The Wang 2200 Portable Computing System is designed to meet the computing demands of educational, laboratory/scientific, engineering and a multitude of business applications.

The self-contained desktop system consists of a powerful and responsive processor with an easy-to-program built-in higher level BASIC interactive language and an expandable memory, a 9-inch Cathode Ray Tube (CRT) display, a Single Tape Cassette Drive, and an Upper/Lowercase Alphanumeric/BASIC Keyword Keyboard.

A number of options and peripherals also are available to meet your particular processing needs. These add-ons include memory expansion to 32,768 bytes in 8,192 byte increments, data output capabilities with the Model 2221W Printer (200 char/sec) and the Model 2231W Printer (120 char/sec), plotting capabilities with the Model 2272-1 Drum Plotter (single pen) and the Model 2272-2 Drum Plotter (three pens) and additional display, data entry, and processing control capabilities with Option 60-Auxiliary Display Connector, Keyboard Clicker, and Audio Alarm.

IN PARTICULAR
The Central Processor

An 8,192 (8K) bytes Random Access Memory (RAM) and I/O capabilities are standard with the Portable Computing System (PCS).

A powerful 42.5K byte BASIC Interpreter is separately "hardwired" into a Read Only Memory (ROM) area of the unit leaving nearly the entire RAM available for user data and programs — only 700 bytes are reserved for system use. By "hardwiring" the interpreter, the PCS is instantly ready to use with user memory directly accessible and fully available for data processing.

In addition to the comprehensive standard version of BASIC provided with the PCS, the system also is equipped with four special BASIC instruction sets hardwired into the ROM, which significantly expand the power and capability of the processor. The SORT ROM set provides a group of advanced programming statements containing six matrix operations for byte and array-element manipulation, sorting, statistical searching, etcetera. The Matrix ROM set offers fourteen mathematical matrix procedures which operate on numeric arrays according to the rules of the linear algebra, invert matrices, simplify and expedite input/output (I/O), and print alphanumeric material. The General I/O ROM set consists of five statements which provide customized data input/output and I/O control operations, and permit high-speed data conversion, packing and unpacking. The EDIT ROM set is designed to simplify editing of program text recalled from memory or data and programs being entered and displayed in the CRT.

THE 2200
PORTABLE COMPUTING SYSTEM

PCS INSTRUCTION SET

GENERAL BASIC STATEMENTS, COMMANDS, AND FUNCTIONS

Many BASIC statements and commands are single keystrokes, input into the PCS via an alphanumeric/BASIC keyword keyboard, and require only one byte of memory.

BASIC Commands

A BASIC command provides the user with a means of communicating with the system. A BASIC command facilitates the running or modifying of a program, but is not part of the program.

CLEAR	HALT/STEP	RENUMBER	RUN
CONTINUE	LIST	RESET	LOAD

Standard BASIC Statements

COM	IF END THEN	READ
COM CLEAR	IF THEN	REM
DATA	(%) Image	RESTORE
DEFFN	INPUT	RETURN
DEFFN'	KEYIN	RETURN CLEAR
DEFFN'HEX( )	LET	SELECT
DIM	NEXT	STOP
END	ON	TRACE
FOR	ON ERROR	
GOSUB	PLOT	
GOSUB'	PRINT	
GOTO	PRINTUSING	

Although this instruction set represents, for the most part, statements most commonly found in BASIC languages, it also has a number of additions which extend the power and versatility of your programming and data processing capabilities. For example, the PRINTUSING and % (Image) statements permit easy and concise formatting of printed reports that include leading dollar signs ($), commas, and decimal point insertion of numbers. The COM and COM CLEAR statements allow the efficient use of memory for passing variable data between overlayed program steps. A number of statements permit extensive customization of the keyboard and display for program data entry. These statements include KEYIN (receives one keyboard character); DEFFN, DEFFN' HEX( ), and RETURN CLEAR (use the 16 keyboard special function keys to execute program subroutines, continue program execution at various points, and enter predetermined text strings of alphanumeric or hexadecimal characters). GOSUB' permits the passing of arguments to subroutines, PLOT provides flexible and efficient plotting capabilities, and ON ERROR allows error recovery processing under program control.

Standard Data Manipulation Statements and Functions

This instruction set contains many unique and powerful statements to perform bit and byte manipulation, binary and logical arithmetic, and data searching and conversion. With these statements, the PCS provides a powerful system for the conversion, editing and efficient use of data.

ADD	LEN
AND, OR, XOR	NUM
BIN	PACK
BOOL	POS
CONVERT	ROTATE
HEX	STR
HEXPRINT	UNPACK
INIT	VAL

The AND, OR, XOR and BOOL instructions perform all logical Boolean operations on two specified arguments. The BIN statement converts the decimal system value of an expression into a binary value and stores the results in a named alphanumeric value; the operation is the inverse of the VAL statement. To set every byte in one or more specified arguments equal to an indicated value, the INIT statement can be used. The ROTATE statement rotates the bits within each byte of a specified alphanumeric variable a designated number of positions. The POS statement allows efficient searching of alphanumeric data. The great power of the bit/byte manipulation statements and functions reduces programming requirements for many data processing and reduction applications.

Advanced BASIC Statements

In addition to the powerful standard BASIC language provided in the PCS, a number of special instruction groups, "hardwired" into the ROM of the system, significantly expand the power and versatility of the system.

Math Matrix Statements

These instructions perform matrix input/output and arithmetic operations including addition, subtraction, multiplication, inversion and transposition. Array default dimensions are 10 by 10 with an alphanumeric element default size of 16 bytes. Redimensioning of arrays is automatic for many arithmetic matrix operations.

MAT addition	MAT PRINT
MAT CON	MAT READ
MAT equality	MAT REDIM
MAT IDN	MAT scalar multiplication
MAT INPUT	MAT subtraction
MAT INV,d	MAT TRN
MAT multiplication	MAT ZER

SORT Statements

The SORT instruction set contains six advanced matrix operations designed to facilitate text editing, and the sorting, searching and moving of data. MAT CONVERT, MAT SORT, MAT MERGE and MAT MOVE are primarily used for data sorting operations. MAT SEARCH along with MAT MOVE provide a powerful capability to do statistical searching of data and text edit searching. Segments of data can be moved with the MAT COPY statement.

MAT CONVERT	MAT MOVE
MAT COPY	MAT SEARCH
MAT MERGE	MAT SORT

General I/O Statements

The five statements included in this instruction set are identified by the following names:

$GIO	$PACK
$IF ON	$UNPACK
$TRAN	

In particular, the $GIO statement is unlike any other BASIC language I/O statement since a technique similar to machine language programming is used to custom-tailor I/O operations sequences which are executable within the framework of the high-level BASIC language. The $IF ON statement is designed to test the device-ready condition of a specified output device or test the data-ready condition of a specified input device and initiate a branch to a specified line number if a ready or busy condition is sensed. The $TRAN statement provides a high-speed character conversion capability implemented by a table look-up procedure or the replacement of specified characters. The $PACK and $UNPACK statements are designed to facilitate data packing and unpacking, by fields or delimiters, between a specified alphanumeric array buffer and specified BASIC numeric and/or alphanumeric variables in an argument list.

Tape Cassette Statements and Commands

The tape cassette instruction set consists of statements and commands for the reading and writing of blocked records.

Tape Cassette:

BACKSPACE	DATARESAVE
DATALOAD	LOAD
DATALOAD BT	REWIND
DATASAVE	SAVE
DATASAVE BT	SKIP

Program and Data Storage and Retrieval

The DATALOAD BT and DATASAVE BT cassette statements, enable the programmer to save and load records which do not contain standard PCS control information.

Since records saved and loaded in this manner are not automatically formatted by the system, the programmer is free to write his own control information, and format his records in a manner appropriate for his application.

The DATALOAD and DATASAVE cassette commands easily read and write lists of variables and arrays from or onto a cassette without preformatting.

Loaded, protected programs cannot be accidentally modified; any attempt to modify a loaded, protected program results in an error message being displayed.

Programs, or specified sections of programs, can be recorded on cassette for future use. When needed, the programs are loaded into the PCS memory to replace or append an existing program. Loading can be effected from the keyboard, or under program control, to ease chained program operation.

When chaining programs, using the COM statement allows program variables and arrays to be defined permitting their passage to subsequent program steps; the COM CLEAR statement removes these variable and arrays when they are no longer needed for subsequent steps.

Stored programs can be identified by an alphanumeric name and then retrieved by searching for the specified program with the LOAD command.

Arithmetic Operators, Relational Symbols and Mathematical Functions

Arithmetic operations are performed with an accuracy of 13 digits. Most trigonometric and exponential functions are calculated to 12 digits of accuracy. Calculations are performed over a range of 10^{-99} to 10^{+100}.

Arithmetic Operators	Relational Symbols
↑ exponentiation	$<$ less than
* multiplication	$<=$ less than or equal to
/ division	$>$ greater than
+ addition	$>=$ greater than or equal to
− subtraction	$<>$ not equal

Mathematical functions

LOG	— natural logarithm
ABS	— absolute value
SQR	— square root
RND	— random number
INT	— greatest integer function
SGN	— assigns 1 if positive, 0 if zero, or −1 if negative
#PI (π)	— 3.14159265350
EXP	— e^x
SIN	— sine*
COS	— cosine*
TAN	— tangent*
ARCSIN	— arcsine*
ARCCOS	— arccosine*
ARCTAN	— arctangent*

(*trig arguments: degrees, radians, gradians)

Variables

Up to 286 variable names can be assigned to each of the following: simple numeric variables, numeric array variables, string variables and string array variables thus providing 1144 unique variable names. Either one- or two-dimensional numeric or alphanumeric string arrays can be used, dimensioned to a maximum of 255.

The lengths of alphanumeric variables and array elements are defined from 1 to 64 bytes, with a 16 byte default size.

The CRT

The PCS integrated 9-inch CRT allows the user to display instantly alphanumeric data in both upper and lower case, as well as numeric data and special characters. Up to 16 lines with a maximum of 64 characters per line may be displayed. As a new line is entered, it appears on the next unused line on the screen. When the screen is full, each entered line appears at the bottom of the display, moving all other lines up. However, under program control a fixed screen format can be supported utilizing a variety of display control and cursor movement codes. Two controls are provided to allow the user to adjust the brightness and contrast of the output on the screen.

The Tape Cassette

The PCS Integrated Single Tape Cassette provides bulk storage capabilities to the system using magnetic tape cassettes.

Two manual controls are provided — a Door Release button for cassette mounting/dismounting and a Rewind button to initiate high-speed rewinding. The drive is operated under BASIC language control by using the unique device address assigned to its controller board.

Programs and data can be recorded on, and read from, tape cassettes using BASIC language statements designed for cassette operations. Information recorded on tape cassettes is formatted automatically in 256-byte blocks called physical records, and each record is recorded twice to ensure the integrity of the information.

The SAVE command automatically formats a "program file" with a header record, program records (as many as required to store the program text), and a trailer record. A program can be recorded with or without an identifying name (up to eight bytes long). If the parameter P is specified, a program is recorded as a "protected program file" — such programs can be read into memory and executed, but they cannot be listed or duplicated.

The DATASAVE statement automatically formats a logical record consisting of as many physical records as required to store all the values corresponding to a specified argument list. If the parameter OPEN and a name are specified, a data file header record is formatted. Similarly, if the parameter END is specified, a data file trailer record is formatted.

The LOAD statement reads program text and the DATALOAD statement reads data from tape cassettes into memory. SKIP and BACKSPACE statements instruct a drive to pass over a specified number of program and data files, or to pass over a specified number of logical records. DATASAVE BT and DATALOAD BT statements provide capabilities useful for program conversion and packing operations.

The Keyboard

A standard typewriter keyboard is combined with a BASIC language keyboard to provide fast and easy program, data and text entry.

The Upper/Lowercase Alphanumeric/BASIC Keyword Keyboard provides two modes of operation for entering data and programs into the PCS. The mode is selected by a toggle switch located in the upper left corner of the keyboard and labelled Keyword/A and A/a. In Keyword/A mode, shifted (SHIFT key depressed) alpha keys produce BASIC words; unshifted alpha keys produce uppercase letters. This mode is most convenient for entering programs. In A/a mode, the keyboard functions as a standard typewriter. Unshifted alpha keys produce lowercase letters; shifted alpha keys produce uppercase letters.

The Integrated Alphanumeric/BASIC Keyword Keyboard is divided into five zones. (See Figure 1.)

Zone 1 contains BASIC keywords, alphanumeric and special character keys and certain operational keys. BASIC keywords are generated with a single keystroke. For convenience, BASIC keywords are arranged in logical groups, e.g., the subroutine group [DEFFN, GOSUB, RETURN], the program control group [FOR, STEP, NEXT], and the tape handling group [SELECT, BACKSPACE, REWIND, SAVE, SKIP]. Additionally, Zone 1 contains operation keys such as STMT NUMBER, which supplies a line number ten greater than the previous line number when entering program lines and TRACE, RENUMBER, LIST, BACKSPACE, LINE ERASE and RETURN(EXEC).

Zone 2 contains a full numeric keyboard, mathematical function keys (ARC, SIN(, COS(, etcetera), arithmetic operators (+, −, *, /, ↑), a second and third RETURN (EXEC) key and a keyboard PRINT key.

Zone 3 consists of keys for loading, controlling and executing a program as well as activating and deactivating the system. An ON/OFF toggle switch is located within easy reach in the upper left corner of the keyboard. RESET stops program execution, clears the CRT, and returns system control to the user. HALT/STEP halts program execution and can be used to execute a program one statement at a time. CONTINUE continues program execution after a STOP verb has been encountered or the HALT/STEP key has been touched. CLEAR followed by no parameters, clears all program text and all variables. CLEAR V removes all variables from memory. CLEAR N clears noncommon variables from memory. CLEAR P removes program text, but not variables, from memory.

Zone 4 contains 16 Special Function Keys used to access up to 32 user-defined routines or to enter a customized data string with a single stroke.

Zone 5 contains the EDIT mode operation keys. There are nine EDIT operation keys:

|	
EDIT	used to enter EDIT mode. When in EDIT mode, the following edit functions are available on the rightmost 8 Special Function keys.
RECALL	used to recall program line in memory to edit.
←------	moves the cursor five spaces to the left.
←	moves the cursor a single space to the left.
------→	moves the cursor five spaces to the right.
⟶	moves the cursor a single space to the right.
INSERT	expands a line for additional text and data entry by inserting a space character at the current CRT cursor position.
DELETE	deletes the character at the current CRT cursor position.
ERASE	erases a line from the current CRT cursor position to the end of the line.
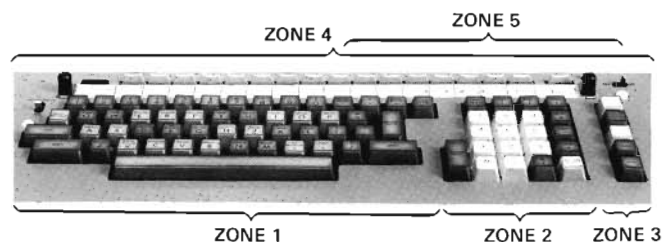
Figure 1

PCS FEATURES

Immediate Mode

- In the Immediate Mode, the user may enter unnumbered BASIC statements as one-line calculations. Multi-statement lines can be entered and executed without altering programs resident in memory, thus allowing the system to be used as a calculator and to make selective program dumps during debugging.

Programming Mode

- The System also processes "multi-statement lines", which save keystrokes and memory.
- A total of 16 User-Defined Special Function Keys can be used for single-keystroke access of up to 32 subroutines, program entry points, program functions, or entry of character strings. A label strip for the Special Function Keys provides easy customization of applications.
- The amount of unused memory is indicated on the CRT when the END statement is included at the completion of a program, or at any time during immediate mode operation.

Editing, Debugging, and Error Diagnostics

- When errors occur during program entry or execution, the program line is displayed and a Diagnostic Error Pointer/Error Code indicates the approximate location in the program line where an error is made and identifies the cause of the error with an error code.
- The programmable TRACE mode traces the program, producing a printout or display whenever a program variable receives a new value or a program transfer is made.
- The HALT/STEP key executes and displays one program statement each time it is depressed, allowing a line-by-line analysis of the program. If TRACE mode is activated, each executed statement as well as received calculated values are displayed.
- The ON ERROR GOTO statement permits a program to execute error recognition and/or recovery procedures under program control:
- The Character EDIT Mode is designed to facilitate editing of lines of program text recalled from memory or data and program lines currently being input and displayed on the CRT: ←---(Multispace cursor left), ← (Space cursor left), → (Space cursor right),---→ (Multispace cursor right), INSERT, DELETE, ERASE, and RECALL. The EDIT key is used to enter EDIT mode. The RECALL key is used to recall a program line previously entered into memory. The Multispace (left and right) keys are provided to move the cursor five spaces to the left or right. Two Space keys are provided to move the cursor a single space to the left or right. The INSERT key is used to expand a line by inserting a space character to allow for additional text or data. When the DELETE key is depressed, the character at the current cursor position is deleted. A program or data line can be erased from the current cursor position to the end of the line by touching the ERASE key.

- The RENUMBER command assigns an entire program, or a specified segment of a program, with user-selectable, equally incremented statement numbers.
- Errors can be corrected in a program statement by using the edit functions; by backspacing (which erases characters) in an unexecuted line to the point where the error was made and properly reentering the remainder of the line; deleting the entire line by reentering the line number, followed by a RETURN(EXEC) command; or replacing the line completely by reentering the line number, followed by the correct program statement.
- Additional statements can be inserted into a program by entering a line number between two existing line numbers. The new line automatically is inserted between the two original line numbers.

Device Selection

- The SELECT statement is used both in the Immediate Mode and under program control to select a device for particular I/O operations (PRINT, INPUT, TAPE).
- Device selections are maintained independently for input and output operations, allowing programs to be modified easily to work with any I/O device.

Plotting Operation

- A powerful BASIC statement (PLOT) controls any of the plotting devices offered with the PCS.
- The plotters can perform any number up to 999 X and Y increments and can print entire words by using a single PLOT statement.
- The PLOT statement allows recursive plot arguments and multi-plot arguments to optimize plotting efficiency.

Add-Ons

- Memory may be expanded in 8,192 (8K) byte increments to 32,768 (32K) bytes.
- Model 2221W Wang Line Printer (132 columns) is a 9 by 9 dot matrix impact printer which produces output at approximately 200 char/sec (60 to 300 lines/minute). Its set of 96 characters include upper and lowercase characters, numerics, and special characters. The 2221W also can produce highlighted print of double-width characters under program control.
- Model 2231W Wang Line Printer is a 7 by 9 dot matrix impact printer which produces output at approximately 120 characters/second (up to 250 lines/minute). Its set of 96 characters contains both upper and lowercase letters, numbers, and symbols. The 2231W also can produce highlighted print of double-width characters under program control.
- Model 2272-1 Digital Drum Plotter (single pen) provides point, line and alphanumeric plotting capabilities to the Portable Computing System. Plotting accuracy is .01 in. plus .1%/in. (.0254 cm plus .1%/cm) and plots can be prepared up to 16 in. (41 cm) wide by any length. Manual controls permit setting the line position of the coordinate axis at one of four orientations (0°, 90°, 180°, and 270°), slewing the pen position as desired, placing the pen in the 'up' position, and clearing the

plotter buffer. (The drum plotter is also available with a three-pen hold which is designated Model 2272-2.)

- Option 60 provides an Auxiliary Display Connector, the Audio Alarm and Keyboard Clicker features.

Software

Wang Laboratories, Inc. provides a comprehensive software library which is continually being updated and expanded to meet the changing needs of the user. Available software includes the General Program Libraries which contain routines in the areas of mathematics, statistics, engineering, finance, and utilities.

SPECIFICATIONS

Unit Size
Height	13½ in. (34.3 cm)
Depth	20½ in. (52 cm)
Width	19¾ in. (50.2 cm)

Weight
57 lb (25.8 kg)

Display Size
9 in. diagonal (22.9 cm)

Display Capacity
16 lines, 64 char/line

Character Size
Height	.125 in. (.32 cm)
Width	.125 in. (.32 cm)

Cassette Drive
Stop/start time . . . . .09/.05 sec

Capacity
Approximately 300 automatically formatted dually recorded 256 byte physical records per 150 ft cassette (i.e., approx 76,800 bytes).

Recording/Search Speed
7.5 in./sec (19 cm/sec)

Transfer Rate
326 bytes/sec (including dual recording on inter-record gaps).

Rewind Speed
7.5 ft/sec (2.3m/sec)

Power Requirements
115 or 230 VAC ± 10%
50 or 60 Hz ± ½ Hz

Wattage
260W

Fuses
3a @ 115V/60 Hz
1.5a @ 230V/50 Hz

Operating Environment
50°F to 90°F (10°C to 32°C)
20% to 80% relative humidity, allowable
35% to 65% relative humidity, recommended.

Memory
8K, 16K, 24K, 32K

Subroutine Stacking
50

ORDERING SPECIFICATIONS

The self-contained Portable Computing System must consist of a keyboard programmable Central Processor (CP), an Upper/Lowercase 9-inch Cathode Ray Tube (CRT), a Single Tape Cassette Drive, and an Upper/Lowercase Alphanumeric/BASIC Keyword Keyboard.

The CP must have the BASIC language on Read Only Memory. Also, the CP must have at least 8,192 bytes of Random Access Memory, expandable in 8,192 byte modules to 32,768 bytes. The Character EDIT mode, General I/O Instruction Set, SORT Instruction Set, and Math Matrix Instruction Set must be standard.

The CRT must be capable of displaying 16 lines, each 64 characters in length.

The Single Tape Cassette must be able to drive a cassette holding 150 ft of magnetic tape on which can be recorded 78,300 bytes. Use of the Tape Cassette Drive must not require preformatting of tapes.

The input keyboard must contain typewriter characters; most BASIC language statements, commands and functions as single keystroke entries, and numerics (0-9). Trig functions, mathematic operators and control keys are also standard on the keyboard, in addition to 16 Special Function Keys capable of accessing 32 user-defined operations.

The following options and peripherals must be available: the Model 2221W Line Printer; the Model 2231W Line Printer; the Model 2272-1, -2 Digital Drum Plotter; and Option 60-Auxiliary Display Connectors, Audio Alarm, and Keyboard Clicker.

Standard Warranty Applies

Wang Laboratories reserves the right to change specifications without prior notice.