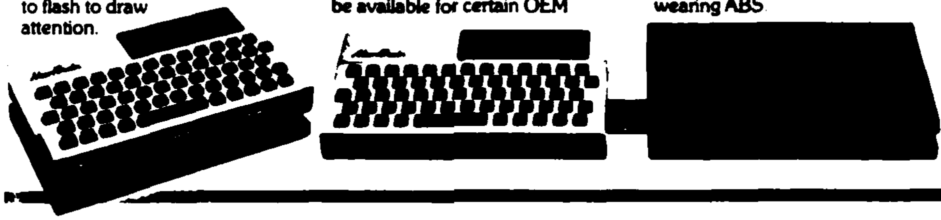
NewBrain's built-in vacuum fluorescent display has large and easily read letters. The fourteen segment pattern represents letters, numbers and punctuation symbols in a natural and pleasing form. The

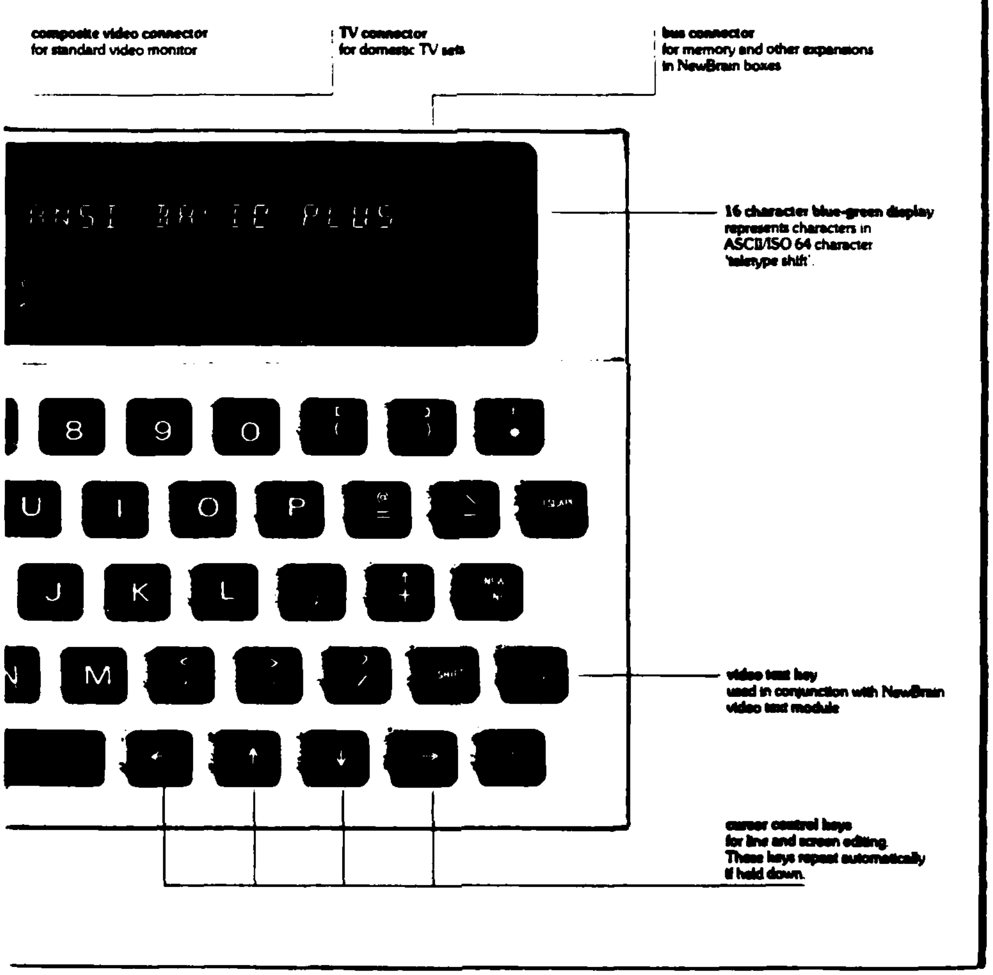


display is tilted forward; it has a wide viewing angle and the blue-green colour minimises eye fatigue. The 64 upper case ASCII/ISO printing characters can be displayed and, in addition, the lower case letters are displayed as capitals. Displayed characters can be made to flash to draw attention.

NewBrain comes in various versions to suit different applications. The fully specified model contains rechargeable batteries and has the vacuum fluorescent read-out. Other models are without the batteries or without the read-out, special models may be available for certain OEM applications. NewBrain expansion boxes are compatible with all standard models; they are connected by cables and can be clipped on under the main module or built up into separate stacks.

The NewBrain case is in hard-wearing ABS.

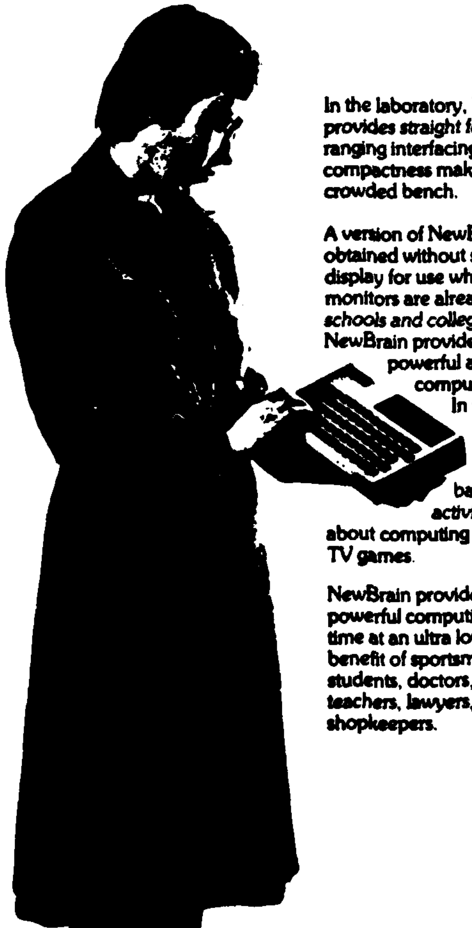




Versatility is NewBrain's hallmark. It fits on the desk as easily as the telephone. Small enough to be held in the hand, it slips into the briefcase as easily as a book.

For outdoor use there is no comparable product. From on-the-spot handicapping and sporting statistics to navigation at sea or in the air, from data collection around site, factory or warehouse to on-the-spot sales and financial calculations while travelling or visiting clients NewBrain has nc equal.

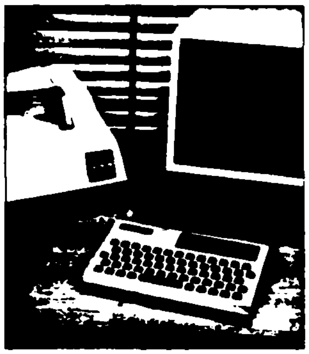
On the desk top NewBrain offers the lowest cost solution to all computing requirements; it can be used as an enquiry or a data entry terminal, as part of a network, as an aide-memoire, a calculator, a word processor, a financial planner and many other things, and, of course, as a stand alone computer. Yet battery back-up is still available allowing the NewBrain to continue working while being taken from office to office or office to home, and ensuring immunity to faults in the mains supply.

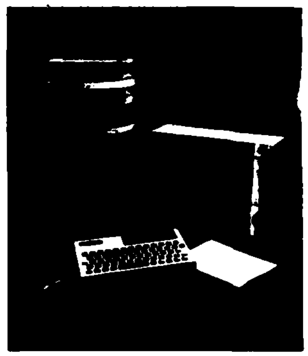


In the laboratory, NewBrain provides straight forward and wide ranging interfacing, and its compactness makes it ideal for the crowded bench.

A version of NewBrain can be obtained without self contained display for use where TV sets or monitors are already available as in schools and colleges. In this way NewBrain provides the most powerful and lowest cost computing realisable. In the home the same model connected to the television is the basis for a thousand activities from learning about computing to playing TV games.

NewBrain provides compact powerful computing for the first time at an ultra low cost for the benefit of sportsmen, scientists, students, doctors, farmers, teachers, lawyers, technicians and shopkeepers.





The NewBrain video and UHF outputs will drive any standard television set or video monitor providing a display of 24 lines of 40 or 80 characters across the line. The display character set includes all 96 ASCII/ISO printing characters, the 64 video text mosaic graphic characters, the Greek alphabet, Western European accented characters, Nordic characters, line drawing graphics, games graphics and other symbols. The display may be mixed with a high resolution display of up to 240 dots vertically by 256 or 512 horizontally.

NewBrain has a dual audio cassette interface suitable for use with most tape recorders for program and data storage. It is highly tolerant of wow, flutter and phase distortion. One or two tape recorders may be used. The data is transferred at a rate of 1200 baud.

All NewBrain models have a V24 serial printer output and a bi-directional V24 interface for modems, VDU's and other equipment. The baud rate is software selectable. Certain models have additional V24 interfaces and extra interfaces for all models are available in expansion boxes.

Some NewBrain models have 8 bit parallel inputs and outputs and analogue inputs and outputs for interfacing to other equipment for laboratory use, control applications and other purposes. Extra ports can be provided in expansion boxes.

All standard NewBrain models have a bus expansion port and a DMA port for connection to the expansion boxes and other NewBrain enhancements. Additional memory and interfaces are implemented in all models in universal expansion boxes.

NewBrain software includes a screen editor, a BASIC compiler, a high speed floating point mathematical package and a powerful operating system. Software modules in development include Z80 Assembler, COBOL, Pascal, statistical and financial packages and text processing systems.

The screen editor provides for the editing of pages of up to 256 lines of text, each line of any length. There are many advanced features including the insertion and deletion of characters and lines at any position; up to 256 pages can be maintained at a time.

NewBrain's BASIC compiler is an enhancement of the ANSI standard language including formatting of numerical output, advanced input/output features and string and logical functions. The high speed floating point mathematical package is accurate to 10 significant figures and all trigonometrical functions and inverse trigonometrical functions are included. The operating system allows the BASIC or any other program in control of the NewBrain to drive all the various NewBrain input/output devices in a simple and uniform way.

NewBrain software expansion modules plug into NewBrain or NewBrain expansion boxes and genuinely extend rather then replace the software already present; once plugged in they need never be removed and up to four megabytes of software can be added in this way.

Grundy Business Systems Ltd.

Sales and Administration
Somerset Road, Teddington,
Middlesex TW1 8TD
Tel 01-977 1171

Marketing and R&D
Science Park, Milton Road,
Cambridge CB4 4BH
Tel 0223 350355

NewBrain

HARDWARE

MODELS

	D	A	AD	M	MD	MDB
Z80 Microprocessor	x	x	x	x	x	x
RAM 32K	x	x	x	x	x	x
Dual Casette	x	x	x	x	x	x
User Ports - 8 bit parallel input and 8 bit parallel output	x			x	x	x
V24 Bi-directional (H/W - autonomous)	x			x	x	x
V24 Printer (H/W - autonomous)	x			x	x	x
Display (16 characters)	x		x		x	x
V24 Bi-directional (S/W - non-autonomous)		x	x			
V24 Printer (S/W - non-autonomous)		x	x			
UHF		x		x	x	x
Video 40 x 24		x	x	x	x	x
Resolution 256 x 240 (max)		x	x	x	x	x
Expansion Port		x	x	x	x	x
ROM 24K		x	x	x	x	x
ROM/PROM 16/32K optional	x					
Advanced Video				x	x	x
Video 80 x 24				x	x	x
Resolution 512 x 240 (max)				x	x	x
V24 Extra two bi-directional ports				x	x	x
Battery Operation						x

EXPANSION MODULES

ROM Buffer Module	BUS buffer, ROM sockets, paging (Models A/AD only - user ports, autonomous V24 and printer ports)
	Analogue Ports
RAM Module	Up to ½ Megabyte
Multiple V24 Module	8, 16, 32 channels
Multiple User Port Module	3 in and 3 out
Videotext Module	Teletext and Viewdata (including Prestel)
Disk Module	Floppy Disks Winchester Disks
Battery Module	

SOFTWARE

ENHANCED ANSI BASIC

- . Independent operating system
- . Unlimited length string handling
- . Uniform I/O commands to handle up to 255 active streams
- . Chaining and run time program generation
- . Full user proofing of applications programs
- . External call capability
- . Direct interrupt handling capability
- . All major routines RAM vectored

SCREEN EDITOR

- . Up to 255 pages each with up to 255 lines of 40 or 80 characters
- . or continuous lines
- . Send page, line and character
- . Access of all functions from keyboard or line
- . Insert and delete lines and characters
- . Selectable character sets

MATHS PACK

- . 10 significant figure floating point arithmetic
- . 2 ms multiply

STATISTICS PACK

- . Data array entry and editing
- . Data array transformation
- . Descriptive statistics
- . Bi-variate correlation analysis
- . Hypothesis testing
- . Contingency table analysis

GRAPHICS

- . Absolute and relative plotting
- . Scaling and linear transformation
- . Line and arc drawing

ASSEMBLER

- . Interactive assembly code editor
- . Interactive debug package with multiple break points
- . Full relocatable, linkable object generation

PERIPHERALS

- . Monitors
- . Printers
- . Floppy and Winchester Disk Drives

GRUNDY BUSINESS SYSTEMS LIMITED, SCIENCE PARK, CAMBRIDGE, ENGLAND.
Telephone: Cambridge (0223) 350355 [5 lines]

APPENDIX I
HHC-RELATED DEVICES

Sinclair Research Limited
6 King's Parade Cambridge CB2 1SN England

US Office: 50 Staniford Street Boston
Massachusetts MA 02114 USA
Telephone (617) 742 4826

sinclair

Photo shows a model of the Sinclair Microvision flat screen pocket TV which will be available during 1982. Designed to retail at around £50 the Microvision incorporates an FM radio and will be able to receive transmissions almost anywhere in the world.

Production of the Microvision is to be sub-contracted by Sinclair Research to the Timex Corporation in Dundee, Scotland, as part of a £5 million capital investment programme announced on 18th February 1981.

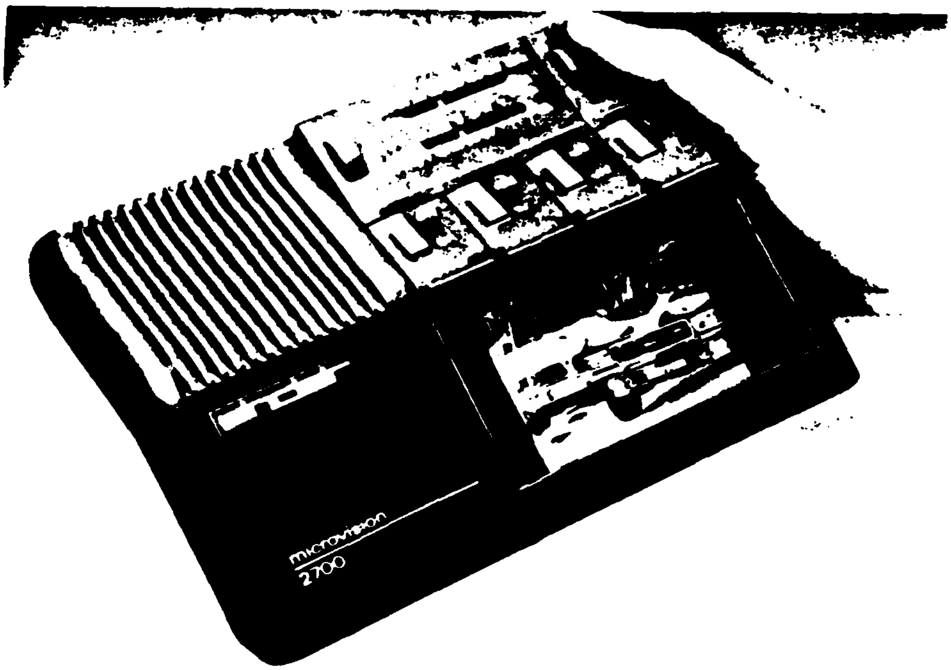
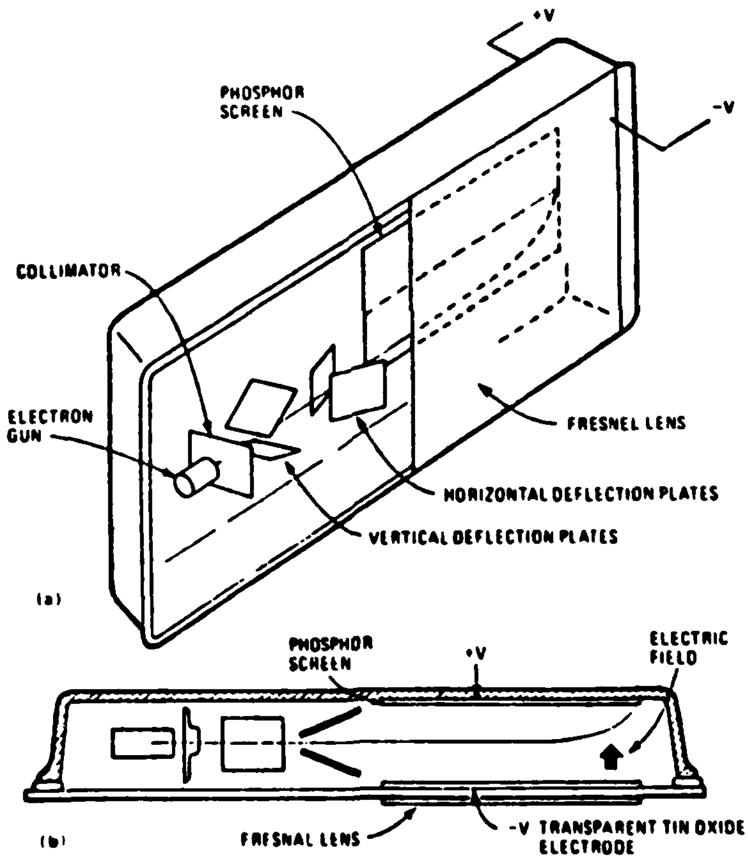


Diagram shows sectional views of the Sinclair Research flat screen TV tube which measures approx. 4 x 2 x 3/4 Initially it will be used in a multi-standard Sinclair Microvision pocket TV which will be available in 1982 and retail at around £50.

The tube is the result of a 5 year, £1 million plus, part NRDC-backed research and development programme. The cathode ray tube's electron gun is placed to the side of and in parallel with the phosphor screen (a). A transparent coating of tin oxide on the front plate forms focusing electrode that guarantees a circular beam spot on the screen (b).

(Reprinted from 'Electronics International'



APPENDIX J

GLOSSARY

GLOSSARY

Acoustic Coupler/Modem: A device which allows computer signals to be encoded, transmitted via telephone lines, and decoded.

Baud: Rate of data transfer in units of "bits per second".

Byte: Several binary digits of storage (often 4 or 8). The smallest addressable piece of storage.

FADAC: Field Artillery Digital Automatic Computer.

Flags Displayed*: On-Off "dots" which indicate a function or feature is active; for example, low battery, shift, degrees vs. radians.

HHC: Hand-Held Computer.

K: One thousand. For example, 3K = 3000.

MOS: Military Occupational Specialty.

Numerical Processing: When the computer is doing numerical processing, it reduces all inputs to their simplest numeric form, e.g., 2x8 would be immediately converted to "16" with no record kept of how that value was produced. (Compare "string processing".)

Parse: To divide a string of alphabetic data into pieces in order to facilitate its analysis on a component basis.

Peripheral: Optional add-on components like printers, extra memory, modems. (Compare "mainframe".)

QWERTY: Standard typewriter keyboard format.

RAM: Random Access Memory - can be both read and changed during execution; requires power or it will "forget".

ROM: Read only Memory - cannot be changed during program execution; requires no power to retain memory.

RPN vs. Algebraic Notation: RPN (Reverse Polish Notation) is a logic system for entering arithmetic operations into a calculator. In order to compute "3x4 = ?", the user types "3", hits an "ENTER" key, types "4" and presses "x". As soon as the "x" is pressed, the answer 12 appears.

The common alternative logic for calculator entry is called "algebraic". The keystroke entry sequence is "3", "x", "4" and "=". When "=" is pressed, the answer appears. Despite the unnaturalness of RPN for users unfamiliar with it, it has been shown (Kasprzyk, Drury, and Bialas, Ergonomics, 1979, No. 9, pages 1011-1019) that with well-trained users of both systems, the RPN logic proved superior consistently in terms of speed, errors, efficiency, etc. Because of this, some high-powered calculators use RPN. Nevertheless, because the training uses anticipated for the HHC involve little use of the HHC as a calculator and because the HHC will ordinarily be available only during training, it seems better to acquire an HHC which uses algebraic logic. Such an HHC can accept formulas nearly exactly as they appear in a textbook or field manual.

RS-232C: A standard high speed connection jack used by the computer industry for transferring data.

Selective Dot Erase*: A display device capability such that any dot on a display can be erased (or written) independently of all others; useful for animations and complex graphics.

String Processing: When the computer is doing string processing, it does no automatic conversions and treats letters, numbers, and punctuation identically; a "5" followed by a "0" is not treated as the number "50", but merely as consecutive entries no more or less meaningful than the entry of "$%" or "WZ". (Compare "string processing" and "parse".)

Trap-Door Encrypting Algorithm: An algorithm for encrypting which allows encoders to have an encryption key which can encode, but not decode, information.

User's Characters*: Characters, e.g., foreign alphabets, or iconic symbols which have been designed and stored in software but can be plotted as a single symbol.

---

* This is a definition for a term used in the table in Appendix A -- it is not a general definition.

FINAL REPORT

on

TASK II

AN EVALUATION OF THE FEASIBILITY OF USING HAND-HELD COMPUTERS FOR TRAINING

to

U.S. ARMY TRAINING DEVELOPMENTS INSTITUTE

April, 1982

by

Girard W. Levy
and
Larry D. Francis

The views, opinions, and/or findings contained in this report are those of the authors and should not be construed as an official Department of the Army position, policy, or decision, unless so designated by other documentation.

BATTELLE
Columbus Laboratories
505 King Avenue
Columbus, Ohio 43201

TABLE OF CONTENTS

LIST OF TABLES

INTRODUCTION

This study was undertaken to examine the feasibility of using hand-held computers (HHCs) for U.S. Army training purposes. Task I of this study surveyed the available HHCs and compared their features with regard to possible uses for training. The purpose of Task II was to survey selected Army courses taught at the U.S. Army Ordnance Center and School (USAOC&S), and identify specific training tasks that could be used to demonstrate the feasibility of using HHCs for training.

This report presents the results of Task II.

CAPABILITIES OF CURRENTLY AVAILABLE HAND-HELD COMPUTERS

The results of Task I showed that a number of significant training applications could be supported by the available technology of HHCs. The information gathered on the available devices did not permit firm, quantitative comparisons among the different devices, due to their different features and the different ways in which training tasks would be implemented on each device to capitalize on these different features. Firm conclusions cannot be made about the best HHC for training or for use in a training feasibility evaluation until a set of benchmark training applications are defined and programmed, and implementation is attempted on the more promising candidate devices. Task I concluded that the Panasonic/Quasar HHC was the most versatile and powerful device currently available, and that it could handle a reasonable subset of the training applications identified. Of course, the technology continues to evolve and improved capabilities and new devices are constantly being introduced into the market.

SURVEY OF SELECTED COURSES TAUGHT AT USAOC&S

Rationale for Course Selection

During meetings at USAOC&S, the various training course offerings, both enlisted and officer, were discussed. Courses were selected for review to represent the range of training activities offered at the school. The following courses were selected for review:

- 63B10 Light Wheel Vehicle/Power Generation Mechanic
- 44E30 Machinist
- 45G10 Fire Control Computer Repairer
- 41C10 Fire Control Instrument Repairer
- C20 Ordnance Officer Basic
- C22 Ordnance Officer Advanced

The enlisted MOS courses selected represent entry level training (63B10, 41C10, and 45G10) and advanced level training (44E30). These courses cover direct support and general support level maintenance. The officer courses selected represent both basic (C20) and advanced (C22) speciality courses.

Review Procedure

Interviews were conducted with the Team Chiefs, who are responsible for Course Development, and with personnel responsible for conducting the courses. In the interviews the concept of using an HHC for training was discussed. The following kinds of questions were asked:

1. What is difficult to teach/learn in this course?
2. Why is it difficult?
3. What parts of the course result in the most drop-outs, failures, or turnbacks?
4. Are there some things that are <u>not</u> taught because of their difficulty, and are left for OJT?
5. What would you gain/lose by using an HHC in this course?

In addition to the interviews, the Program of Instruction (POI) for each course was reviewed, and Lesson Plans for selected subjects in each course were studied.

Rationale for Task Selection

Tasks suitable for training on an HHC were selected in each course based on:

- Course need - the lesson was difficult and students could benefit from enhanced training
- Interesting application - the lesson offered an opportunity to illustrate a different way of applying HHCs to training
- Generalizability - the lesson represented a type of activity common to many courses (e.g., troubleshooting)

A variety of ways to enhance training using an HHC in the school environment were suggested during the course survey. These ways include reinforcement training, remedial training, self-testing, proficiency testing (examinations), and training management. Reinforcement training could involve review and practice prior to examinations, and computer guided practice with additional problems. Remedial training could involve additional work with an HHC as assigned by the instructor.

The HHC does not appear to be particularly useful for initial instruction (i.e., the traditional CAI tutorial mode). This is due to the limited display capabilities of existing devices. Neither does the HHC appear useful for tasks involving "seeing and feeling" or hands-on use of equipment. Since much of the course for MOS 41C10 (Fire Control Instrument Repairer) involves training for these types of tasks, applications of an HHC were difficult to conceptualize. No applications were identified for this course and it was eliminated from further consideration. Applications in the C20 course (Ordnance Officer Basic) were found to be very similar in approach (but not content) to applications in the C22 course (Ordnance Officer Advanced). In addition, more of the C22 course appears devoted to problem solving and practice exercises. For these reasons the C20 course was not studied further.

Description of Potential Applications

Potentially useful applications were found for most courses examined. Of course, many parts of the courses cannot effectively utilize an HHC to enhance training. As previously noted, the HHC does not appear useful for initial instruction. Many of the potential applications will require reference to supplemental sheets or student handouts to circumvent the display limitations.

63B10

The most promising applications in the 63B10 course involve troubleshooting vehicle systems and use of various TMs (helping soldiers understand TMs and checking soldiers' use of TMs). Table 1 presents the potential applications identified and a detailed example of how troubleshooting using a TM can be taught.

44E30

The most promising applications in the 44E30 course involve aiding the student in the use of shop math at the machines. This application is possible because of the size and portability of HHCs. Table 2 presents the potential applications identified and a detailed example of how use of shop math can be reinforced.

45G10

The most promising applications in the 45G10 course involve digital electronics. Table 3 presents the potential applications identified and a detailed example of drill-and-practice in one basic subject.

TABLE 1. POTENTIAL APPLICATIONS IN THE 63B10 COURSE

Course: 63B10 Light Wheel Vehicle/Power Generation Mechanic.

Lessons: Parts of A-3, A-5, A-6, A-8, A-10, A-11, C-1, C-7, C-13, C-14, C-17, D-1, D-3, E-1, E-8, E-11, H-1, H-3 (Lessons related to Power Generation have been excluded, due to possible revisions in the POI.)

Applications: Drill and practice for characteristics of vehicles and tools*, automotive electricity*, shop safety, use of reference material, and engine principles*.

Problem solving for troubleshooting vehicle systems*, and for vehicle recovery problems*.

Games to practice troubleshooting.

Training management for testing, and for diagnosing student learning problems related to the referenced lessons.

*- Will probably require reference to printed illustrations or problems.

63B10 Example: A student wants self-testing on troubleshooting prior to the course examination. The student is provided with an HHC with preprogrammed and preloaded programs to randomly generate a series of troubleshooting problems.

The HHC is used to generate troubleshooting problems, display symptoms and test results, provide feedback on the tests selected, monitor use of the TM, and score the final decision (identification of the failed component).

TABLE 1. POTENTIAL APPLICATIONS IN THE 63B10 COURSE (Continued)

	General Flow	Example
1	Student (S) turns HHC on	
2	Computer (C) displays menu of available lessons	For example, the menu of lessons might be: 1 - Troubleshoot fuel system 2 - Troubleshoot electrical system 3 - Troubleshoot clutch 4 - Troubleshoot service brakes 5 - Troubleshoot steering
3	S selects appropriate choice	Suppose S enters "1"
4	C acknowledges choice	C displays "You have chosen Lesson 1"
5	C asks S to choose vehicle	C displays "Which vehicle? M151, M880, or M35?"
6	S selects appropriate vehicle	S enters "M35"
7	C acknowledges choice	C displays "O.K. Troubleshooting the fuel system on the M35"
8	C randomly selects component to fail (but does not tell student)	C selects defective injection fuel pump from list of possible malfunctions
9	C displays appropriate symptom(s) of malfunction	C displays "Symptom is engine cranks but will not start"
10	C asks S to indicate appropriate TM	C displays "Enter TM number?"
11	S enters TM number	S enters "TM9-2320-209-20-1"
12	C indicates whether correct or incorrect	C displays "Correct TM"
13	C asks S to indicate page number from TM	C displays "Enter page number?"
14	S enters page number	S enters "2-19"
15	C indicates whether page is correct or incorrect	C displays "Correct page number"
16	C asks S to select test number from page in TM	C displays "Enter check"
17	S enters test number	S enters "2.1" or "Check fuel level"
18	C displays test result(s)	C displays "Gage reads full and fuel in tank"
19	C asks S to select next test	C displays "Enter check"
20	S enters test number	S enters "2.2" or "Check fuel pump"

TABLE 1. POTENTIAL APPLICATIONS IN THE 63B10 COURSE
(Continued)

	General Flow	Example
21	C displays test result(s), etc.	C displays "No fuel in pump"
22	C asks S to select next test	C displays "Enter Check"
23	S enters instructions to go to new page	S enters "Go to 2-17"
24	C acknowledges choice	C displays "Going to 2-17"
25	C asks S to select next test	C displays "Enter check"
26	S enters test number	S enters "2.2" or "Examine fuel pump"
27	If incorrect, C provides correct test number, etc.	C displays "No, you should perform check 2.1 first"
28		C displays "Enter check"
29		S enters "2.1" or "Check filters and lines"
30		C displays "No plugs or defects"
31		C displays "Enter check"
32		S enters "2.2" or "Examine fuel pump"
33		C displays "Pump does not operate"
34		C displays "Enter check"
35		S enters "Replace fuel pump"
36		C displays "No, you should go to page 2-101 first"
	[After completing checks on pages 2-101 and 2-102]	
37	S enters decision to perform some maintenance action	S enters "Replace fuel pump"
38	C acknowledges choice	C displays "Fuel pump replaced"

TABLE 1. POTENTIAL APPLICATIONS IN THE 63B10 COURSE
(Continued)

	General Flow	Example
39		C displays "Enter check"
40		S enters "Crank engine"
41		C displays "Engine starts"
42	C indicates whether correct or incorrect and scores performance	C displays "Good. You completed this problem in 125 seconds."
43	C returns to lesson selection step (Step 2)	C displays "Select lesson?"

After completing the problems, the HHC can store and display the number of problems attempted, the number of errors and the type of errors by system (fuel system, electrical system, etc.). This information can be used as the basis of a game or contest among students.

TABLE 2. POTENTIAL APPLICATIONS IN THE 44E30 COURSE

Course: 44E30 Machinist BTC

Lessons: Parts of EA-1, EA-2, EA-4, EC-16, EC-23, EE-2, G-1, H-1, H-2, H-4 and H-5.

Applications: Drill and practice for basic math, metric conversion, use of trig tables, shop safety, welding symbols*, nomenclature for tools, machines, drills, threads, and gears*.

Problem solving for shop math problems*, job estimate problems*, and layout problems*.

Job aid for guiding problem solving while at the machines (not functioning as a calculator or substituting for use of the FM).

Training management for testing, and for diagnosing student learning problems related to the referenced lessons.

*- Will probably require reference to printed illustrations or problems.

44E30 Example: A student is working on shop math problems. The student is provided with a sheet of shop math problems, a sheet of formulae, the necessary FM, and an HHC with preprogrammed and preloaded programs to match the problems.

For example, the problems might be:

1. Find the correct drill speed (in rpm) for drilling a 1/2-inch hole in a stainless steel plate 1/4-inch thick.
2. Find the correct drill speed (in rpm) for drilling with a Number 35 twist drill in forged steel that is 1/8-inch thick.
3. Find the correct spindle speed for cutting a 1-1/2-inch diameter aluminum stock 4-inches long on a lathe.
4. Compute the tap drill size for a 3/8-16 UNC thread.
5. Find the major diameter for a No. 10-32 screw.
6. Compute the tap drill size for a No. 10-32 screw.

The HHC is used to guide the selection of the correct formula, provide feedback on values being used (from problem statement or TM), guide arithmetic computations (but not perform the computations), and score the problem solution.

TABLE 2. POTENTIAL APPLICATIONS IN THE 44E30 COURSE (Continued)

	General Flow	Example
1	Student (S) turns HHC on	
2	Computer (C) displays menu of available lessons	For example, the menu of lessons might be: 1 - Basic Math 2 - Metrics 3 - Use of Trig Tables 4 - Shop Math Problems 5 - Job Estimate Problems 6 - Layout Problems
3	S selects appropriate lesson	Suppose S enters "4"
4	C acknowledges choice	C displays "You have selected Lesson 4"
5	C asks S to enter problem identification from sheet	C displays "Enter Problem Number"
6	S enters problem identification	Suppose S enters "1"
7	C acknowledges choice	C displays "You have selected Problem 1"
8	C asks S to select equation from sheet	C displays "Select equation"
9	S enters equation or identification number	S enters "RPM = (CS x 4)/D"
10	C indicates whether correct or incorrect	C displays "Right equation!"
11	If correct, C asks S to enter value for first variable	C displays "Enter CS"
12	S enters value from TM	S enters "30"
13	C checks and acknowledges if within range and in correct units	C accepts values between 30 and 40 C displays "What units?" S enters "rpm"
14	C asks to enter value for second variable, etc.	C displays "Correct, Enter D"
15	S enters value	S enters "1/4 inch" C displays "Correct"
16	When all values have been entered, C asks for partial solutions	C displays "What is CS x 4?"
17	S enters partial solutions	S enters "120"
18	C indicates whether correct or incorrect	C displays "Correct"

TABLE 2. POTENTIAL APPLICATIONS IN THE 44E30 COURSE
(Continued)

	General Flow	Example
19	If correct, C asks for final solution	C displays "What is correct RPM?"
20	S enters final solution	S enters "480"
21	C indicates whether correct or incorrect	C displays "That's right!"
22	If correct, C asks for S decision (drill size, machine setting, etc.) if appropriate	(Not applicable in this example)
23	S enters decision	
24	If correct, C scores problems, displays results and returns to enter problem identification step (Step 5)	C displays "You have 1 right out of 1 problems. Enter Problem Number"
	Suppose the S makes a mistake at 20:	
20	S enters final solution	S enters "30" or other wrong answer
	C indicates whether correct or incorrect	C displays "That's not correct. Try again."
		S enters "30" again
	C aids S	C displays "You must divide 120 by 1/4. That's the same as multiplying by 4. Try again."
		S enters "480"
	C indicates whether correct or incorrect	C displays "That's right!"
	C indicates results and returns to Step 5	C displays "You have 1 right out of 1 problems. You have made 1 errors. Enter Problem Number"
	Advanced Lessons	
	Steps 1-7 as above:	
8'	C asks S for final answer	C displays "Enter final answer"
9'	S enters answer	S enters "400" or other wrong answer
10'	C indicates whether correct or incorrect and (if error cannot be diagnosed from the answer) begins step-by-step mode of Problem Solving (goes to Step 8 in main sequence)	C displays "Not quite correct. Let's check how you got that answer"

TABLE 2. POTENTIAL APPLICATIONS IN THE 44E30 COURSE
(Continued)

After completing the problems, the HHC can store and display the number of problems attempted, the number of errors, and the type of errors (selecting formulae, looking up tabled data in the FM, arithmetic errors, decision errors, etc.). Some of this information can be used as the basis of a game or contest among students.

TABLE 3. POTENTIAL APPLICATIONS IN THE 45G10 COURSE

Course: 45G10 Fire Control Systems Repairer

Lessons: Parts of A-5, B-1, B-2, B-3, B-4, B-5, B-6, B-7, B-8, B-9, B-10, B-11, B-14, B-15, B-16, B-17, B-18, B-19, B-20, C-1, C-2, C-3 and C-5.

Applications: Drill and practice for shop safety, electrical safety, basic electricity, circuit analysis*, basic digital circuits*, logic applications* and number system conversions.

Problem solving for circuit analysis and logic mechanization problems*.

Training management for testing, and for diagnosing student learning problems related to the referenced lessons.

*- Will probably require reference to printed illustrations or problems.

45G10 Example: A student requires reinforcement training on binary/octal/hexadecimal conversions. The student is provided with an HHC with preprogrammed and preloaded programs to randomly generate a series of number system conversion problems.

The HHC is used to generate and display the problems, adjust the difficulty level to student performance (adaptive program), guide the problem solution, and score the answer.

TABLE 3. POTENTIAL APPLICATIONS IN THE 45G10 COURSE (Continued)

	General Flow	Example
1	Student (S) turns HHC on	
2	Computer (C) displays menu of available lessons	For example, the menu of lessons might be: 1 - Number Systems 2 - Decimal - Binary Conversion 3 - Decimal - Octal Conversion 4 - Decimal - Hexadecimal Conversion 5 - Binary Arithmetic 6 - Boolean Logic 7 - Flip-Flop Circuits 8 - Logic Mechanization Problems
3	S selects appropriate lesson	Suppose S enters "2"
4	C acknowledges choice	C displays "You have chosen Lesson 2"
5	C generates and displays initial problem (using random number generator)	C displays "3(10) = _ _ (2)?"
6	S enters answer	S enters "11"
7	C indicates whether correct or incorrect	C displays "Right!"
8	C generates and displays second problem	C displays "101(2) = _ (10)?"
9	S enters answer	S enters "5"
10	C indicates whether correct or incorrect. If S answers three problems in sequence correctly, C increases difficulty of subsequent problems. If S answers two problems in sequence incorrectly, C decreases difficulty of subsequent problems. If S makes an error, C repeats problem after 2 or 3 intervening problems.	C displays "Right!"

TABLE 3. POTENTIAL APPLICATIONS IN THE 45G10 COURSE
(Continued)

General Flow	Example
11 When many (10 to 20) problems have been attempted, C displays results and returns to select lesson step (Step 2). C stores S difficulty level until deliberately cleared. (This allows S to extend lessons at latest difficulty level.) C stores problems missed for instructor diagnosis.	C displays "You got 19 out of 20 problems correct. Very good. Enter Problem Number".

After completing the problems, the HHC can store and display the problem difficulty level and percent correct score. This information can be used as the basis of a game or contest among students.

C22

The most promising applications in the C22 course involve problem solving for preparing orders, completing forms and performing exercises. Table 4 presents the potential applications identified and a detailed example of how preparation of orders can be taught.

Priorities for Implementation

The potential applications identified in four courses reviewed during the survey were ranked in order of priority for implementation for a feasibility test and evaluation study.

In rank ordering the courses consideration was given to (a) satisfying training needs of the course and (b) providing a useful setting for a test and evaluation study. This means that there must exist a substantial block of instruction (not bits and pieces) in the course that can benefit from introduction of an HHC for training. In addition, the student volume of the course should be large enough so that number of participant students will not be a problem in a statistical study. Finally, the applications should be generalizable to other TRADOC courses.

The courses are listed below from highest to lowest priority:

1. 63B10 Light Wheel Vehicle/Power Generation Mechanic
2. 45G10 Fire Control Systems Repairer
3. 44E30 Machinist
4. C22 Ordnance and Chemical Officer Advanced

The 63B10 course has blocks of instruction devoted to troubleshooting vehicle systems and has a high volume of students. Troubleshooting is a significant part of many TRADOC courses.

The 45G10 course has a block of instruction devoted to basic digital electronics. In addition, students in this course (concerned with computer maintenance) would be motivated to use HHCs in their training.

The 44E30 course has blocks of instruction devoted to basic and shop math. The HHC could be useful at the machines.

The C22 course has numerous problems and exercises. These occur throughout the course, and require the development of large amounts of supplemental material (handouts) to implement training using an HHC.

TABLE 4. POTENTIAL APPLICATIONS IN THE C22 COURSE

Course: C22 Ordnance and Chemical Officer Advanced

Lessons: Parts of A2-10, A2-12, A2-14, A2-15, A2-19, A2-21, A3-2 through A3-8, A3-10, A3-11, A3-12, B1-2, B2-1, B2-5, B2-7, D1-6, D2-5, D2-6, E-3, E-5, I1-2, I1-3, I1-6, I1-9, I1-11, I1-12, I1-15, I1-21, I1-23, I1-40, I2-8, I3-5, I4-6, I5-2 through I5-8, I5-14 through I5-27, I5-31, I6-2, I6-3, I6-5, I6-6, I6-7, I9-8 (POI dated January 1980).

Applications: Problem solving for reading printouts*, responding to situations*, solving managerial problems*, computing requirements*, computing weapons effects*, and analyzing reports*.

Inquiry for developing plans*, and completing forms*.

Games to practice estimating and computing skills*.

Training management for testing, and for diagnosing student learning problems related to the referenced lessons.

*- Will probably require reference to printed illustrations or problems.

C22 Example: A student needs reinforcement training in preparation of Operation Orders. The student is provided with a sheet containing order and plan problems, an HHC with preprogrammed and preloaded programs to match the problems, partial information corresponding to each problem (but not in correct format or sequence), and a set of blank standard forms.

The student identifies the situation or problem, and then selects the questions he needs to ask to get information from the HHC to complete the form. The partial information provided for each problem obviates the need to display lengthy pieces of information. Nevertheless, the student must identify which crucial pieces of information (dates, unit designations, etc.) needed to complete the OPORD are missing, and must determine where to place the available information in the OPORD form. Extraneous information may also be present in the information sheet provided for each problem. In response to the student's questions, the HHC provides the requested information, or indicates that it is already available in the information sheet. The student then indicates where the information goes on the OPORD form. Upon completion, the HHC scores the solution, and, when connected to a printer, can print the OPORD, if desired.

TABLE 4. POTENTIAL APPLICATIONS IN THE C22 COURSE
(Continued)

	General Flow	Example
1	Student (S) turns HHC on	
2	Computer (C) displays menu of available lessons	For example, the menu of lessons might be: 1 - OPORD/OPLANS 2 - ADMIN/LOG orders 3 - SOP's 4 - Warning orders 5 - FRAGO's
3	S selects appropriate lesson	Suppose S enters "1"
4	C acknowledges choice	C displays "You have selected OPORD/OPLANS
5	C asks S to enter problem identification from sheet	C displays "Enter Problem Number"
6	S enters problem identification	Suppose S enters "1"
7	C acknowledges choice	C displays "You have selected DISCOM OPORD Problem A"
8	C asks S to enter first question	C displays "Your question?"
9	S enters question to obtain information not available in the handout	S enters "What is enemy forces situation?"
10	C provides relevant information or the location of the requested information in the handout	C displays "Annex A (Intelligence) to 25th Armed Division OPORD 26"
11	C asks S to indicate where in the OPORD the information should be placed	C displays "Placement?"
12	S indicates location in OPORD form	S enters "Paragraph 1 a"
13	C asks S to enter next question	C displays "Your question?"
14	S enters question	S enters "What is friendly forces situation?"
15	C provides the location of the requested information in the handout	C displays "See Note 3" (Note 3 in the handout contains a description of friendly forces situation, but lacks certain essential items of information necessary to complete Paragraph 1 b.)

TABLE 4. POTENTIAL APPLICATIONS IN THE C22 COURSE
(Continued)

	General Flow	Example
16	C asks S to indicate where in the OPORD the information should be placed	C displays "Placement?"
17	S indicates location in OPORD form	S enters "Paragraph 1 b"
18	C asks S to enter next question	C displays "Your question?"
19	S enters question	S enters "When does attack occur?" (Apparently Note 3 did not contain this needed information.)
20	C provides relevant information	C displays "100500 May"
21	C asks S to indicate where in the OPORD the information should be placed	C displays "Placement?"
22	S indicates location in OPORD form	S enters "Paragraph 1 b"
23	C asks S to enter next question, etc.	C displays "Your question?"
24	When S has asked all questions he needs, he indicates placement of remaining items in handout. C indicates whether additional questions need to be asked and/or information placed in the OPORD form. C scores the problem based on the number of unnecessary questions asked and the placement of only relevant information in the correct paragraphs of the OPORD. C displays the results, determines if a printout is desired, and returns to the problem identification step (Step 5).	

TABLE 4. POTENTIAL APPLICATIONS IN THE C22 COURSE
(Continued)

General Flow	Example
When connected to a printer, C will print out the OPORD as prepared and sequenced by S along with the problem number, the number of unnecessary questions asked, the number of irrelevant items of information included, the number of essential items of information omitted, the number of items incorrectly placed, etc.	

After completing the problems, the HHC can store and display the number of problems completed, the number of errors, and the type of errors made. This information can be used for diagnostic purposes by the instructor.

DISCUSSION

Considerations Regarding the Choice of a Specific Device

New Devices

Since computer technology is an area of such active exploration and development, it is hardly surprising that new HHCs are being marketed regularly and that little advanced information is supplied. Specifically in this case, two significant new devices have become available in the few months since Part I of this study was prepared. Tandy (Radio Shack) has announced the TRS-80 PC2, a considerably enhanced version of the PC1. Several of the major limitations (especially expandable memory size) have been improved, but no actual devices or detailed specifications are available at this time. The cost should be about $280 and deliveries are promised in the second quarter of 1982. Note that the table in Part I refers only to the older PC1.

Hewlett-Packard has announced nearly a dozen new peripherals which enhance the HP-41C. A bar code printer and extra memory (4K) are the most important additions for Army training needs. An important set of business software was released for the Panasonic/Quasar. Although none is related to Army training needs, the availability of such software opens the possibility that Army units may acquire the device as an everyday tool and thus have it available for embedded training applications (see section on piggybacking and embedding capabilities).

Memory Considerations

The size of the available memory remains a significant issue. In general, nearly all microcomputer users eventually become sophisticated enough in their needs and applications that they run out of memory space. Although large memories may not be needed for a demonstration project, eventual usefulness of a device will probably be limited by memory size. Flexibility in memory type can be useful, as well. Although pre-programmed ROM is optimal for long-term, field-use delivery, the demonstration project would be advised to use the more easily modifiable RAM memory. Later, a ROM could be produced by the manufacturer from the program stored in the RAM. Thus, ideally, large amounts of both types of memory should be available.

It is true that many instructional examples (including those noted in this study) can be programmed in a few thousand bytes. However, most of those uses are not cost-effective if they stand alone.

One would not put a small drill-and-practice lesson on an intelligent device: flashcards would be cheaper. Only if a large number of items were to be learned and a sophisticated feedback paradigm were to be used would an HHC be cost justified. Likewise, a simple simulation or problem-solving task can be programmed on almost any HHC, but a job performance aid would be only a few pages for such a task. Only for a complex, interrelated system could cost-effectiveness result from an HHC implementation.

To summarize, the availability of modular RAM and ROM memory in large amounts is very important for choosing an appropriate HHC for training.

Display

Because the display is so limited on an HHC, it is important to consider the types of training problems which need to be solved. Information presentation via the HHC (e.g., a tutorial) is clearly impractical. The matrix LCDs offers little over the segment displays unless one designs his own characters or iconics. Iconics can be useful since they concisely "picture" some piece of information. For example on a system which required temperatures, humidity, angle, etc., to be entered, it might be possible to display each input next to its iconic representation (thermometer, raindrop, pie-slice) on a single line, rather than paging through several lines to review all input. Upper and lower case letters are also important for some topics (e.g., chemistry: Co is not CO).

Language

Since no HHCs have a CAI language (e.g., PILOT), it is clear BASIC will have to be used. However, it is possible to use BASIC effectively if the developers have access to a library of CAI subroutines which emulate CAI commands.

Speed

For most CAI applications, computer speed is rarely a limiting factor. Computation can and should be broken up so it is done as each input is made. All the available HHCs appear to have adequate computational power for the kinds of tasks envisioned.

Peripherals

Although the number and range of peripherals (other than memory, discussed above) may not be important for training delivery, they do decrease courseware production costs. Furthermore, they tend to promote general acceptance by a large community of users with whom experience can be exchanged.

Logistical Considerations

The discussion of modes of use for a limited test and evaluation study is clouded by "chicken-and-egg" problems. Some of the most exciting and most cost-effective modes of use require considerable front-end investment. For example, most HHCs could be interfaced to a large mainframe computer or a central microcomputer. Such a system could store training materials and load them individually as needed into each student's HHC. Likewise, all results from students could be fed by interface to the main computer for compilation and long-term storage. Alternatively, for some HHCs, such data could be centralized in the instructor's HHC. But for a demonstration program, it is perhaps most feasible to use less automated means to disseminate courseware and to record results.

In the long range view, it might be advantageous to issue trainees HHCs which they carry with them during and after class. This would allow extra practice to be encouraged in the manner that video games motivate users. For the demonstration project, however, a simpler approach in which HHCs are handed out by instructors at the beginning of class and collected when class is over should provide an adequate test. Different devices would have different sets of lessons preloaded.

User Acceptance

User acceptance by students is expected to be high because calculators and computers tend to be intrinsically interesting, high status items. The "extra" features some HHCs have built in (e.g., the clock/calendar functions) may offer a considerable distraction to students and this may lower instructor acceptance. Further, during interviews with course instructors, Battelle researchers noted continuing confusion in the minds of instructors between calculators (which the school does not provide or encourage students to use) and HHCs. This difference will be important to point out to instructors during any demonstration project. Complicating this issue, and probably contributing to a negative image of any HHC chosen, is the "calculator feature" built into most HHCs. It would require a new ROM to eliminate this feature from the HHCs -- a fairly costly step.

Instructional Applications Amenable to HHCs

HHCs offer certain specific advantages and disadvantages based on their characteristics. The sections below discuss how such issues affect potential instructional uses.

Reasons for Using HHCs

The four main reasons for considering HHCs as an instructional delivery device are:

- portability
- capability for piggybacking or embedding training
- size
- cost

Portability. Portability of training is probably the best reason for using an HHC. Though microcomputers are often called personal computers, HHCs may be considered even more personal; they can be carried in one's pocket in most cases and in a briefcase-sized compartment in all cases. Replaceable or rechargeable batteries provide at least 100 hours of power. Thus, it is easy to imagine never being without a computer more than a few seconds away. This concept is so new, its implications are still not clear. What is clear, however, is that at least for some time few trainees are likely to have an HHC bought for them by the U.S. Army. The Radio Shack PC2 may have and the Panasonic/Quasar does have features of great use to high ranking officers. These devices have a real-time clock, alarm, and message system which lets one set multiple alarms for the future and attach a message to each. A user of this HHC should never again forget a meeting, appointment, or medication. The same device lets the user create and search files he has constructed: phone numbers, "tickler" files, etc.

If an HHC is always with the user, the training applications are endless. Even with the more typical situation (HHCs that are not regularly carried with the user), there are at least two good applications of the portability capability of HHCs; field training and salvaged time. Often trainees must walk around or be a passenger in a vehicle to perform their duties. In such cases there may be a considerable advantage to a portable training system. Moving great distances is not necessary: a lab or shop technician being trained to perform a multi-step task in a large work area will find it much more convenient to carry an HHC (plus a chemical flask, or a machine part) from workstation to workstation rather than returning to a central, fixed CAI terminal after each step.

If HHCs were adopted by the Army for certain MOSs, wasted time could be recaptured. Salvaging wasted time can, in effect, add one to four hours of training time to a soldier's day. By carrying an HHC loaded with training material, anyone who spends a lot of time waiting (e.g., a derrick operator or a security guard) can regain time which is otherwise boring.

Piggybacking and Embedding Capabilities. Piggybacking training is typically a sound and cost-effective concept whether the computer system used is a maxi-, mini-, micro-, or hand-held. Because many HHCs have keys that can be reprogrammed for each application package, it is very feasible to place a keyboard overlay on an HHC which does Civil Engineering or aviation calculations, exchange the read-only memory chip (ROM) so training rather than computation can be done, and commence training. Easy access to and familiarity with the computer tend to promote convenient training. The extra advantage of HHCs is the range of subject matter which they are expected to have will expand the range of training opportunities.

Embedded training is another capability which is feasible on other devices, but which may find more applications with HHCs. Embedded training is training which is an intrinsic part of a tool or machine (generally an "intelligent" device). When an operator of the intelligent device uses it, it may sense training is appropriate and branch the operator to a training routine. An oversimplified example: if the user of an office copier pressed the "COPY" button three times without inserting a new original, an intelligent copier could surmise the user is unfamiliar with the multiple copy controls and provide a short set of directions. Such a copier does not yet exist: intelligent copiers exist, but they would use an internal microprocessor for embedded training, not a separate HHC. However, few of the existing machines used by the Army are intelligent. To upgrade these devices without retooling, the Army or a manufacturer may find it cost-effective to retrofit an HHC into a new or existing machines for monitoring and controlling purposes. Once this has been accomplished, embedding training in the monitoring and controlling programs is straightforward.

Size. Even when a power cord is not a disadvantage, the tiny size of a HHC may offer advantages over a microcomputer. No doubt that is why an HP-41C was chosen for use by space shuttle astronauts. Most situations requiring miniaturization are related to moving vehicles and have already been discussed under the "portability" heading; nevertheless, there is usually an advantage to consuming less space: a desk with a HHC on it is less crowded than a desk with a microcomputer on it.

Cost. Smaller devices have, in general, meant smaller prices. This has been one of the reasons for the success of microcomputers. The HHCs now on the market list in the $170 to $250 range. The Panasonic/Quasar lists for $500-$600. These prices are very low; however, as with microcomputers, peripherals can raise the price to nearly $2,500.

Reasons for Using Other Media

The portability of HHCs places severe constraints on the keyboard and display. No pocket-size HHC has a keyboard on which one can easily touch type, although it is barely possible on the Panasonic/Quasar. A standard-size keyboard would limit portability considerably. Some HHCs use an ABCDE-format keyboard with a 10-key numerical layout which may be easier for some types of users to operate. However, no matter which HHC is considered, it is clear that entering large amounts of information is slower and less desirable on an HHC.

The same constraints that make the keyboard small limit the size of the display. Information presentation in the traditional mode of a CBI tutorial is not practical. It would be practical to use other portable media (e.g., printed matter) to provide background information, rules for simulation and games, etc., and to perform the interaction on the HHC. Within the space constraints of the display, the dot matrix screen provides much more flexibility for generating graphics and user-designed characters. For reasonable graphics, however, a flat TV image is needed. Animation of the existing displays is limited by the speed of the microprocessor and the persistence of the LCD display.

In conclusion, it is apparent that the tradeoff between small size (for portability) and large size (for better keyboards and displays) is not clearly resolvable via technological advance. Battelle believes the severe display constraints will restrict the CAI role of HHC at least until voice input and output capabilities are added. We feel that initially HHCs will be used in those cases where mobility of the training device is paramount.

Instructional Strategies

CAI on any type or size of machine is often found to be most accepted and cost-effective when the computer is used for the "high level" (a la Bloom) types of instruction (inquiry, problem solving, simulation, etc.) or when large data bases are used (e.g., foreign language training). These techniques cannot be accomplished via other media.

Individualized instruction has also been found to produce consistent cost savings, and sometimes increased effectiveness. The Army is increasing the use of computer-supported delivery systems in selected training situations. Use of computers in the resident training environment is also increasing. Thus, computer managed instruction (CMI) may provide appropriate situations for implementing HHCs. The development of a CMI capability for an HHC, however, is a considerable investment and many of the feasibility concerns for CMI on an HHC can be satisfied by a study of CAI feasibility. Thus, a test and evaluation plan of CMI for HHCs is not recommended at this time.

Compelling Instructional Uses for the HHC

The first uses of HHCs for instruction are likely to be similar in some ways to the first uses of large computers for instruction -- but for different reasons. Years ago the first CAI instruction was often concentrated in math because math is so easy to program. On HHCs, mathematical topics are especially promising because the inputs and outputs are very concise and thus are not constrained by the limited display capabilities.

Examples of uses where an HHC makes an outstanding contribution to instructional services should not be expected at this time in standard MOS school courses. Over time solutions have been found for most training needs or these needs have been "buried" by the structured nature of the training. For example, experienced automotive mechanics can use engine noises and other sounds to troubleshoot mechanical problems. Since these sounds are difficult to produce and control in a learning environment, they are not usually included as part of the course objectives, and alternative troubleshooting and preventative maintenance techniques are established. Eventually, the need for auditory simulation of various engine noises for training is forgotten. Sound synthesizers capable of simulating engine noises are now available, but the "need" no longer exists.

Probably one should expect to find the best examples of HHC applications in non-traditional settings: exported training, skill maintenance training, games for off-hours use, etc. Many of the applications could come in places where little or no training is currently provided. For example, an HHC could be provided on the job where a soldier is required to use a large number of acronyms or part numbers.

These more expansive uses of an HHC may be impractical for a demonstration project, but they should be kept in mind for the long range. Furthermore, such uses might prove to be so popular that evaluations would be flavored with the strong emotional reaction to the HHC, not the rational, fact-based reaction which would be more generalizable.

CONCLUSIONS AND RECOMMENDATIONS

Recommendations for Training Developers on Use of HHCs

Although HHCs have not been applied to Army training needs and tested for effectiveness, a number of recommendations can be made, based on analogies to other CAI applications and the characteristics of available devices.

First, HHCs do not appear useful for delivery of initial instruction, due to their display limitations. They do appear useful for delivery of reinforcement (supplemental) or remedial training. Inputs and outputs must be kept brief, and references to student handouts will often be required to circumvent the display limitations.

Second, the availability of large amounts of modular ROM for the device chosen is important.

Third, applications that capitalize on the HHCs size and portability or that use the HHC for piggybacking training will be useful.

Fourth, applications that involve drill-and-practice on a large (~100) number of items, that involve adaptive difficulty, or that involve branching, will prove useful on an HHC. Applications that involve complex problem solving, graphics, or complex response judging will prove difficult on an HHC.

Tasks to be Implemented

Two courses with different types of applications should be chosen to demonstrate the feasibility of using HHCs for enhancing training. These courses should be the 63B10 course (troubleshooting using TM's) and the 45G10 course (basic digital electronics). Sufficient material can be programmed for each course to provide a test and evaluation of HHCs for enhancing training.

Hardware Availability and Appropriateness

Many of the commercially available HHCs can handle the applications identified. All have extra features that are not needed for training. Extra capabilities (e.g., memory) may be needed for initial applications, to accommodate multiple applications, or for conducting a test and evaluation study.

The Panasonic/Quasar HHC appears capable of handling all the applications identified. The HP-41C and the TI-59 are most suitable for math problem solving and math drill and practice, as found in the 45G10 and 44E30 courses. The Sharp/Radio Shack PC1 and Pinetree have insufficient memory capability for most applications.

If two courses are chosen to demonstrate the feasibility of using HHCs for enhancing training, the Panasonic/Quasar HHC would make a good choice for the 63B10 course applications, and the HP-41C would make a good choice for the 45G10 course applications. The HP-41C's recently announced peripherals and its comparatively large quantity of existing software (for example, an algorithm for number system conversions) make it more attractive than the TI-59 for this application.

Conduct of a Feasibility Test and Evaluation Study

A feasibility test and evaluation study is recommended to evaluate the effectiveness of HHCs compared to traditional modes of supplementing training. Two courses and two different devices should be chosen to provide a range of device types and course applications.

The applications should be refined and programmed in consultation with subject matter experts for each course. After programming is completed, several devices of each type to be used in the test should be procurred and used in a pilot test.

A detailed feasibility test and evaluation study plan should be developed for the HHC segments of the courses. This plan should include the conduct of a pilot test and full-scale tests to evaluate the effectiveness of HHCs. Among other matters, the plan should describe the source of control group data for the test.

Finally, sufficient HHCs should be procurred for the test, and the test conducted.