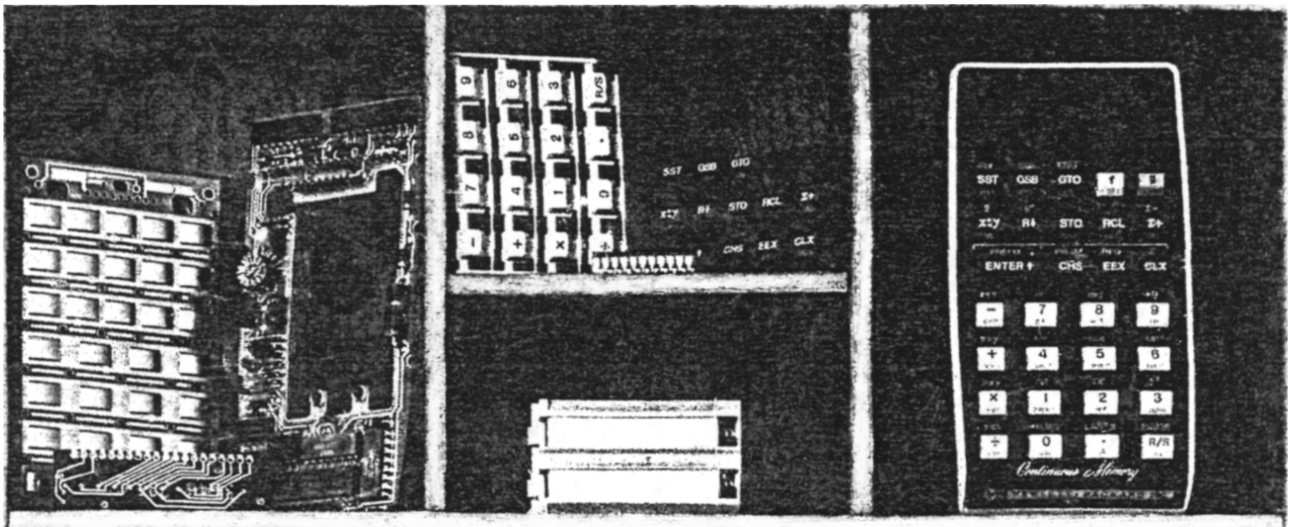
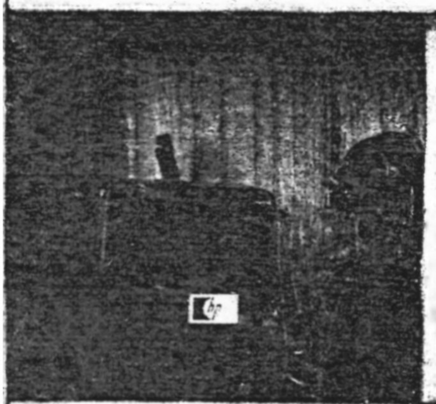
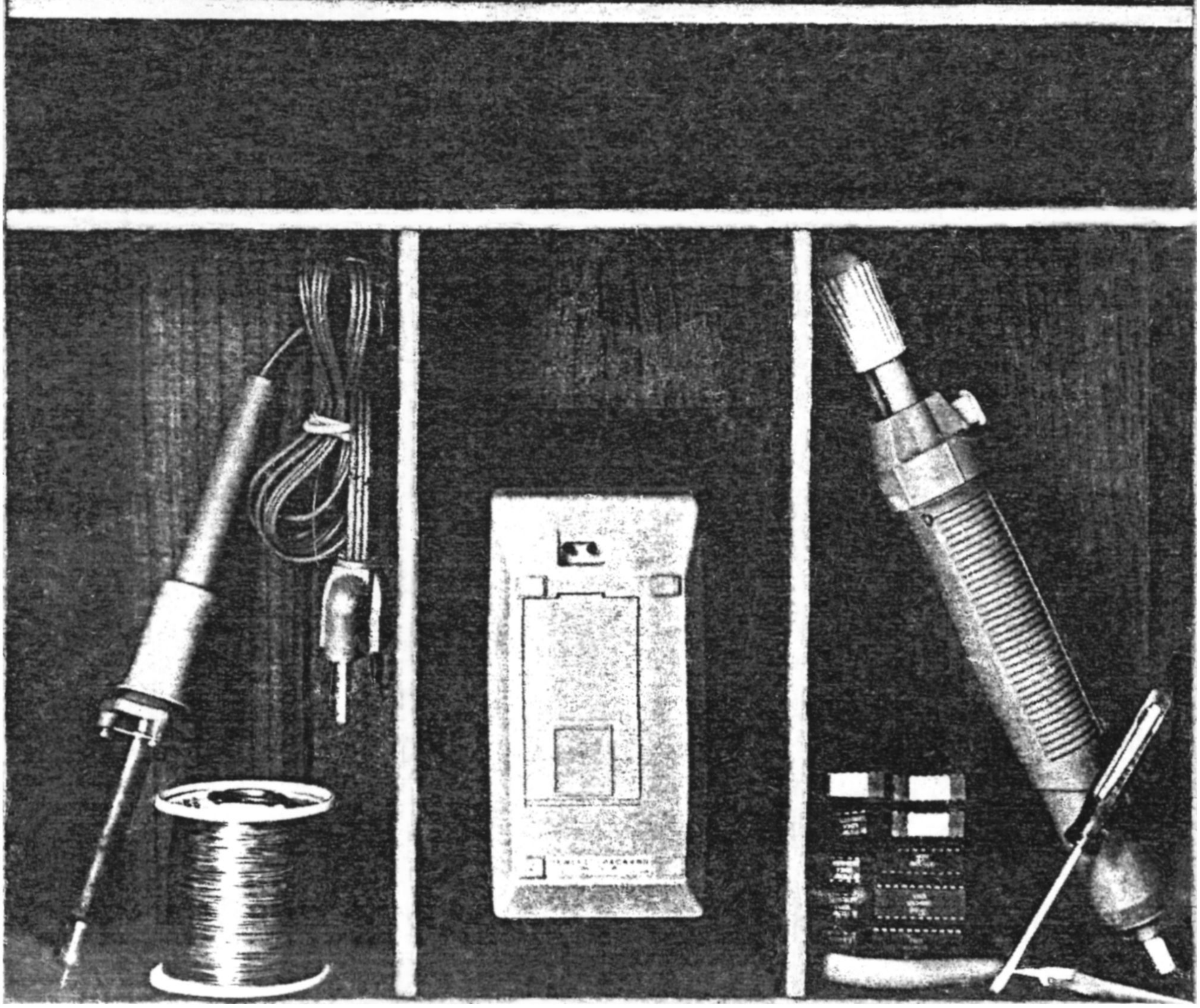




Hewlett-Packard

HP-29C Advanced Scientific Programmable Calculator

SERVICE MANUAL



HEWLETT hp PACKARD

HP-29C
Advanced Scientific
Programmable Calculator

SERVICE MANUAL

00029-90001

1000 N.E. Circle Blvd., Corvallis, Oregon 97330

Printed August 1977

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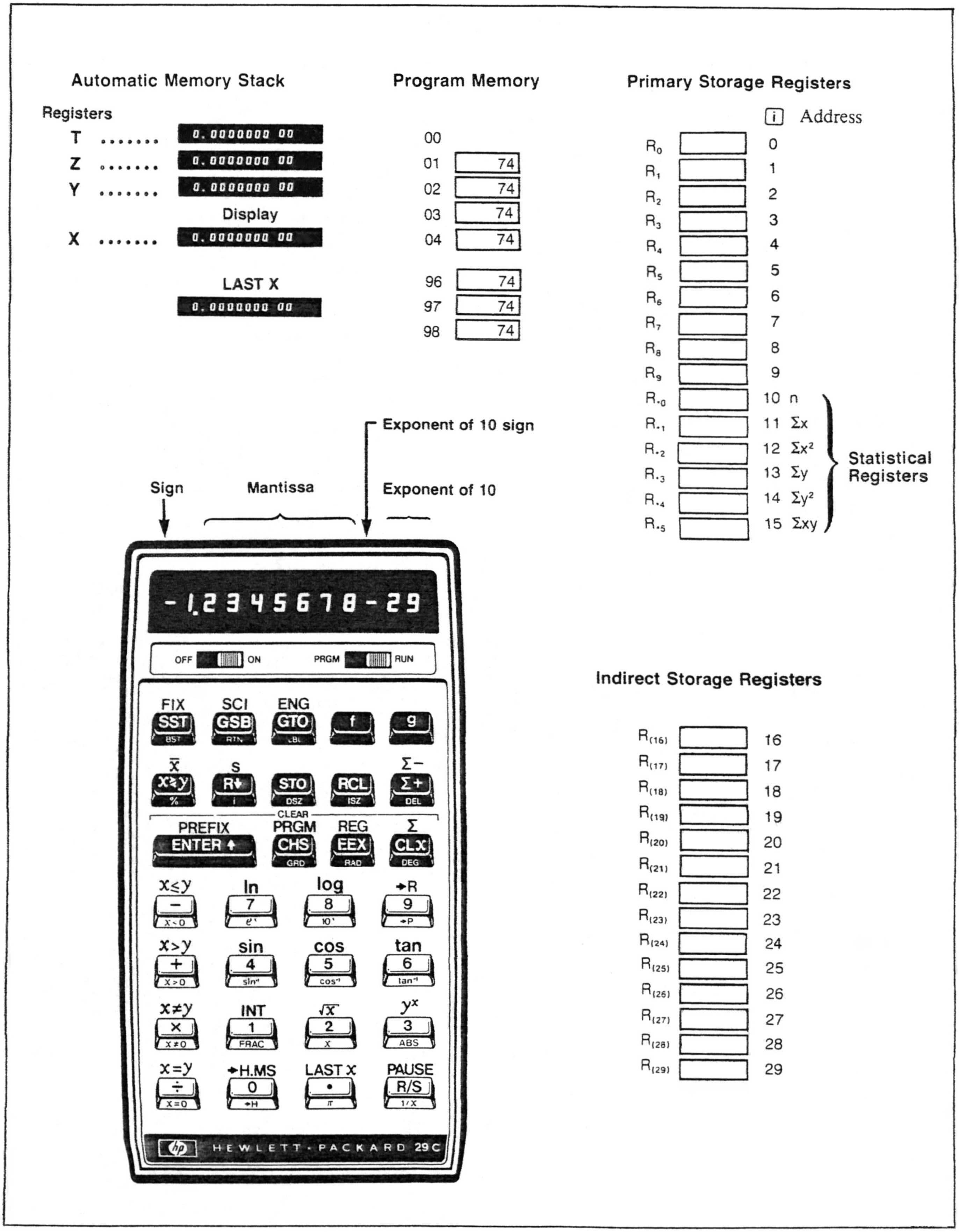

Figure 1-1. HP-29C Keyboard, Registers, and Memory

General Information

1-1. INTRODUCTION

1-2. This service manual presents the information needed to troubleshoot, disassemble, repair, reassemble, and test the HP-29C calculator.

1-3. *Service procedures, with supporting documentation,* are grouped into assembly-level service and component-level service. Thus:

a. Using the information in section III, Assembly-Level Service, isolate the cause of a problem to a malfunction in a particular assembly.

b. Using the information in section IV, Component-Level Service, isolate the cause of the problem to a malfunction of a particular part of that assembly.

1-4. The remaining sections of the manual contain the principles of operation, performance tests, and replaceable parts lists.

1-5. *Special assembly reference designations, listed in* table 1-1, are found throughout the manual. For example, the reference designation LU2 refers to integrated circuit U2 on the logic PCA.

Table 1-1. Assembly Reference Designations

REFERENCE DESIGNATION	ASSEMBLY
L	Logic PCA
K	Keyboard Assembly and Keyboard PCA
R	AC Adapter/Recharger
B	Battery Pack

1-6. DESCRIPTION

1-7. **The HP-29C is a handheld, scientific, programmable calculator with a nonvolatile memory.** (See figure 1-1.) Mechanically, the HP-29C is similar to other members of the HP-21 family of calculators. The features and operation of the HP-29C are summarized in tables 1-2 and 1-3; its specifications are given in table 1-4. Improper operations leading to an error display are listed in appendix A.

1-8. IDENTIFICATION

1-9. The serial number of the calculator is used for identification and determination of warranty status. It is located on the bottom case between the recharger input plug and the battery pack case. Its format is explained below:

Calculator Serial Number

YYMM {A B S} XXXXX ← Sequence number

Location manufactured:
A = USA
B = Brazil
S = Singapore

Month manufactured.

Year manufactured (YY = years since 1960).

1-10. The serial numbers located on the battery and on the ac adapter/recharger are used to determine the week the unit was fully charged and the date of manufacture, respectively. The format for each is described below:

Battery Charge Date

YYWW

Week of charging.

Year of charging (YY = Years since 1960).

AC Adapter/Recharger Manufacture Date

YYMM

Month manufactured.

Year manufactured (YY = Years since 1960).

1-11. STANDARD ACCESSORIES

1-12. The HP-29C comes complete with each of the following accessories:

- Carrying Case.
- AC Adapter/Recharger.
- *HP-19C/HP-29C Owner's Handbook.*
- *HP-19C/HP-29C Quick Reference Card.*
- Battery Pack.

1-13. OPTIONAL ACCESSORIES

1-14. The following items are optional accessories to the HP-29C and as such are sold separately:

- HP 82028A Reserve Power Pack.
- HP 82029A Security Cradle.
- Programming Pad (part number 00097-13154).

Table 1-2. Function Key Index

Manual RUN Mode. PRGM-RUN Switch PRGM RUN set to RUN.

Function keys pressed from the keyboard execute individual functions as they are pressed. Input numbers and answers are displayed. All function keys listed below operate either from the keyboard or as recorded instructions in a program.

OFF ON
OFF-ON Switch.

f Pressed before function key, selects gold function printed above key.

g Pressed before function key, selects blue function printed on lower face of key.

CLEAR PREFIX after f, g, STO, RCL, or GTO cancels that key.

Digit Entry

ENTER↑ Enters a copy of number displayed in X-register into Y-register. Used to separate numbers.

CHS Changes sign of mantissa or exponent of 10 in displayed X-register.

EEX Enter exponent. After pressing, next numbers keyed in are exponents of 10.

0 through 9 Digit keys.

. Decimal point.

Number Manipulation

R↓ Rolls down contents of stack for viewing in displayed X-register.

x⇄y Exchanges contents or X- and Y-registers of stack.

CLx Clears contents of displayed X-register to zero.

Display Control

FIX Fixed point display. Followed by a number key, selects fixed point notation display.

SCI Scientific display. Followed by a number key, selects scientific notation display.

ENG Engineering display Followed by a number key, selects engineering notation display.

Number Alteration

ABS Gives absolute value of number in displayed X-register.

INT Leaves only integer portion of number in displayed X-register by truncating fractional portion.

FRAC Leaves only fractional portion of number in displayed X-register by truncating integer portion.

Manual Storage

STO Store. Followed by number key, decimal point and number key, or i stores displayed number in storage register specified. Also used to perform storage register arithmetic.

RCL Recall. Followed by number key, decimal point and number key, or i recalls value from storage register specified into the displayed X-register.

CLEAR REG Clears contents of all storage registers.

LAST X Recalls number displayed before the previous operation back into the displayed X-register.

Mathematics

$\sqrt{x}$ Computes square root of number in displayed X-register.

x^2 Computes square of number in displayed X-register.

$1/x$ Computes reciprocal of number in displayed X-register.

π Places value of pi (3.141592654) into displayed X-register.

+ − × ÷ Arithmetic operators.

Table 1-2. Function Key Index (Continued)

Trigonometry

[DEG] Sets decimal degrees mode for trigonometric functions.

[RAD] Sets radians mode for trigonometric functions.

[GRD] Sets grads mode for trigonometric functions.

[sin] [cos] [tan] Computes sine, cosine, or tangent of value in displayed X-register.

[$\sin^{-1}$] [$\cos^{-1}$] [$\tan^{-1}$] Computes arc sine, arc cosine, or arc tangent of number in displayed X-register.

[→H.MS] Converts decimal hours or degrees to hours, minutes, seconds or degrees, minutes, seconds.

[→H] Converts hours, minutes, seconds or degrees, minutes, seconds to decimal hours or degrees.

Polar/Rectangular Conversion

[→P] Converts x, y rectangular coordinates placed in X- and Y-registers to polar magnitude r and angle θ.

[→R] Converts polar magnitude r and angle θ in X- and Y-registers to rectangular x and y coordinates.

Logarithmic and Exponential

[y^x] Raises number in Y-register to power of number in displayed X-register.

[10^x] Common antilogarithm. Raises 10 to power of number in displayed X-register.

[e^x] Natural antilogarithm. Raises e (2.718281828) to power of number in displayed X-register.

[log] Computes common logarithm (base 10) of number in displayed X-register.

[ln] Computes natural logarithm (base e, 2.718281828) of number in displayed X-register.

Statistics

[Σ+] Accumulates numbers from X- and Y-registers into storage registers $R_{.0}$ through $R_{.5}$.

[Σ-] Subtracts x and y values from storage registers $R_{.0}$ through $R_{.5}$ for correcting [Σ+] accumulations.

[$\bar{x}$] Computes mean (average) of x and y values accumulated by [Σ+].

CLEAR [Σ] Clears storage registers used for accumulations ($R_{.0}$ through $R_{.5}$) to zero.

[s] Computes sample standard deviations of x and y values accumulated by [Σ+].

Percentage

[%] Computes x% of y.

Indirect Control

[i] When preceded by [GTO], [GSB], [STO], or [RCL], the address or control value for that function is specified by the current number in R_0.

[ISZ] Increment R_0, skip if zero. Adds 1 to contents of R_0. Skips one step if contents are then zero.

[DSZ] Decrement R_0, skip if zero. Subtracts 1 from contents of R_0. Skips one step if contents are then zero.

Table 1-3. Programming Key Index

PROGRAM Mode	Automatic RUN Mode	
PRGM-RUN switch set to PRGM. PRGM RUN All function keys except the functions shown below are loaded into program memory when pressed.	PRGM-RUN switch set to RUN. PRGM RUN Function keys may be executed as part of a recorded program or individually by pressing from the keyboard. Input numbers and answers are displayed by the calculator, except where indicated.	
Active Keys:	**Pressed from keyboard:**	**Executed as a recorded program instruction:**
In PRGM mode only the following operations are active. These operations are used to help record programs, and cannot themselves be recorded in program memory.		[0] [1] [2] [3] [4] [5] [6] [7] [8] [9] Label designators. When preceded by [LBL], define beginning of routine. When preceded by [GTO] or [GSB], cause calculator to stop execution, search downward through program memory to first designated label, and resumes execution there.
[GTO] Go to. Followed by [•] n n positions calculator to step n n of program memory. No instructions are executed.	[GTO] Go to. Followed by [•] n n sets calculator to step n n of program memory without executing instructions. Followed by label designator ([0] through [9] or [i]) causes calculator to search downward through program memory to first designated label. No instructions are executed.	[GTO] Go to. Followed by label designator [0] through [9] or [i], causes calculator to stop execution, search through program memory to first designated label, and resume execution there.
	[GSB] Go to subroutine. Followed by label designator, [0] through [9], [i], causes calculator to start executing instructions, beginning with designated label.	[GSB] Go to subroutine. Followed by label designator [0] through [9] or [i], causes calculator to search through program memory to first designated label and execute that section of program memory as a subroutine.

Table 1-3. Programming Key Index (Continued)

PROGRAM Mode	**Automatic RUN Mode**	
Active keys:	**Pressed from the keyboard:**	**Executed as a recorded program instruction:**
	RTN Return. Sets calculator to step 00 of program memory.	RTN Return. If executed as a result of pressing GSB and a label designator or execution of a GTO instruction, stops execution and returns control to keyboard. If executed as a result of a GSB instruction, returns control to next step after the GSB instruction.
CLEAR PRGM Clear program. Clears program memory to all R/S instructions, sets calculator to step 00.	CLEAR PRGM After f prefix key, cancels that key. After other keys, does nothing. Does not disturb program memory or calculator status.	
		PAUSE Stops program execution and displays contents of X-register for 1 second, then resumes program execution.
BST Back step. Moves calculator back one step in program memory.	BST Back step. Sets calculator to and displays step number and keycode of previous program memory step when pressed; displays original contents of X-register when released. No instructions are executed.	
		$x \neq y$ $x = y$ $x > y$ $x \leq y$ $x \neq 0$ $x = 0$ $x > 0$ $x < 0$ Conditionals. Each tests value in X-register against 0 or value in Y-register as indicated. If true, calculator executes instruction in next step of program memory. If false, calculator skips one step before resuming execution.

Table 1-3. Programming Key Index (Continued)

PROGRAM Mode	Automatic RUN Mode	
Active keys:	**Pressed from the keyboard:**	**Executed as a recorded program instruction:**
SST Single step. Moves calculator forward one step in program memory.	SST Single step. Displays step number and keycode of current program memory step when pressed; executes instruction, displays result, and moves calculator to next step when released.	
	R/S Run/stop. Begins execution from current step of program memory. Stops execution if program is running.	R/S Run/stop. Stops program execution.
DEL Delete. Deletes current instruction from program memory. All subsequent instructions move up one step.	DEL After g prefix key, cancels that key. After other keys, does nothing. Does not disturb program memory or calculator status.	
CLEAR PREFIX, After f, g, STO, RCL, or GTO, cancels that key.	CLEAR PREFIX, After f, g, STO, RCL, or GTO, cancels that key.	
	Any key. Pressing any key on the keyboard stops execution of a running program.	

Table 1-4. Specifications

Calculator Dimensions

- Length: 130.2 mm (5.125 inches).
- Width: 68.3 mm (2.6875 inches).
- Height: 30.2 mm (1.1875 inches).

Weight

- Calculator with battery pack: 170 g (6 oz.).
- U.S. recharger: 141.8 g (5 oz.).
- Shipping weight: 680 g (1.5 lb.)

Power

- Rechargers

HP 82024A	115/230 Vac	European
HP 82025A	230 Vac	UK
HP 82025A Opt 001	230 Vac	UK with Australian plug
HP 82025A Opt 002	230 Vac	UK with RSA plug
HP 82026A	115/230 Vac	US
HP 82041A	115 Vac	US

- Battery

  Two cell, 2.5 V, quick-charge, nickel-cadmium battery pack.

  - Operating time: 2 to 5 hours.

    Note: Battery must be in place to operate the calculator.

  - Recharging time: 7 to 10 hours, calculator OFF; 17 hours, calculator ON.

Display

- Rounding to last displayed digit. Internal operations are calculated with 10 digits.
- Numeric and decimal point: Eight segment, light-emitting diode (LED). Digit and decimal point are contained within a single eight-segment LED.
- 12-digit display including two sign digits.
- Minimum/maximum displayed number: $\pm 1 \times 10^{-99}$ to $\pm 9.9999999 \times 10^{99}$.
- Formats:

Fixed Point:	Numbers are shown with "n" places to the right of the decimal point.
Scientific:	Numbers are shown in scientific notation with "n" places to the right of the decimal point.
Engineering:	Numbers are shown with "1 + n" digits and an exponent of 10 that is the nearest multiple of three.

- Special indications:

Error:	***Error*** written on display when improper operation is attemped. (Refer to appendix A.)
Overflow:	Overflow of the X-register results in a display of all nines (±**9.9999999 99**).
Underflow:	Zero in scientific notation. If in fixed notation, automatically reverts to scientific notation for small numbers that would otherwise appear as zero.
Low Battery:	Decimal point blinks for 30 seconds to 10 minutes before display blanks.

Data/Program Retention (Power Not Applied)

- Five seconds to 10 minutes, depending on:
  a. State of battery charge before power interrupt.
  b. Capacitor C8.
  c. Data storage IC's.

Environmental Specifications

- Operating: 0° to 45°C (32° to 113°F).
- Charging: 15° to 40°C (59° to 104°F).
- Calculator Storage: −40° to 55°C (−40° to 131°F).

Principles of Operation

2-1. HP-29C ARCHITECTURE

2-2. The HP-29C architecture (see figure 2-1) is based on seven MOS (metal-oxide-semiconductor) integrated circuits (IC's):

a. The ACT (Arithmetic, Control, and Timing).

b. Four read-only-memory IC's (ROM s) containing *microprogrammed instructions. One of these IC's—* ROM 0—also contains the anode drivers used by the display; another—ROM 1—contains sixteen 56-bit registers of data storage (DS 1).

c. Two CMOS (complementary metal-oxide-semiconductor) IC's for data and program storage—DS 0 and DS 2—referred to as "continuous memory" since their contents are preserved even while the calculator is *switched off.*

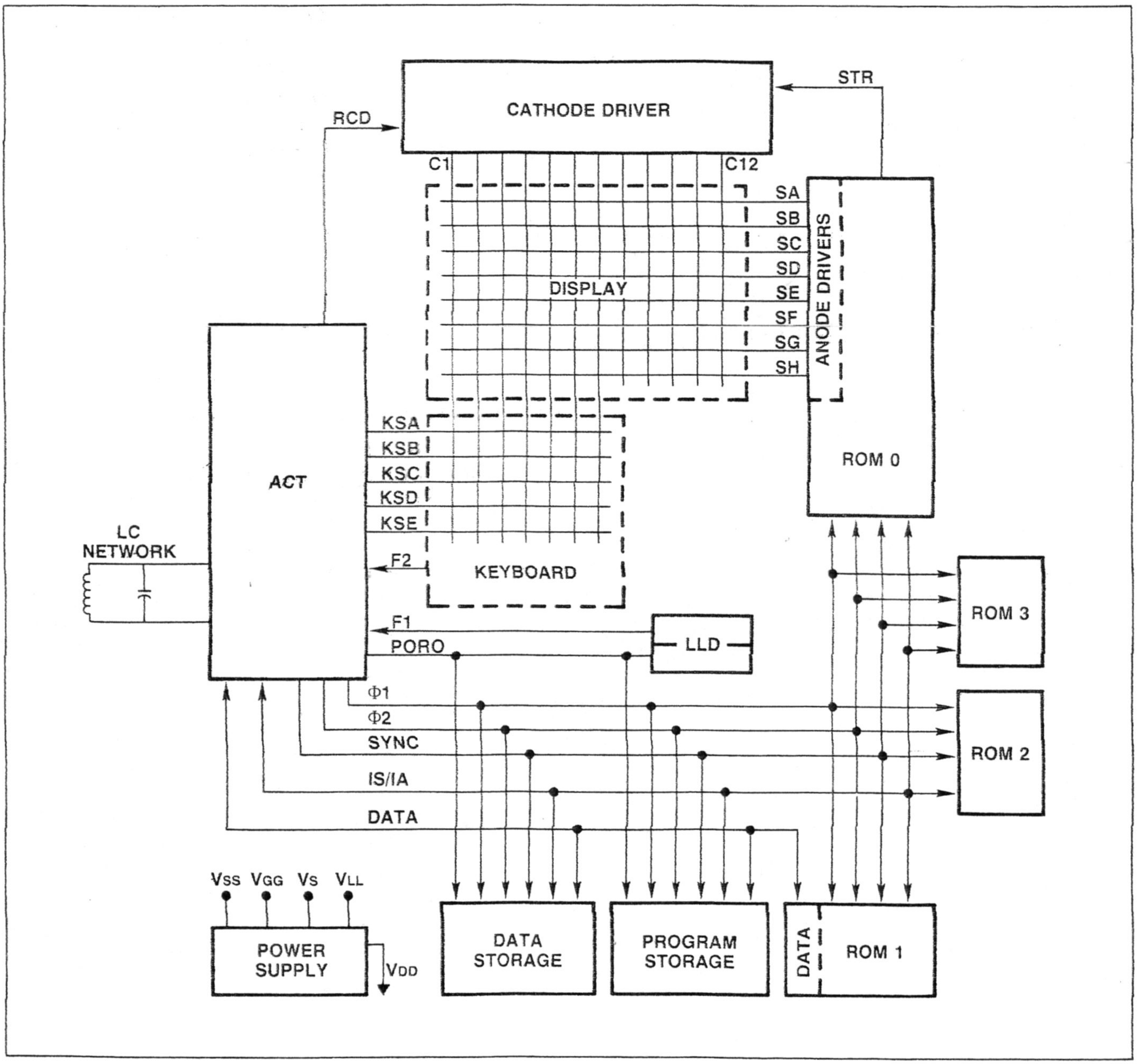

Figure 2-1. HP-29C Block Diagram

2-3. Input to the calculator is through a keyboard with 30 keys; output is through an LED (light-emitting-diode) display module with 12 character positions. In addition to the MOS IC's listed above, two bipolar IC's are used: one contains cathode drivers to interface between the ACT and both the keyboard and display; the other contains circuitry to indicate when the battery voltage falls below a predetermined value and also to insure proper data retention in the CMOS IC's DS 0 and DS 2. The remaining circuitry consists of the power supply and recharger interface.

2-4. ACT

2-5. The ACT is the heart of the HP-29C, corresponding roughly to the central processing unit (CPU) of a digital computer. It operates serially on 56-bit information, with data represented as binary-coded-decimal (BCD) numbers, and instructions and addresses as octal numbers. The ACT consists of six basic sections:

a. Timing.

b. Address and status control.

c. Instruction buffer and decoding.

d. Keyboard control.

e. Data registers (each containing 14 digits or 56 bits):

(1) Three registers (A, B, and C) used for arithmetic and certain other operations. For example, the A- and B-registers are used to display the number in the C-register, which contains displayed x in normalized form. The contents of the C-register are maintained identical to the contents of a register, referred to as the current-X register, located in the DS 2 CMOS IC. When the HP-29C is turned on, the contents of this register in DS 2 are copied into the C-register in the ACT. Conversely, when the result of a calculation appears in the C-register, it is immediately copied into the current-X register located in DS 2. The C-register is connected to the DATA line (see below) and therefore is also used for all data transfer operations.

(2) Three registers (Y, Z, and T) used for stack operations.

(3) One register (N) containing the program step number and subroutine return stack.

(4) One register (M) used for scratch purposes.

f. Arithmetic and logic unit, which is basically a serial BCD adder/subtracter. This portion performs:

(1) Arithmetic operations on all or part of the data in the registers.

(2) Data transfers among the ACT registers.

2-6. The ACT generates three timing signals used by the various IC's in the calculator: Φ1, Φ2, and SYNC. The system clock frequency is determined by a parallel LC network, connected to the LC1 and LC2 pins of the ACT, with a nominal frequency of 715 KHz. The ACT generates pulses on the Φ1 and Φ2 lines at one-fourth the oscillator frequency, with Φ2 trailing Φ1 by approximately two pulse widths. (See figure 4-2.) Bits of information on the IS/fifi and DATA bus lines (see below) extend between successive trailing edges of Φ2 pulses.

2-7. The SYNC signal, consisting of a 10-bit pulse generated at the end of each 56-bit word time, has a dual function. Initially, the second (DS 0 and DS 2) or first (all other IC's) SYNC pulse generated by the ACT following power-on is used by the other IC's to synchronize their internal timing circuits. Subsequently, the presence or absence of the SYNC pulse signifies to DS 0, DS 1, and DS 2 whether information on the IS/IA line is an instruction or an address. (Refer to paragraph 2-42.)

2-8. The ACT also generates the RCD (Reset Cathode Driver) signal to trigger a sequential scan of the cathode driver lines by the cathode driver IC.

2-9. In addition to these synchronization signals, two other bus lines carry information between the ACT and the other IC's:

a. The IS/IA (instruction/address) line to DS 0, DS 2, and the ROM's.

b. The DATA line to DS 0, DS 1 (in ROM 1), and DS 2.

2-10. The F1 and F2 signals are flags which indicate to the ACT the status of the LLD (Low battery Level Detector) signal and the PRGM/RUN switch, respectively.

2-11. The ACT contains a resistor connected through its POR (Power-On Reset) pin to an external capacitor leading to the V_{SS} supply. This provides an RC delay after power application sufficient to initialize the ACT status. Another signal—PORO (Power-On-Reset-Output)—is generated after a delay determined by POR to enable the CMOS IC's DS 0 and DS 2. This prevents them from responding to spurious signals at that time, which could erroneously alter their contents. This protection is provided at power-off by the LLD IC (see below), which forces PORO low before spurious signals are generated which could alter the contents of the CMOS IC's.

2-12. ROM'S

2-13. The ROM's, which contain microprogrammed instructions for performing functional operations, correspond roughly to the main program memory of a digital computer. Each of the four ROM's contains 1024 10-bit words in read-only-memory.

2-14. All operations on the calculator are implemented by microprograms of 10-bit instructions stored in at least two ROM's; most operations require instructions stored in more than two. A typical operation requires execution of certain instructions from a particular ROM, followed by execution of a set of instructions from another ROM, and so on. The simple operation ENTER↑, for example, is implemented using instructions stored in ROM's accessed in the following order: ROM 0, ROM 3, ROM 0, ROM 1, ROM 0. The complex operation log is implemented using instructions stored in ROM's accessed in the following order: ROM 0, ROM 3, ROM 2, ROM 1, ROM 0, ROM 1, ROM 0. Execution of every operation begins with instructions from ROM 0, which encode the key pressed, followed by instructions from ROM 3, which initiate the required microprogram. Most mathematical functions go on to instructions in ROM 1 and/or ROM 2.

2-15. Because of this multiple accessing of the various ROM's in the calculator, it is difficult to attribute an inoperative operation unambiguously to failure of one particular ROM. For a given operation, the probability of failure of each of the ROM's accessed is proportional to the relative percentage of instructions used from that ROM.

2-16. Only one of the ROM's is used at any time. A ROM address register in each ROM receives a 12-bit address from the ACT on the IS/IA line, least significant bits first. A decoder inside each ROM compares the two most significant bits of the address to the ROM's preassigned enable code. If a match occurs, the enabled ROM outputs the instruction onto the IS/IA line, while the remaining ROM's are disabled. Each ROM has an internal timing circuit to synchronize it to the system timing using the Φ1, Φ2, and SYNC signals generated by the ACT.

2-17. In addition to its read-only-memory, the ROM 0 IC contains the anode drivers. Once each 56-bit word time, the ACT sends over the IS/IA line to ROM 0 a seven-bit code representing the character to be displayed. The ROM decodes the input into one of the digits *0* through *9* (with or without decimal point), minus sign (−), a blank, or (for the purpose of displaying ***Error***) the leters *E*, *r*, or *o*.

2-18. The ROM 1 IC contains, in addition to its read-only-memory, sixteen 56-bit registers of data storage (DS 1): the 14 indirect storage registers and the LAST X register accessible to the user, and 1 scratch register used internally.

2-19. CMOS DATA STORAGE

2-20. One of the CMOS data storage IC's—DS 0—contains the 16 primary storage registers (each 56 bits) accessible to the user. The other—DS 2—contains the 56-bit current-X register (the contents of which are maintained identical to the contents of the ACT's C-register as described above), machine status information such as display format and trigonometric function mode, and 14 registers each with seven eight-bit program steps. The contents of these IC's are preserved even while the calculator is switched off because the CMOS technology of the IC's requires very little standby power (on the order of 5 μW).

2-21. CATHODE DRIVER

2-22. The bipolar cathode driver IC consists of:

a. Twelve cathode drivers, each with a current limiting feature.

b. A 12-bit shift register that turns on the cathode drivers one at a time.

c. Timing control.

2-23. LLD (LOW LEVEL DETECTOR)

2-24. The bipolar LLD IC contains circuitry to implement two independent functions. One portion of the IC consists of a very precise differential amplifier and voltage divider, designed so that the output signal LLD at pin 3 of the IC has one of two voltage levels, depending on the supply voltage V_{CC}. When V_{CC} drops below 2.225V, the LLD signal goes low, sinking about 5 mA; when V_{CC} is greater than 2.225V, the LLD signal remains high. The IC communicates the signal to the ACT through its F1 flag.

2-25. The second portion of the IC is similar to the first, in that it is designed to sink current when the supply voltage drops below a certain level. When the calculator is switched off, breaking the circuit between the battery pack and the power supply, V_{CC} drops to zero. When V_{CC} falls below 1.0V, the PORO signal goes low, sinking about 5 mA. This signal is fed to the CMOS IC's DS 0 and DS 2. When PORO is low, they do not respond to input; thus, spurious signals generated during power-off cannot erronously alter their contents.

2-26. KEYBOARD

2-27. Data is input to the calculator through the keyboard. It consists of 30 keys mounted over the keyboard PCA, from which seven cathode lines (C1 through C7) run to the cathode driver IC and five key lines (KSA through KSE) run to the ACT. The cathode lines cross the key lines so that when a key is pressed, one cathode line makes electrical contact with one key line. (See figure 2-2.) Since each cathode line is scanned by the cathode driver IC once every 12 word times, this key line is brought low by the cathode line at the same rate. The ACT waits 48 word times (approximately 15 ms) after the low key line is first detected to negate the effects of key bounce (which causes multiple entries), then loads into its key buffer an eight-bit keycode corresponding to the key line and cathode line which are simultaneously low.

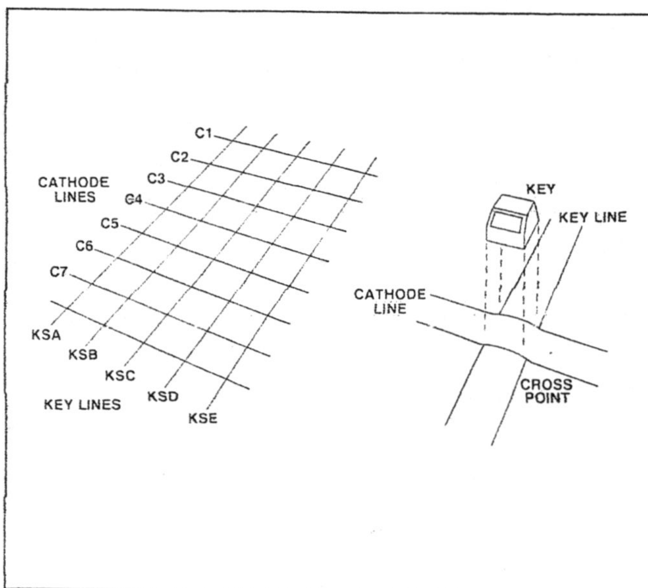

Figure 2-2. Keyboard Operation

stored in ROM's accessed in the following order: ROM 0, ROM 3, ROM 2, ROM 1, ROM 0, ROM 1, ROM 0. Execution of every operation begins with instructions from ROM 0, which encode the key pressed, followed by instructions from ROM 3, which initiate the required microprogram. Most mathematical functions go on to instructions in ROM 1 and/or ROM 2.

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2-24. The bipolar LLD IC contains circuitry to implement two independent functions. One portion of the IC consists of a very precise differential amplifier and voltage divider, designed so that the output signal LLD at pin 3 of the IC has one of two voltage levels, depending on the supply voltage V_{CC}. When V_{CC} drops below 2.225V, the LLD signal goes low, sinking about 5 mA; when V_{CC} is greater than 2.225V, the LLD signal remains high. The IC communicates the signal to the ACT through its F1 flag.

2-25. The second portion of the IC is similar to the first, in that it is designed to sink current when the supply voltage drops below a certain level. When the calculator is switched off, breaking the circuit between the battery pack and the power supply, V_{CC} drops to zero. When V_{CC} falls below 1.0V, the PORO signal goes low, sinking about 5 mA. This signal is fed to the CMOS IC's DS 0 and DS 2. When PORO is low, they do not respond to input; thus, spurious signals generated during power-off cannot erronously alter their contents.

2-26. KEYBOARD

2-27. Data is input to the calculator through the keyboard. It consists of 30 keys mounted over the keyboard PCA, from which seven cathode lines (C1 through C7) run to the cathode driver IC and five key lines (KSA through KSE) run to the ACT. The cathode lines cross the key lines so that when a key is pressed, one cathode line makes electrical contact with one key line. (See figure 2-2.) Since each cathode line is scanned by the cathode driver IC once every 12 word times, this key line is brought low by the cathode line at the same rate. The ACT waits 48 word times (approximately 15 ms) after the low key line is first detected to negate the effects of key bounce (which causes multiple entries), then loads into its key buffer an eight-bit keycode corresponding to the key line and cathode line which are simultaneously low.

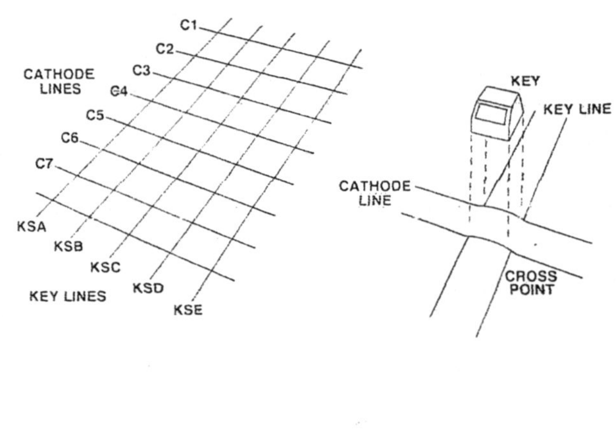


Figure 2-2. Keyboard Operation

2-28. DISPLAY

2-29. Data is output from the ACT through a display module consisting of 12 character positions. Each position is capable of displaying a character represented by a pattern of seven segments, plus an additional segment for the decimal point. (See figure 2-3.) Each segment is a group of light-emitting-diodes (LED's); therefore, each segment must be forward-biased (that is, simultaneously have both its cathode grounded and its anode driven) if it is to light. Grounding of the cathodes and driving current through the anodes occurs sequentially during recurrent scans, regulated by the ACT in conjunction with the cathode driver IC and ROM 0 as follows.

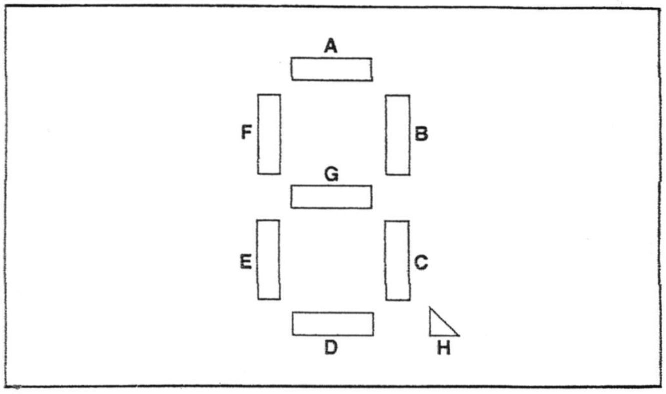


Figure 2-3. Displayed Digit Structure

2-30. All eight LED segments at each character position share a common cathode. (See figure 2-4.) Every 12 word times, the RCD pulse sent by the ACT to the cathode driver IC triggers a scan of the character positions from left to right, beginning with position 12 and followed by position 1. (See figure 2-5.) This scan successively grounds the common cathode at each character position, so that every 12 word times, all eight LED segments at each character position have their cathode grounded for 1 word time. At the end of each word time, ROM 0 sends a strobe (STR) pulse to the cathode driver IC, which then grounds the common cathode of the LED segments in the next character position.

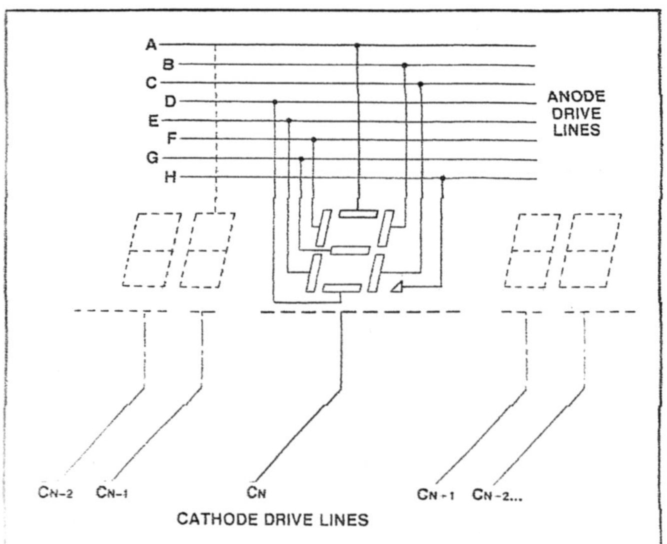


Figure 2-4. Anode and Cathode Drive Lines

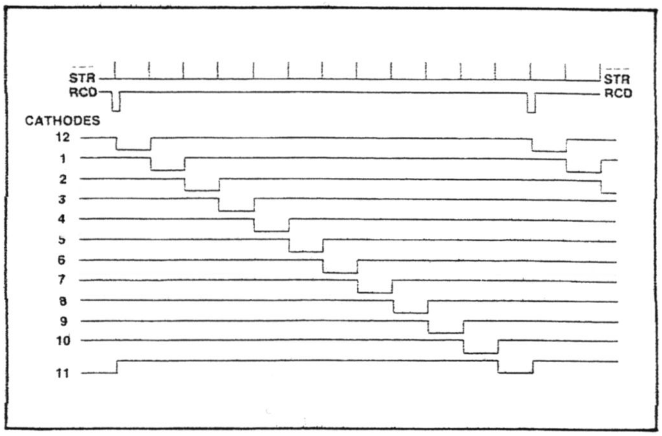


Figure 2-5. Cathode Driver Scan

2-31. The STR pulse simultaneously triggers a sequential scan of the anode drivers. The particular anodes to be driven during each word time are determined by ROM 0 in accordance with a code received from the ACT. For example, to display the digit *8* with a decimal point, the anodes of segments *A* through *H* are successively driven as shown in figure 2-6. For a hypothetical display of all *8*'s, all with decimal points, the LED segments would be lit one at a time as follows: first, segments *A* through *H* of character position 1, followed by segments *A* through *H* of character position 2, and so on until segments *A* through *H* of character position 11 have been driven, after which (assuming the number to be displayed has not changed) another RCD pulse triggers the entire process anew.

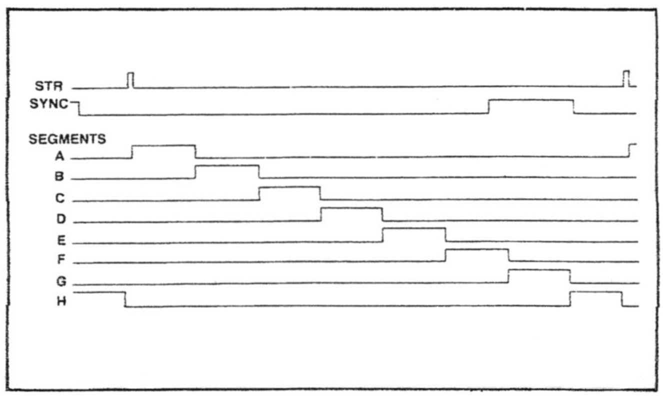


Figure 2-6. Anode Driver Scan

2-32. Each anode driver pulse is seven bit times long, with the exception of that for segment *H* which is five bit times long. Although only one segment in one character position is lit at any given instant, the scan rate is sufficiently high that the flickering of the displayed number is imperceptible, since the eye cannot detect flicker at refresh rates greater than about 100 per second.

2-33. POWER SUPPLY

2-34. Quick-charge nickel-cadmium batteries are the primary power source for the HP-29C. The +2.5 Vdc nominal battery voltage is converted to +6.00 Vdc and to −12.0 Vdc by the transistor inverter circuit shown in figure 2-7.

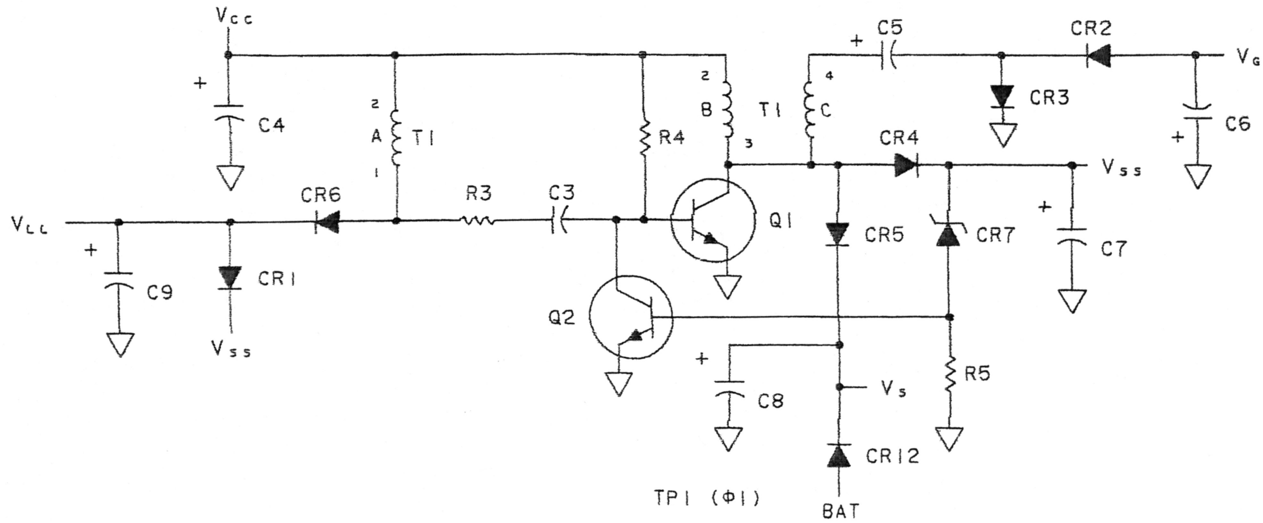


Figure 2-7. Power Supply Circuitry

2-35. Transistor Q1 and toroidal transformer T1 form the basic inverter circuit. With feedback from winding A, Q1 oscillates at a frequency between 30 and 200 kHz. Winding B of T1 forms the transformer primary from which V_{SS} is derived; CR4 rectifies and C7 filters the voltage from winding B. The voltage from winding C is rectified, filtered, and doubled by the combined actions of C5, C6, CR2, and CR3 to produce the output voltage V_{GG}. Voltage regulation of V_{SS} is provided by controlling the frequency of oscillation of Q1 through the combined action of zener diode CR7 and transistor Q2. V_{LL}, an unregulated 4.6V source to drive the anodes of the display LED's, is obtained from CR6 and filtered by C9 CR1 prevents V_{LL} from rising above V_{SS}.

2-36. The CMOS IC's are powered by V_S, which is obtained from either V_{SS} or V_{CC} as follows. During normal calculator operation, the voltage at the anode of CR4 is V_{SS} + 0.7V, which is higher than V_{CC}. Therefore, CR12 is reverse-biased and CR5 conducts, supplying V_S at approximately V_{SS}. When the calculator is turned off, the anode of CR4 goes to ground potential. Therefore, CR5 is reverse-biased and CR12 conducts, supplying V_S at approximately V_{CC}. When no power is applied—as when batteries are being changed—V_S is supplied by stored charge in C8.

2-37. BATTERY CHARGING

2-38. Figure 2-8 illustrates the battery charging circuitry. The ac adapter/recharger is a transformer that drops the line voltage to 10.00 ± 0.15 V_{rms} (for 115V line) at the input terminals of the calculator. Diodes CR8 through CR11 rectify the alternating current, and resistor R1 limits the dc current applied to the batteries. When the ON-OFF switch is turned ON, R1 is shunted and the dc voltage is applied directly to the battery pack and the calculator power supply.

Note: With batteries removed, the calculator could be damaged by connecting the ac adapter/recharger to the input terminals; therefore, do not operate the calculator until the batteries have been reinstalled.

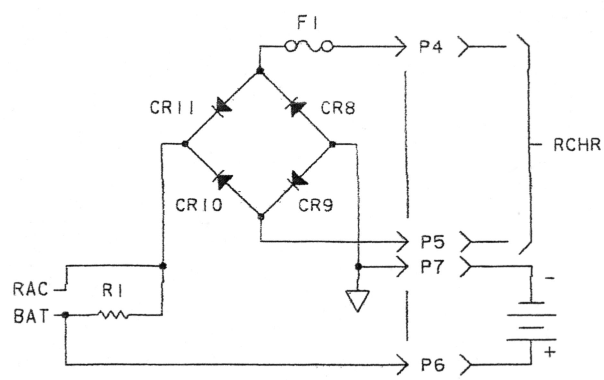


Figure 2-8. Battery Charging Circuitry

2-39. SYSTEM OPERATION

2-40. While the calculator is on but idle, the ACT continually refreshes the display and simultaneously calls and executes instructions from a microprogram loop in ROM 0. These instructions tell the ACT to interrogate its keyboard control and status control portions to determine whether a key has been pressed, the PRGM/RUN switch has been changed, or the LLD IC has detected a low battery level.

2-41. If a key has been pressed, the ACT loads into its key buffer an eight-bit keycode corresponding to the key pressed. If the key pressed is a prefix key, the ACT continues refreshing the display and monitoring the keyboard and status until the next key is pressed. Instructions from ROM 0 then merge the keycodes for the prefix and subsequent key (or keys, in some cases) into a single, eight-bit, merged keycode.

2-42. To fetch an instruction from a ROM, the ACT places the 12-bit address of the instruction on the IS/IA line during bit times t_{16} through t_{27}. (See figure 2-9.) In response, the ROM containing the location addressed places the 10-bit contents of that location onto the IS/IA line during bit times t_{46} through t_{55}. Usually, these contents are an instruction to be executed by the ACT, and the ACT generates a SYNC pulse during the same interval to signify to DS 0, DS 1 (in ROM 1), and DS 2 that an instruction is present on the IS/IA line. Each of these IC's monitors the instruction to check whether action (such as outputting data) is required of it. The ACT executes the instruction during the following word time, and increments the contents of its instruction address register by 1 to specify the new address.

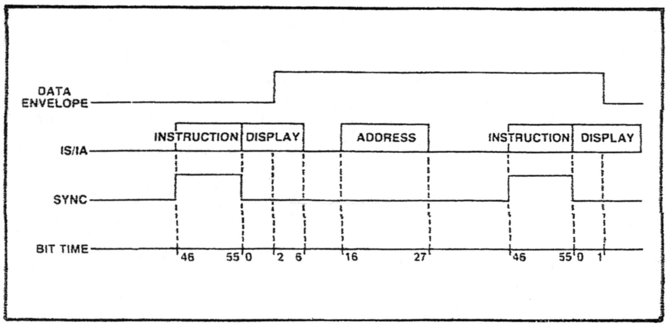


Figure 2-9. DATA, SYNC, and IS/IA Timing

2-43. Whenever an instruction is on the IS/IA line, a pulse is also present on the SYNC line. Frequently, however, the instruction in the location addressed specifies branching to an address elsewhere in the same ROM. For many such instructions, this branch address is stored as 10 bits in the location immediately following the location containing the branch instruction. In this case, the ACT suppresses the SYNC pulse, signifying to DS 0, DS 1, and DS 2 that the information now appearing on the IS/IA line during bit times t_{46} through t_{55} is an address rather than an instruction. Therefore, these IC's do not respond to it. The ACT, however, inputs the branch address from the IS/IA line into its program counter and sends it back out of its instruction address register during the next word time.

2-44. If the instruction output by the ROM specifies a transfer of data, the transfer is made serially, least significant bits first, over the DATA line. The IC's involved wait two bit times following the end of the SYNC pulse before they begin the data transfer; thus, the 56-bit transfer begins at bit time t_2 of the following word time.

2-45. Meanwhile, using instructions from ROM 0, the ACT continually outputs the number represented in its C-register to the calculator display as follows. The number is formatted using instructions from ROM 1, selected according to whether the user has specified FIX, SCI, or ENG. Each character to appear in one of the 12 positions is represented by four bits in the A-register and four in the B-register. (Four of the remaining eight bits in the A-register serve as a counter to time the blinks of the decimal point when a low battery level is detected.) The four bits in the A-register represent, in BCD, the digit or letter; those in the B-register signify whether the character position is to display a minus sign or decimal point. During bit times t_0 through t_3, the ACT sends over the IS/IA line to ROM 0 the four bits in the A-register for one character position. During bit times t_4 through t_6, it sends three bits from the B-register—recoded from the previous four—for the same character position. During t_0 through t_6 of the following word time, the ACT sends to ROM 0 the seven bits of information for the next character position in the display, and so on.

Assembly-Level Service

3-1. INTRODUCTION

3-2. Procedures for assembly-level service of the HP-29C consist of the following:

a. Isolate the cause of a problem to a malfunction in a particular assembly: refer to table 3-2.

b. If necessary, check out the ac adapter/recharger: refer to paragraph 6-7.

c. If necessary, check out the battery pack: refer to paragraph 6-4.

d. Disassemble the calculator to permit replacement or repair of the assembly believed to be causing the problem: refer to paragraph 3-4.

e. Reassemble and test the calculator to determine if it is functioning properly using:

(1) The Abbreviated Operational Test, paragraph 5-14.

(2) The Full Operational Test, paragraph 5-20.

3-3. Tools and fixtures facilitating service are listed in table 3-1.

Table 3-1. Recommended Tools and Fixtures

HP PART NUMBER	DESCRIPTION
ET-7249 Opt 001	Test Fixture
ET-7249 Opt 002	Test Fixture
ET-7249 Opt 003	Test Fixture
ET-9613-21-A	*Automatic Tester Option*
ET-9610	Test System Mainframe
00021-92035-29C	Sequence PROM Assembly for ET-7249 Opt 003
00091-92137-29C	Sequence PROM Assembly for ET-9610

CAUTION

Ensure that the bench setup for troubleshooting and disassembly has adequate electrostatic protection; otherwise, IC's may be damaged.

Table 3-2. Assembly Failure Symptoms

FAILURE SYMPTOM \ ASSEMBLY FAILURE*	LOGIC PCA	KEYBOARD ASSEMBLY	DISPLAY	BATTERY PACK	AC ADAPTER/ RECHARGER
Calculator Inoperative	1	3		2	4
Calculator Operative on Battery Pack Only	2			3	1
Calculator Operative on AC Adapter/Recharger Only	1			2	3
Functions Inoperative Or Give Incorrect Results	1	2			
Low Battery Level Detector Not Operating Correctly	1		2		
No Key Entry	1	2			
Numbers Not Stored	1				
Digit(s) And/Or Segment(s) Missing Or Added in Display	1	3	2		

*The numbers in the columns indicate the probability of assembly failure and therefore the order in which to replace the assemblies. For a given failure symptom, the assembly under which the number 1 is shown should be replaced first.

3-4. DISASSEMBLY

3-5. The following procedures describe the disassembly of the HP-29C. To reassemble the calculator, perform the procedures in reverse order.

a. Hold the calculator as shown in figure 3-1 and place your thumb on the square inset in the battery pack case.

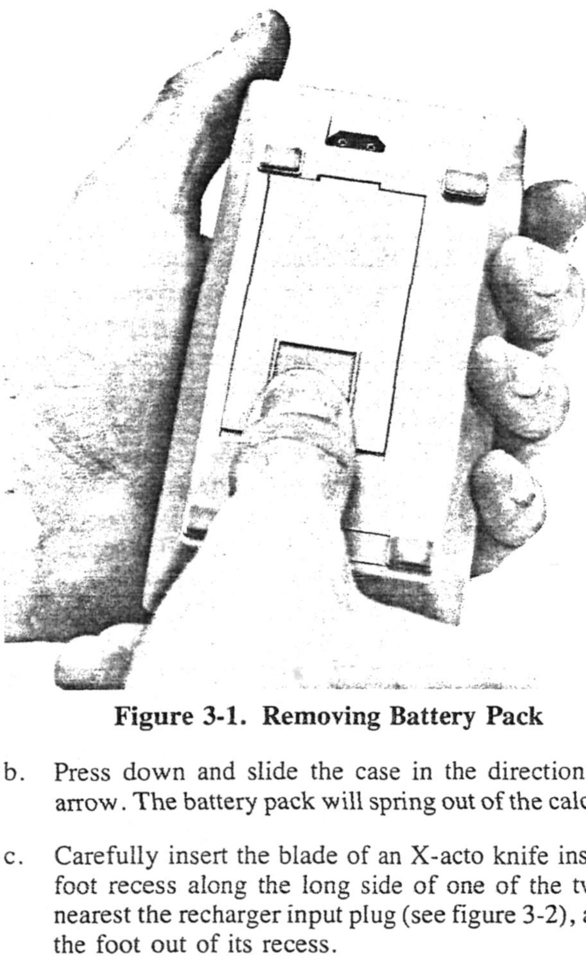


Figure 3-1. Removing Battery Pack

b. Press down and slide the case in the direction of the arrow. The battery pack will spring out of the calculator.

c. Carefully insert the blade of an X-acto knife inside the foot recess along the long side of one of the two feet nearest the recharger input plug (see figure 3-2), and pry the foot out of its recess.

d. Repeat the preceding step for the other foot.

e. Using a small Phillips screwdriver, unscrew the screws in the exposed wells beneath the foot recesses.

f. Lift up the calculator and press toward the keyboard assembly the two battery contacts protruding into the battery compartment. (See figure 3-3.) This should dislodge the keyboard assembly from the case; if not, press with the tip of the small Phillips screwdriver on one of the pins of the ac adapter/recharger input plug.

g. Simultaneously press downward on the keyboard assembly and upward on the case, and tilt the top of the keyboard out of the top of the case until the two battery contacts clear the slots in the case. Continue separating the tops of the keyboard and case until their bottoms snap apart.

Figure 3-2. Removing Foot

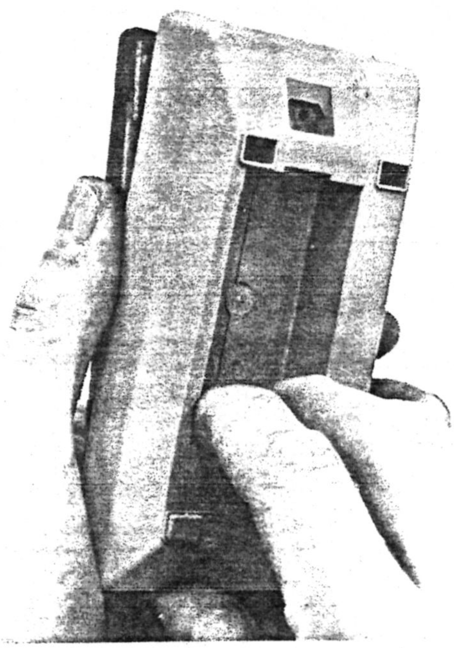


Figure 3-3. Dislodging Keyboard Assembly

h. Grasp the keyboard assembly in one hand and the logic PCA in the other hand. Separate them by pulling apart the connectors at the top and bottom.

i. Separate the LED display module from the logic PCA.

Component-Level Service

4-1. INTRODUCTION

4-2. This section presents information to assist in troubleshooting and repairing the HP-29C to the component level. Included are:

a. Checkout and diagnostic procedures: paragraph 4-3.

b. Component failure symptoms: paragraph 4-10 and table 4-3.

c. Troubleshooting hints: paragraph 4-12.

d. A list of replaceable parts on the logic PCA: table 4-5.

e. A component location diagram for the logic PCA: figure 4-7.

f. A schematic diagram for the entire calculator: figure 4-8.

> **CAUTION**
>
> Ensure that the bench setup for troubleshooting and disassembly has adequate electrostatic protection; otherwise, IC's may be damaged.

4-3. COMPONENT-LEVEL TROUBLESHOOTING

4-4. Component-level troubleshooting of the HP-29C should begin with checking the power supply voltages and the system timing waveforms. Table 4-2 gives the specifications for the various voltages supplied, plus the possible causes if the voltages measured are not within specifications. Figures 4-2 through 4-4 show the timing waveforms Φ1, Φ2, SYNC, STR, and RCD. If one or more of these waveforms are not present, check for open or shorted traces. If no faults are found, replace successively the ACT, capacitor C1, and then the remaining IC's until all waveforms are present.

Table 4-1. Recommended Tools and Fixtures

HP PART NUMBER	DESCRIPTION
ET-7249 Opt 001	Test Fixture
ET-7249 Opt 002	Test Fixture
ET-7249 Opt 003	Test Fixture
ET-9613-21-A	Automatic Tester Option
ET-9610	Test System Mainframe
00021-92035-29C	Sequence PROM Assembly for ET-7249 Opt 003
00091-92137-29C	Sequence PROM Assembly for ET-9610

Table 4-2. Power Supply Troubleshooting

VOLTAGE	SPECIFICATIONS		REPAIR IF OUT OF SPECIFICATIONS
	VDC	RIPPLE (MV)	
V_{CC}	2.2 to 3.5	—	Battery pack.
V_{SS}	5.5 to 6.5		1. If oscillator not operating (see figure 4-1), Q1. 2. If V_{SS} is high, Q2 and CR7. 3. If V_{SS} is low, check IC's for excessive load.
		250 max	1. CR4, C7. 2. Traces between V_{SS} and C7.
V_{GG}	−11.0 to −13.0		1. If V_{GG} = 0, CR2 and CR3. 2. If V_{GG} is low, check IC's for excessive load.
		250 max	C5,* C6,* CR2, CR3.
V_{LL}	3.4 to V_{SS}	250 max	CR1, CR6, C9.
V_S	5.5 to 6.5	250 max	CR5, CR12, C8.

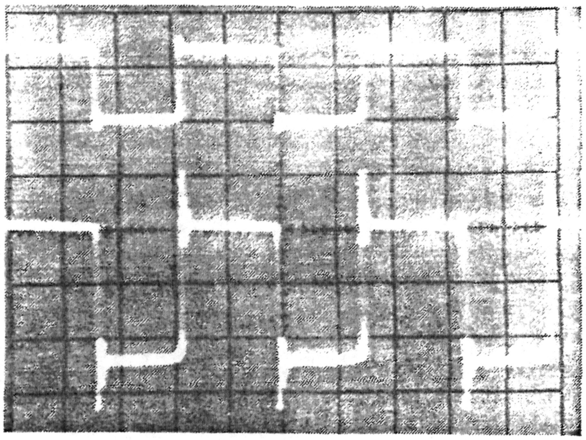
*If the ripple on V_{GG} exceeds the specified value, replace capacitors C5 *and* C6 with 3.3 μF capacitors rather than with 2.2 μF capacitors. (Refer to table 4-5.) Capacitors C5 and C6 must always have the same value, either 2.2 μF or 3.3 μF.

CR4

0-

0-

CR3

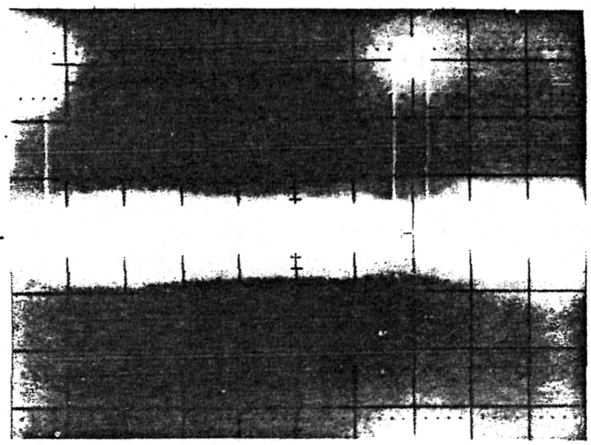


TEST POINTS: ANODES OF CR3 AND CR4
OSCILLOSCOPE TIME BASE: 2 μS/DIV
VERTICAL GAIN: 5 V/DIV

Figure 4-1. CR3 and CR4 Anode Waveforms*

SYNC

0-



TEST POINT: PIN 20 OF ACT (U3)
TIME BASE: 0.1 MS/DIV
VERTICAL GAIN: 2 V/DIV

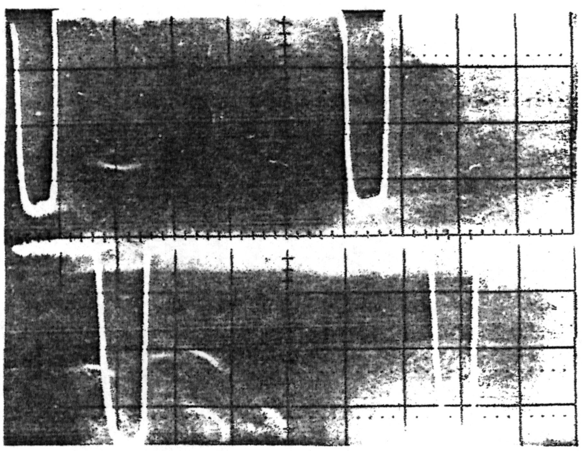
Figure 4-3. SYNC Waveform*

Φ1

0-

Φ2

0-



TEST POINT: PINS 16 (Φ2) AND 17 (Φ1) OF ACT (U3)
OSCILLOSCOPE TIME BASE: 1 μS/DIV
VERTICAL GAIN: 5 V/DIV

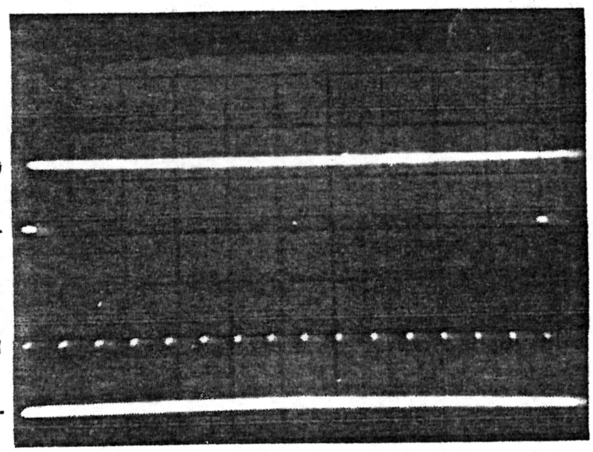
Figure 4-2. Φ1 and Φ2 Waveforms*

RCD

0-

STR

0-



TEST POINTS: RCD: PIN 21 OF ACT (U3)
STR: PIN 11 OF ROM 0 (U1)
TIME BASE: 5 MS/DIV
VERTICAL GAIN: 2 V/DIV

Figure 4-4. STR and RCD Waveforms*

*These waveforms are as seen with an HP 182C Oscilloscope, HP 1804A Vertical amplifier Plug-In. Vertical bandwidth: 50 MHz. Calculator ON, with 0.00 in display.

4-5. If the power supply is functioning properly and all system timing waveforms are present, the cause of the problem must be isolated to failure of a component on the logic PCA or of the display module. To do so, consider the contents and failure symptoms of each IC, given in table 4-3, in light of the troubleshooting guidelines given in paragraph 4-12. For further information regarding failure of which IC is the most likely cause for a malfunctioning operation, refer to paragraph 5-4. Additional diagnostic information can be obtained by performing the Abbreviated Operational Test (paragraph 5-14) and the Full Operational Test (paragraph 5-20). IC failures are indicated for each step of these tests when the correct results are not obtained.

4-6. For diagnostic aid in isolating a display problem to either the cathode driver IC or the display module, refer to paragraph 4-14.

4-7. If it is necessary during the course of repair to replace the cathode driver IC, it might also be necessary to replace R2 on the logic PCA. Refer to paragraph 4-17 for this procedure.

4-8. If the low battery indication is not functioning properly, refer to paragraph 4-19 for a checkout and troubleshooting procedure.

4-9. After all repairs have been made to the logic PCA, the following performance tests should be run to ensure proper functioning of all components on the logic PCA:

a. The Abbreviated Operational Test, paragraph 5-14.

b. The Full Operational Test, paragraph 5-20.

4-10. COMPONENT FAILURE SYMPTOMS

4-11. Failure of each IC on the logic PCA can result in just one or a number of symptoms, which depend upon the function and contents of the particular IC. Most of these symptoms are listed in table 4-3. One of the IC's on the HP-29C logic PCA contains both data storage and read-only-memory (ROM) within a single package (and is therefore sometimes termed a "data ROM"). For this IC, the table differentiates between symptoms resulting from failure of the data storage portion of the IC and those resulting from failure of the read-only-memory portion.

Table 4-3. Component Failure Symptoms

COMPONENT	FUNCTION	ROM/DS CONTENTS	FAILURE SYMPTOMS
U1	ROM 0	Overhead	• PRGM RUN switch incorrectly decoded. (See also ACT.) • Correct program step number not displayed. (See also ACT and ROM 1.) • Correct keycode not displayed. (See also ROM 1.) • No response to function keys. • Blank display at turn-on. (See also ACT, ROM 1, and ROM 3.) • Low battery indication (blinking decimal point) not operating correctly. (See also ACT, ROM 3, and LLD.) • One or more of the following functions not operating correctly: CLEAR PREFIX SST CLEAR PRGM BST CLEAR REG R/S GTO • nn • Illegal number displayed. • Incorrect character(s) in display of ***Error.*** • Executes function other than that selected. (See also ROM 3.) • Prefix key(s) ignored. (See also ACT.)
	Anode Drivers		• Missing digits, incorrect or missing segments in display. • Incorrect character(s) in display of ***Error.***

Table 4-3. Component Failure Symptoms (Continued)

COMPONENT	FUNCTION	ROM/DS CONTENTS	FAILURE SYMPTOMS
U7	ROM 1	Math Functions	• Incorrect decimal point, sign, or blank. (See also ROM 0.) • Incorrect formatting. (See also DS 2.) • One or more of the following functions not operating correctly: + e^x $\bar{x}$ − 10^x s × y^x Σ+ ÷ % Σ− x^2 →H RCL Σ+ $\sqrt{x}$ →H.MS DSZ $1/x$ ISZ • Overflow not operating correctly. • Indirect label search skipping or not finding labels. (See also ROM 3.) • Correct program step number not displayed. (See also ROM 0.) • Blank display at turn-on. (See also ACT, ROM 0, and ROM 3.)
	DS 1	Indirect Storage Registers $R_{(16)}$ Through $R_{(29)}$ LAST X Scratch Register (Digit Entry)	• Storage and/or recall with indirect register(s) $R_{(16)}$ through $R_{(29)}$ not operating correctly. • LAST X not operating correctly. • Display shows ***0.0000000 00*** or ***-00000000000*** following attempt at digit entry.
U6	ROM 2	Trig Functions	• One or more of the following functions not operating correctly: sin $\sin^{-1}$ cos $\cos^{-1}$ tan $\tan^{-1}$ →R →P ln log e^x 10^x y^x • Insertion and/or deletion of program step not operating correctly. • PAUSE not operating correctly. • Unable to change from one trigonometric mode to another. (See also DS 2 if unable to change from DEG mode or RAD mode.)

Table 4-3. Component Failure Symptoms (Continued)

COMPONENT	FUNCTION	ROM/DS CONTENTS	FAILURE SYMPTOMS
U5	ROM 3	Overhead	• Executes function other than that selected. (See also ROM 0.) • Label search (GSB or GTO) not operating correctly. • Digits can be entered but no functions can be executed. • Blank display at turn-on. (See also ACT, ROM 0, and ROM 1.) • *Error* displayed at power-on without power to CMOS memory interrupted. (See also ROM 0.) • *Error* not displayed at power-on when power to CMOS memory interrupted. (See also ROM 0.) • Low battery indication (blinking decimal point) not operating correctly. (See also ACT, ROM 0, and LLD.) • Digit or [•] entry, EEX, or CHS not operating correctly. • Indirect operations not operating correctly. (See also ROM 1.) • Storage arithmetic not operating correctly. (See also ROM 1.) • One or more of the following functions not operating correctly: RCL R↓ ISZ LAST X (See also ROM 1.) CLx ENTER↑ INT FRAC ABS CLEAR Σ+ RTN π (See also ROM 2.) • Unable to change from one display formatting mode to another. (See also DS 2 if unable to change from FIX mode or SCI mode.) • One or more of the following tests not operating correctly: x=y x=0 x≠y x≠0 x≤y x<0 x>y x>0

Table 4-3. Component Failure Symptoms (Continued)

COMPONENT	FUNCTION	ROM/DS CONTENTS	FAILURE SYMPTOMS
U8	DS 0	Data Storage Registers R_0 Through R_9 and Statistics Registers $R._0$ Through $R._5$	• STO and/or RCL gives incorrect results. • Statistical functions operate incorrectly. (See also ROM 3 and ROM 1.)
U9	DS 2	Program Storage Current X Status Registers (Display Format and Trigo-nometric Mode)	• Program steps 0 through 98 not recorded properly; appear as ***74*** or ***15 13 .5*** in blocks of seven. • After switching OFF then ON, number in display is not identical to that before switching OFF (except possibly for formatting, if number was the result of a digit entry). • Unable to change number of digits displayed from 0 in FIX *mode or 1 in SCI mode.* • Unable to change from DEG or RAD trigonometric mode.
U3	ACT	Arithmetic, con-trol, and timing	• Blank display at turn-on. (See also ROM 0, ROM 1, and and ROM 3.) • No Φ1, Φ2, SYNC, or RCD signal. • Incorrect instructions or data used. • Complete or partial machine malfunction. • Incorrect answers for all functions. • Value in X-, Y-, Z-, or T-register incorrect. • PRGM RUN switch incorrectly decoded. (See also ROM 0.) • Low battery indication (blinking decimal point) not oper-ating correctly. (See also ROM 0, ROM 3, and LLD.) • Keys ignored.
U4 (LLD)		Low Level Detection Power-On Reset Output	• Low battery indication (blinking decimal point) at battery voltage greater than 2.225V. • Contents of CMOS data/program storage lost or altered when calculator switched OFF, then ON (and capacitor C8 is not discharged or defective).

4-12. TROUBLESHOOTING HINTS

4-13. Given below are general guidelines, specific operating characteristics, and failure modes. Based on theoretical considerations and assumptions derived from limited data, they are neither comprehensive nor absolute; nevertheless, they can greatly expedite the process of isolating a malfunctioning logic PCA to failure of a particular IC upon it.

a. As discussed in section II, most operations require microinstructions contained in several ROM's, which makes it difficult to ascribe an inoperative operation unambiguously to failure of one particular ROM. Fortunately, however, when a failure occurs in read-only-memory, it generally incapacitates the entire ROM portion of the IC (and therefore is frequently termed a "catastrophic" failure), rather than affecting only one or a few bits, or one or a few 10-bit words. Consequently, it is likely—though not certain—that failure of the ROM portion of an IC will result in most, if not all, of its characteristic failure symptoms. Therefore, after an observed symptom is found listed in table 4-3 for a particular IC, test the logic PCA in the calculator or a test fixture to ascertain whether other failure symptoms characteristic of that IC are exhibited. If not, look for another IC for which is listed not only the initially observed symptom, but also other symptoms that appropriate testing elicits. The IC most likely to have failed, which is the one to be replaced first in the effort to correct the problem, is that for which the most characteristic failure symptoms are observed.

b. When a failure occurs in data storage, it generally is confined to one register, rather than affecting the entire data storage portion of the IC. Since each register is a 56-bit circular shift register, a failure in data storage usually results in a register filled with 56 0's or 56 1's. When recalled to the display, each of these conditions appears as the number zero, displayed according to the display formatting mode in effect. A failure in a program storage register appears as ***74*** when the register is filled with 0's or ***15 13 .5*** when the register is filled with 1's.

c. Many operations access data storage in addition to read-only-memory. These operations include the statistical functions as well as stores and recalls. When such an operation gives incorrect results, the cause can be failure either of the ROM portion of one IC or another, or of the data storage portion of an IC. In such situations, it is important to attempt to determine whether the incorrect results are due to failure of read-only-memory or to failure in data storage. To this end, the following facts should be considered:

(1) If failure of the ROM portion of an IC is responsible, it is likely that the other symptoms of failure of that ROM, listed in table 4-3, will be exhibited.

(2) If failure in data storage is responsible, this failure will produce incorrect results for other operations accessing the same data register(s). Therefore, after determining the location of the register(s) involved using table 4-3, perform such an operation (such as a simple store and recall). If incorrect contents are recalled from these register(s), while correct contents are recalled from registers located in the data storage portions of other IC's, it is likely that the failure is in data storage rather than in read-only-memory.

d. Certain functions—in particular, trigonometry and statistics—not only access the data storage registers containing numbers entered by the user, but also access repeatedly a number of registers in DS 1 and DS 2, not accessible to the user, for temporary storage of intermediate answers during the course of a calculation. When such functions appear to give incorrect results, vary the data in the user-accessible registers and check whether the result of the calculation varies. If it does not, one of these internal scratch registers may have failed.

e. Successful turn-on of the calculator involves the ACT using instructions from ROM 0, ROM 3, and DS 2. Therefore, if the calculator appears to turn on improperly or not at all, the failure is most probably in the ACT, next in ROM 0, next in ROM 3, and finally in DS 2.

f. ROM 0 contains the instructions used for key entry. Therefore, a totally inoperative keyboard may be caused by failure of ROM 0.

g. All displayed numbers are formatted using instructions contained in ROM 1 in accordance with format specifications stored in DS 2. Therefore, incorrect formatting (including the extreme case of all blanks) in the display could be caused by a failure either of ROM 1 or in DS 2.

h. All operations except stack manipulation, digit entry, and stores and recalls use, to various degrees, the math routines contained (for the most part) in ROM 1 and ROM 2. Therefore, failure of either of these ROM's will probably cause incorrect results for all operations except those listed here.

i. Frequently, when an operation is attempted that uses instructions contained in ROM 1 or ROM 2 (which are not essential for turn-on), a failure in the ROM accessed may cause the calculator to appear to "go dead" with no display.

j. If pressing [$\bar{x}$] or [s] results in a display of ***Error,*** register $R_{.0}$ has failed. This can be confirmed by storing a number into this register and then recalling it to the display. If it appears as zero, DS 0 should be replaced.

k. If a program appears to be entered correctly in PRGM mode, but when executed results in a display of ***74*** with the [R/S] or [SST] key down and the last displayed number with the key up, the cause is probably a failure in DS 2.

l. If pressing any function key following the entry of a number results in a display of ***0.***, the cause is probably a failure in DS 2.

4-14. DISPLAY TROUBLESHOOTING

4-15. To test the LED display module and display circuitry (see the displayed digit structure in figure 4-5):

a. Key in *0.123456789*. If segments are added to any digit, either ROM 0 or the LED display is probably faulty.

b. Observing the display after each keystroke, key in *-88888888.-88*. Check for the following possible problems, illustrated in figure 4-6:

(1) Digit too bright or dim.

(2) Digit has tendency to turn on another digit, causing ghost image to appear.

(3) One digit missing segment(s).

(4) All digits missing same segment(s).

(5) Single digit missing.

(6) Segment has tendency to turn on another segment, causing ghost image to appear.

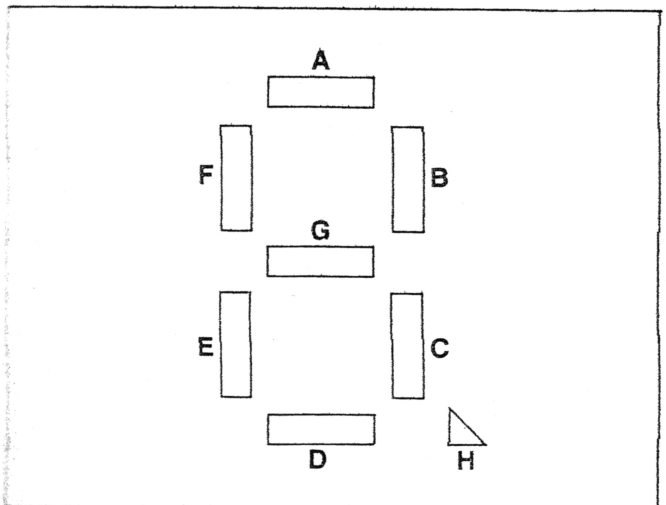


Figure 4-5. Displayed Digit Structure

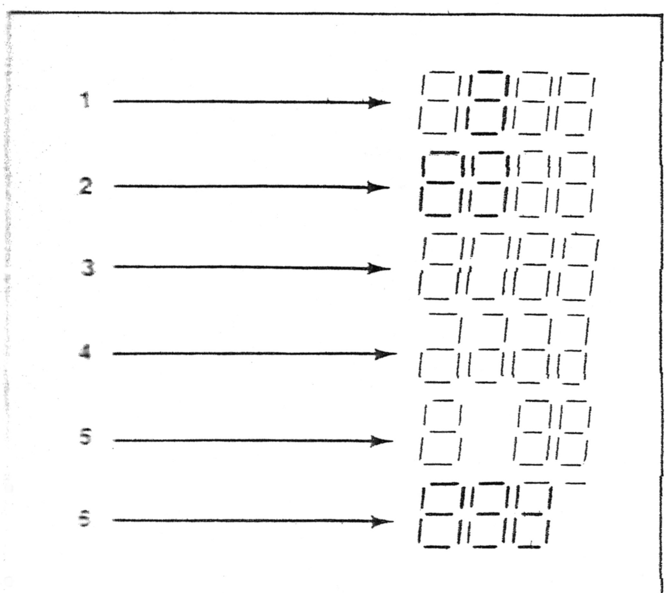


Figure 4-6. Display Problems

4-16. Probable causes for the problems listed above are:

Problem	Caused By
4, 6	ROM 0
1, 2, 5	Cathode Driver. (Refer to paragraph 4-17.)
3, 4, 5	LED Module.
4, 5	Bad connection at connector P3.

4-17. CATHODE DRIVER REPLACEMENT

4-18. The value of R2 is selected to match the characteristics of the particular cathode driver IC (U2) used. Table 4-4 shows the six possible combinations, listed according to the display brightness category code of the IC, which is stamped upon it. If this IC is replaced in the course of repair, check whether the new IC has the same category code. If not, replace R2 with a resistor of the proper value.

Table 4-4. ***Resistor Selection for Cathode Driver***

CATHODE DRIVER CATEGORY CODE	R2
N	2K
M	2.2K
L	2.4K
K	2.7K
J	3K
I	3.3K

4-19. LOW BATTERY LEVEL INDICATION

4-20. To check (and repair, if necessary) the circuitry for indicating a low battery level, proceed as follows:

a. Ensure that the dc levels of V_{SS} and V_{GG} are within specifications. (Refer to table 4-2.)

b. Connect a dc voltmeter to pin 3 of the LLD IC (U4).

c. Connect a dc power supply to the calculator battery terminals.

d. Switch the calculator ON and vary the power input from +2.5 to +2.0 Vdc. The voltage at pin 3 of U4 should vary from +5.0 Vdc or more to +0.4 Vdc or less, and the decimal point should begin blinking.

e. If the voltage does not vary as specified in step *d* or the decimal point does not blink, connect temporarily a 100K resistor between pin 3 and pin 8 of U4, then vary the power input from +2.0 to +3.0 Vdc. The voltage between pin 3 and ground should vary from +1.0 to +5.0 Vdc. If it does not, replace U4, then return to step *d*. If it does, check the traces between, and the connections at, pin 3 of U4 and pin 3 of the ACT (U3). If all traces and connections are good, replace successively the ACT, ROM 0, and ROM 3, returning to step *d* after each replacement, until the voltage varies properly.

Table 4-5. Logic PCA (L) Replaceable Parts

REFERENCE DESIGNATION	HP PART NUMBER	DESCRIPTION
C1	0180-0575	CAPACITOR, 2.2 μF, 20%, 15V
C2	0160-4292	CAPACITOR, 330 pF, 5%, 50V
C3	0160-3457	CAPACITOR, 2000 pF, 10%, 250V
C4, 10	0180-2616	CAPACITOR, 60 μF, 20%, 6V
C5, 6*	0180-0575	CAPACITOR, 2.2 μF, 20%, 15V
C5, 6*	0180-2664	CAPACITOR, 3.3 μF, 20%, 15V
C7, 8	0180-2602	CAPACITOR, 47 μF, 20%, 8V
C9	0180-2206	CAPACITOR, 60 μF, 10%, 6V
CR1 thru CR6, CR12	1901-1098	DIODE, switching
CR7	1902-0642	DIODE, zener, 5.62V
CR8 thru CR11	1901-0704	DIODE, silicon rectifier
F1	2110-0537	FUSE, 0.375A, 125V
L1	9100-2278	INDUCTOR, 150 μH
P1, 2	1251-3955	CONNECTOR, 9-pin, male
P3	1251-3956	CONNECTOR, 20-pin, male
P4, 5	5020-9210	CONNECTOR, 1-pin, male
P6, 7	0361-0535	CONNECTOR, rivet
Q1	1854-0668	TRANSISTOR, npn
Q2	1854-0071	TRANSISTOR, npn
R1	0689-1505	RESISTOR, 15 ohms, 5%, 1W
R2†	0683-2025	RESISTOR, 2K, 5%, ¼W
R2†	0683-2225	RESISTOR, 2.2K, 5%, ¼W
R2†	0683-2425	RESISTOR, 2.4K, 5%, ¼W
R2†	0683-2725	RESISTOR, 2.7K, 5%, ¼W
R2†	0683-3025	RESISTOR, 3K, 5%, ¼W
R2†	0683-3325	RESISTOR, 3.3K, 5%, ¼W
R3	0683-5605	RESISTOR, 56 ohms, 5%, ¼W
R4	0683-1815	RESISTOR, 180 ohms, 5%, ¼W
R5	0683-1025	RESISTOR, 1K, 5%, ¼W
R6	0683-1045	RESISTOR, 100K, 5%, ¼W
R7	0683-3305	RESISTOR, 33 ohms, 5%, ¼W
T1	9100-3594	TRANSFORMER, toroidal
U1	1818-0431	INTEGRATED CIRCUIT, ROM 0
U2	1820-1382	INTEGRATED CIRCUIT, cathode driver
U3	1820-1596	INTEGRATED CIRCUIT, ACT
U4	1820-1983	INTEGRATED CIRCUIT, LLD
U5	1818-0376	INTEGRATED CIRCUIT, ROM 3
U6	1818-0377	INTEGRATED CIRCUIT, ROM 2
U7	1818-0379	INTEGRATED CIRCUIT, ROM 1 & DS 1
U8	1820-1886 ‡ 5061-0469 ‡	INTEGRATED CIRCUIT, DS 0
U9	1820-1886 ‡ 5061-0469 ‡	INTEGRATED CIRCUIT, DS 2
	00029-80001	BOARD, printed-circuit
	0360-1723	PIN, spacer
	5040-8958	STANDOFF

*The value of capacitors C5 and C6 on a new logic PCA is 2.2 μF. When excessive ripple is found in V_{GG} during service, C5 and C6 should be replaced with 3.3 μF capacitors. (Refer to table 4-2.)

†The value of R2 is selected according to the display brightness category code of the cathode driver IC.

‡Either of these part numbers can be used for DS 0 and DS 2; however, the same part number need not be used for both IC's.

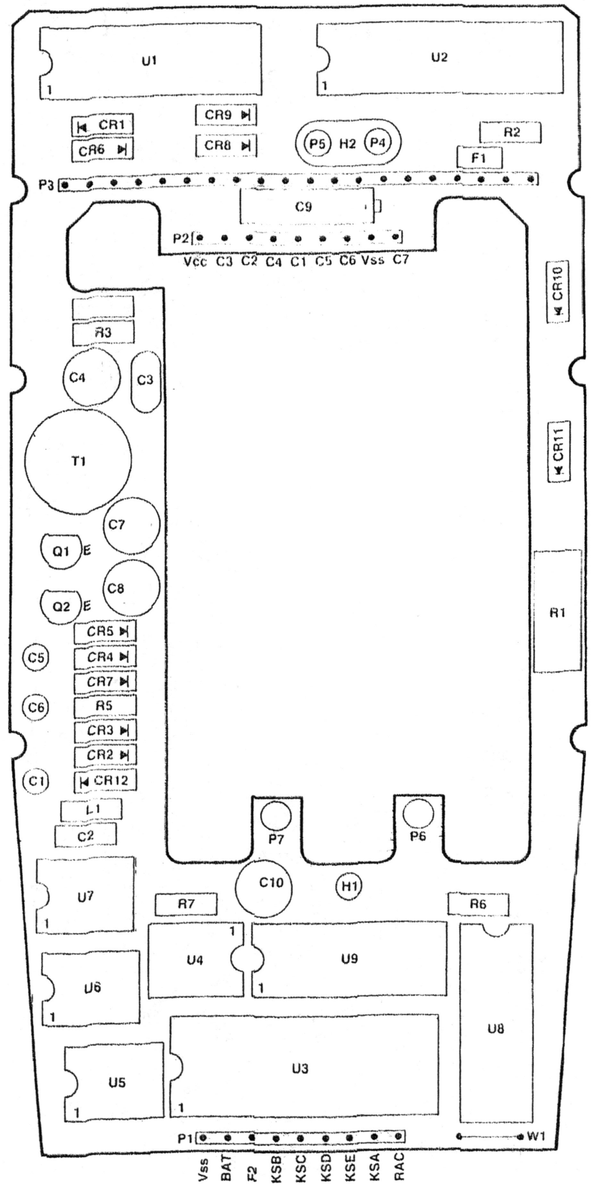


Figure 4-7. Logic PCA Component Location Diagram

NOTES:

1. CHARACTER POSITIONS NUMBERED LEFT TO RIGHT IN USUAL VIEWING POSITION.
2. SEGMENTS LETTERED AS SHOWN OPPOSITE.

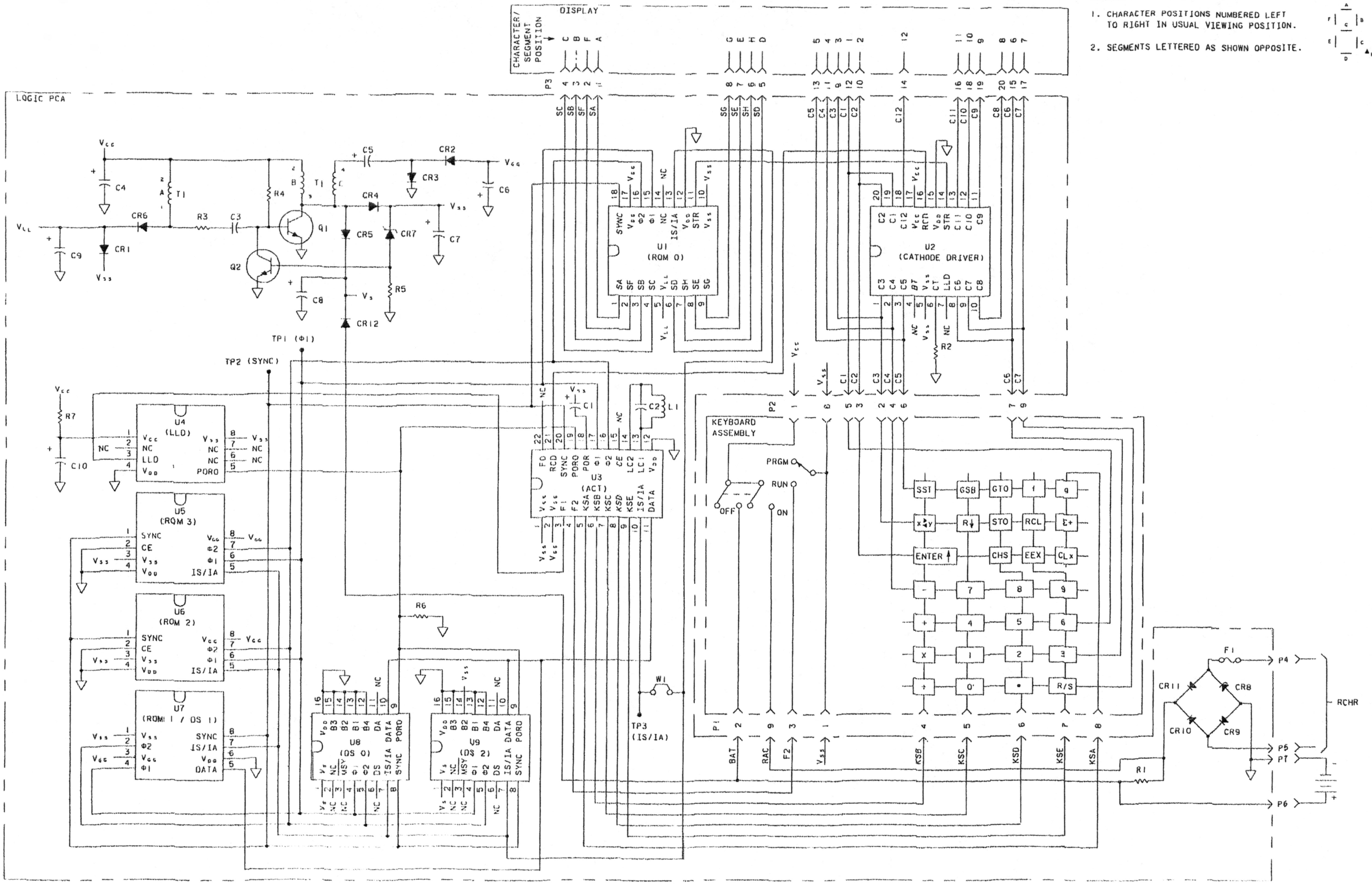


Figure 4-8. HP-29C Schematic Diagram

Performance Tests

5-1. INTRODUCTION

5-2. This section presents the following performance tests:

a. Tests of Specific Operations: paragraph 5-4.

b. Abbreviated Operational Test: paragraph 5-14.

c. Full Operational Test: paragraph 5-20.

5-3. When performed during assembly-level service, these tests are used to verify proper operation of the calculator. When performed during component-level service of the logic PCA, the tests are used not only to verify proper operation of the logic PCA, but also diagnostically to isolate the cause of a problem to a particular IC on the logic PCA.

5-4. TESTS OF SPECIFIC OPERATIONS

5-5. If an HP-29C is returned for repair because a specific operation is believed to be functioning improperly, the appropriate key sequence given below can be used to ascertain whether the problem actually exists (in case the customer is operating the calculator incorrectly) or still exists (in case replacement of the logic PCA or an IC upon it has corrected the problem). Note that in some cases, correct results with the key sequence given does not guarantee that the operation performs properly with all proper key sequences. Therefore, if the calculator was returned with an indication of a particular key sequence that does not yield correct results, the key sequence supplied by the customer rather than that given here should be used to check the problem.

5-6. As presented, the test procedures are for component-level service of the logic PCA. To employ them during assembly-level service of the calculator, merely replace the logic PCA whenever the directions specify replacement of an IC.

5-7. Tests of the operations performable on the HP-29C are grouped as follows:

a. General calculator operations (all operations except program control and conditional tests): paragraph 5-8.

b. Program control operations: paragraph 5-10.

c. Conditional test operations: paragraph 5-12.

5-8. General Calculator Operations

5-9. Tests of all operations except program control and conditional tests are given in table 5-1. To test each function or operation:

a. Set switches to: ON RUN

b. Press: CLx f REG f FIX 2.

c. Press the keys indicated in table 5-1 for the operation of interest. The display indicated in the table should be obtained.

d. If the display indicated in the table is not obtained, switch to PRGM and again press the keys indicated for the operation of interest.

(1) If the correct keycode is not obtained, replace successively DS 2, ROM 0, ROM 1, ROM 2, and ROM 3 until the correct display or keycode is obtained, returning to step *a* after each replacement.

(2) If the correct keycode is obtained, replace the IC or, successively, the IC's indicated. When more than one IC is given for a particular operation, return to step *a* after each replacement.

5-10. Program Control Operations

5-11. A test of program control operations is given in table 5-2. The operations are tested as a group: some of them are entered as program steps in PRGM mode, the others are performed afterwards in RUN mode. To perform the test:

a. Switch to PRGM mode as directed in step 1 of the test and press the keys listed in steps 2 through 10 to enter the program. Note the following:

(1) If program steps cannot be entered and stored (appearing improperly as ***15 13 .5*** or ***74***), replace DS 2.

(2) If the program step number in the display does not increment properly, replace the ACT.

(3) If the proper keycode is not obtained following each step, replace the IC indicated in the table.

b. Switch to RUN mode as directed in step 11 and press the keys listed in steps 11 through 17. If the display shown following each step is not obtained, replace the IC indicated.

Table 5-1. Tests of General Calculator Operations

OPERATION	KEYSTROKES	DISPLAY	KEYCODE	IC FAILURE
Digit Entry	55	55.	05	ROM 0; ROM 3; DS 1
.	.	0.	73	ROM 0; ROM 3
CHS	5 CHS	-5.	32	ROM 3
CLx	5 CLx	0.00	34	ROM 3
√x	25 f √x	5.00	14 63	ROM 1
x^2	5 g x^2	25.00	15 63	ROM 1
1/x	5 g 1/x	0.20	15 74	ROM 1
PAUSE	f PAUSE	0.00*	14 74	ROM 1
INT	5 . 2 f INT	5.00	14 61	ROM 3
FRAC	5 . 2 g FRAC	0.20	15 61	ROM 3
LAST X	5 g 1/x f LAST X	5.00	14 73	DS 1; ROM 0; ROM 3
π	g π	3.14	15 73	ROM 2; ROM 3
R↓	5 R↓ R↓ R↓ R↓	5.00	22	ROM 3; DS 2
ENTER↑	5 ENTER↑ CLx R↓	5.00	31	ROM 3
x⇄y	5 ENTER↑ 2 x⇄y	5.00	21	ROM 3
−	5 ENTER↑ 2 −	3.00	41	ROM 1
+	5 ENTER↑ 2 +	7.00	51	ROM 1
×	5 ENTER↑ 2 ×	10.00	61	ROM 1
÷	5 ENTER↑ 2 ÷	2.50	71	ROM 1
EEX	EEX 9	1. 09	33	ROM 3
ABS	5 CHS g ABS	5.00	15 64	ROM 3
y^x	2 ENTER↑ 3 f y^x	8.00	14 64	ROM 1; ROM 2
%	150 ENTER↑ 6 g %	9.00	15 21	ROM 1
ENG	123 f ENG 3	123.0 00	14 13 03	ROM 1; DS 2
SCI	123 f SCI 4	1.2300 02	14 12 04	ROM 1; DS 2
FIX	123 f FIX 2	123.00	14 11 02	ROM 1; DS 2
ln	11 f ln	2.40	14 42	ROM 1; ROM 2

Table 5-1. Tests of General Calculator Operations (Continued)

OPERATION	KEYSTROKES	DISPLAY	KEYCODE	IC FAILURE
[e^x]	1 [g] [e^x]	2.72	15 42	ROM 1; ROM 2
[log]	20 [f] [log]	1.30	14 43	ROM 1; ROM 2
[10^x]	3 [g] [10^x]	1000.00	15 43	ROM 1; ROM 2
[sin]	30 [f] [sin]	0.50	14 52	ROM 2
[sin⁻¹]	[g] [sin⁻¹]	30.00	15 52	ROM 2
[cos]	60 [f] [cos]	0.50	14 53	ROM 2
[cos⁻¹]	[g] [cos⁻¹]	60.00	15 53	ROM 2
[tan]	45 [f] [tan]	1.00	14 54	ROM 2
[tan⁻¹]	[g] [tan⁻¹]	45.00	15 54	ROM 2
[→P]	3 [ENTER↑] 4 [g] [→P]	5.00	15 44	ROM 2
	[x⇄y]	36.87		
[→R]	5 [f] [→R]	4.00	14 44	ROM 2
	[x⇄y]	3.00		
[RAD]	[g] [π] [g] [RAD] [f] [cos]	-1.00	15 33	ROM 3; DS 2
[GRD]	200 [g] [GRD] [f] [cos]	-1.00	15 32	ROM 3; DS 2
[DEG]	30 [g] [DEG] [f] [sin]	0.50	15 34	ROM 3; DS 2
[→H.MS]	6 [.] 7 [f] [→H.MS]	6.42	14 72	ROM 1
[→H]	[g] [→H]	6.70	15 72	ROM 1
[STO] n†	5 [STO] 1		23 01	DS 0; ROM 3
[RCL] n†	[CLx] [RCL] 1	5.00	24 01	DS 0; ROM 3
[STO] [.] n‡	5 [STO] [.] 1		23 .1	DS 0; ROM 3
[RCL] [.] n‡	[CLx] [RCL] [.] 1	5.00	24 .1	DS 0; ROM 3
[STO] [+] n†	5 [STO] 1 2 [STO] [+] 1 [RCL] 1	 7.00	23 51 01	DS 0; ROM 3; ROM 1
[STO] [−] n†	5 [STO] 1 2 [STO] [−] 1 [RCL] 1	 3.00	23 41 01	DS 0; ROM 3; ROM 1
[STO] [×] n†	5 [STO] 1 2 [STO] [×] 1 [RCL] 1	 10.00	23 61 01	DS 0; ROM 3; ROM 1
[STO] [÷] n†	5 [STO] 1 2 [STO] [÷] 1 [RCL] 1	 2.50	23 71 01	DS 0; ROM 3; ROM 1

Table 5-1. Tests of General Calculator Operations (Continued)

OPERATION	KEYSTROKES	DISPLAY	KEYCODE	IC FAILURE
STO + . n‡	5 STO . 1 2 STO + . 1 RCL . 1	 7.00	23 51 .1	DS 0; ROM 3; ROM 1
STO − . n‡	5 STO . 1 2 STO − . 1 RCL . 1	 3.00	23 41 .1	DS 0; ROM 3; ROM 1
STO × . n‡	5 STO . 1 2 STO × . 1 RCL . 1	 10.00	23 61 .1	DS 0; ROM 3; ROM 1
STO ÷ . n‡	5 STO . 1 2 STO ÷ . 1 RCL . 1	 2.50	23 71 .1	DS 0; ROM 3; ROM 1
STO i§ RCL i§	16 STO 0 5 STO i CLx RCL i	 5.00	23 22 24 22	DS 1; ROM 3 DS 1; ROM 3
STO + i§	16 STO 0 5 STO i 2 STO + i RCL i	 7.00	23 51 22	DS 1; DS 0; ROM 3; ROM 1
STO − i§	16 STO 0 5 STO i 2 STO − i RCL i	 3.00	23 41 22	DS 1; DS 0; ROM 3; ROM 1
STO × i§	16 STO 0 5 STO i 2 STO × i RCL i	 10.00	23 61 22	DS 1; DS 0; ROM 3; ROM 1
STO ÷ i§	16 STO 0 5 STO i 2 STO ÷ i RCL i	 2.50	23 71 22	DS 1; DS 0; ROM 3; ROM 1
ISZ	g ISZ RCL 0	 1.00	15 22	DS 0; ROM 3
DSZ	g DSZ RCL 0	 −1.00	15 23	DS 0; ROM 3
CLEAR REG	5 STO 1 f REG RCL 1	 0.00	14 33	DS 1 or DS 0; ROM 0
CLEAR Σ	5 STO . 0 f Σ RCL . 0	 0.00	14 34	DS 0; ROM 0

Table 5-1. Tests of General Calculator Operations (Continued)

OPERATION	KEYSTROKES	DISPLAY	KEYCODE	IC FAILURE
CLEAR [PREFIX]	12 [STO]			ROM 0; ACT
	[f] [PREFIX] 3	123.		
	[CLx] 12 [STO]			
	[g] [PREFIX] 3	123.		
[Σ+]	1 [ENTER↑] 2 [Σ+]	1.00	25	DS 0; ROM 1
	2 [ENTER↑] 3 [Σ+]	2.00		
	3 [ENTER↑] 6 [Σ+]	3.00		
[Σ-]	3 [ENTER↑] 6 [f] [Σ-]	2.00	14 25	DS 0; ROM 1
[RCL] [Σ+]	[RCL] [Σ+]	5.00	24 25	DS 0; ROM 1
	[x⇄y]	3.00		
[x̄]	[f] [x̄]	2.50	14 21	DS 0; ROM 1
	[x⇄y]	1.50		
[s]	[f] [s]	0.71	14 22	DS 0; ROM 1
	[x⇄y]	0.71		

* Delayed blink.

† n represents an integer, 0 through 9. The example uses n = 1; however, the operation should be performed on the register specified by the customer, if any.

‡ n represents an integer, 0 through 5. The example uses n = 1; however, the operation should be performed on the register specified by the customer, if any.

§ The example uses register $R_{(16)}$ (indirect address 16), which is located in DS 1 as indicated under "IC FAILURE". However, the operation should be performed on the register specified by the customer, if any. For the probable IC failure, recall that registers R_0 through R_9 and $R_{.0}$ through $R_{.5}$ are located in DS 0; while registers $R_{(16)}$ through $R_{(29)}$ are located in DS 1. The indirect addresses of all data storage registers are shown in figure 1-1.

Table 5-2. Test of Program Control Operations

STEP	OPERATION	PRESS/SWITCH	DISPLAY	IC FAILURE
1	PRGM	PRGM [switch]	00	ROM 0
2	CLEAR [PRGM]	[f] CLEAR [PRGM]	00	ROM 0
3	[LBL]	[g] [LBL] 0	01 15 13 00	ROM 3
4	[DEL]	123 [g] [DEL]	03 02	ROM 2; ROM 0
5	[BST]	[g] [BST]	02 01	ROM 0
6	Insert Step	4	03 04	ROM 2
7	[SST]	[SST]	04 02	ROM 0
8	[RTN]	[g] [RTN]	05 15 12	ROM 3
9	[R/S]	[R/S]	06 74	ROM 0
10	[GTO] [·]	[GTO] [·] 00	00	ROM 0
11	RUN	[switch] RUN	0.00	ROM 0
		[CLx] [R/S]	142.00	ROM 0
12	[GSB]	[CLx] [GSB] 0	142.00	ROM 0; ROM 3
13	[GTO]	[CLx] [GTO] 0 [R/S]	142.00	ROM 3
14	[GTO] [i]*	0 [STO] 0	0.00	
		[GTO] [i]	0.00	
		[R/S]	142.00	ROM 3
15	[GSB] [i]*	[CLx] [GSB] [i]	142.00	ROM 3
16	[GTO] [i]†	5 [CHS] [STO] 0	-5.00	
		[GTO] [i] [R/S]	142.00	ROM 3
17	[GSB] [i]†	[GSB] [i]	142.00	ROM 0; ROM 3

* Contents of R_0 positive.

† Contents of R_0 negative.

5-12. Conditional Test Operations

5-13. A test of the conditional test operations is given in table 5-3. The operations are tested as a group. To perform the test:

a. Switch to PRGM ▯▮ .

b. Press the keys listed in table 5-3, checking the keycode each time to ensure that the proper keys have been pressed.

c. Switch to ▮▯ RUN .

d. Press: CLx GSB 1. When execution of the program is completed, the display will show the number of conditional tests functioning properly. Since there are eight tests, the display should show ***8.00***. If not, replace ROM 3.

Table 5-3. Test of Conditional Test Operations

OPERATION	KEYSTROKES	KEYCODE
	f CLEAR PRGM	00
	g LBL 1	01 15 13 01
	0	02 00
	STO 0	03 23 00
	2	04 02
	ENTER↑	05 31
	5	06 05
x≤y	f x≤y	07 14 41
	GTO 2	08 13 02
	g ISZ	09 15 24
x<0	g x<0	10 15 41
	GTO 2	11 13 02
	g ISZ	12 15 24
x=y	f x=y	13 14 71
	GTO 2	14 13 02
	g ISZ	15 15 24
	CHS	16 32
x>y	f x>y	17 14 51
	GTO 2	18 13 02
	g ISZ	19 15 24
x>0	g x>0	20 15 51
	GTO 2	21 13 02
	GTO ISZ	22 15 24
x=0	g x=0	23 15 71
	GTO 2	24 13 02
	g ISZ	25 15 24
	CHS	26 32
	5	27 05
x≠y	f x≠y	28 14 61
	GTO 2	29 13 02
	g ISZ	30 15 24
	CLx	31 34
x≠0	g x≠0	32 15 61
	GTO 2	33 13 02
	g ISZ	34 15 24
	g LBL 2	35 15 13 02
	RCL 0	36 24 00
	g RTN	37 15 12

5-14. ABBREVIATED OPERATIONAL TEST

5-15. The abbreviated operational test is used to quickly check the operating capabilities of the HP-29C prior to the more lengthy full operational test. During troubleshooting of the logic PCA, it can also be used diagnostically to help isolate and identify failure of an IC. As presented, the test procedures are for component-level service of the logic PCA. To employ them during assembly-level service of the calculator, merely replace the logic PCA whenever the directions specify replacement of an IC.

5-10. This test consists of two parts:

a. Part 1, which test approximately 69 percent of the contents of the ROM's: paragraph 5-11.

b. Part 2, which tests the entire program memory: paragraph 5-13.

5-16. Abbreviated Operational Test, Part 1

5-17. To perform part 1 of the abbreviated operational test:

a. Switch:

OFF ON PRGM RUN

b. Press: f CLEAR PRGM.

c. Press the keys listed in table 5-4. Note the following:

(1) If the program step number in the display following each step does not increment properly, replace the ACT.

(2) If the keycode in the display following any step does not agree with that shown in the table, replace successively DS 2, ROM 0, ROM 1, ROM 2, and ROM 3, returning to step *a* after each replacement, until the correct keycode is obtained for every step in the table.

(3) If the correct program step number and keycode are obtained for every step in the table, proceed with step *d*.

d. Switch to: *RUN*.

e. Press the keys listed in table 5-5. After each step the displayed number should agree with that shown in the table under "DISPLAY." If so, part 1 of the abbreviated operational test is passed; proceed with part 2. If not, replace the IC or IC's indicated under "IC FAILURE" and return to step *a*. If more than one IC is listed, replace them successively, returning to step *a* after each replacement, until the correct display is obtained following each step in the table.

Table 5-4. Abbreviated Operational Test, Part 1, Program Entry

STEP	KEYSTROKES	DISPLAY
1	g LBL 4	01 15 13 04
2	STO 0	02 23 00
3	g DSZ	03 15 23
4	g LBL 5	04 15 13 05
5	RCL 0	05 24 00
6	×	06 61
7	g DSZ	07 15 23
8	GTO 5	08 13 05
9	R/S	09 74
10	g LBL 7	10 15 13 07
11	RCL . 1	11 24 .1
12	÷	12 71
13	EEX	13 33
14	2	14 02
15	×	15 61

Table 5-5. Abbreviated Operational Test, Part 1, Program Execution

STEP	KEYSTROKES	DISPLAY	IC FAILURE
1	6	6.	DS 1; ROM 3
2	f FIX 8	6.00000000	DS 2; ROM 3
3	f CLEAR Σ	6.00000000	ROM 0; DS 0
4	1	1.	DS 1; ROM 3
5	Σ+	1.00000000	DS 0; ROM 1
6	RCL Σ+	1.00000000	DS 0; ROM 1
7	+	7.00000000	ROM 1
8	GSB 4	5040.000000	ROM 3; ROM 0
9	5	5.	DS 1; ROM 3
10	STO − . 1	5.00000000	DS 0; ROM 3; ROM 1
11	x⇄y	5040.000000	ROM 3
12	GTO 7	5040.000000	ROM 3
13	R/S	−126000.0000	ROM 0
14	CHS	126000.0000	ROM 3
15	f √x	354.9647870	ROM 1

Table 5-5. Abbreviated Operational Test, Part 1, Program Execution (Continued)

STEP	KEYSTROKES	DISPLAY	IC FAILURE
16	g π	3.14159265	ROM 2; ROM 3
17	f →R	3.12946908	ROM 2
18	g π	3.14159265	ROM 2; ROM 3
19	×	9.83151706	ROM 1
20	f INT	9.00000000	ROM 3
21	g 1/x	0.11111111	ROM 1
22	EEX	1. 00	ROM 3
23	29	1. 29	DS 1; ROM 3
24	ENTER↑	1.0000000 29	ROM 3
25	3	3.	DS 1; ROM 3
26	f y^x	1.0000000 87	ROM 1; ROM 2
27	÷	1.1111111-88	ROM 1
28	STO (i)	1.1111111-88	DS 0; ROM 3
29	8	8.	DS 1; ROM 3
30	STO × 0	8.00000000	DS 0; ROM 3; ROM 1
31	RCL (i)	8.8888888-88	DS 0; ROM 3
32	CHS	-8.8888888-88	ROM 3

5-18. Abbreviated Operational Test, Part 2

5-19. To perform part 2 of the abbreviated operational test:

a. Set switches: OFF ON   PRGM RUN (switches set to ON and RUN)

b. Press: f FIX 2.

c. Switch to: PRGM.

d. Press: f CLEAR PRGM.

e. Press + 97 times, watching the step number increment with the keycode remaining at ***51***.

f. Press R/S. The final display should be ***98   74***.

g. Switch to: RUN.

h. Press:
1 ENTER↑ ENTER↑ ENTER↑
GTO . 00 R/S

i. The display should show ***98.00***. If so, part 2 of the abbreviated operational test is passed; proceed with the full operational test. If not, proceed with step *j*.

j. Press: GTO . 00.

k. Press SST repeatedly, carefully watching the keycode displayed each time the key is pressed. The keycode for program steps 1 through 97 should be ***51***; that for program step 98 should be ***74***. If any keycode is incorrect and cannot be corrected by pressing g DEL and then the correct key (+ or R/S), replace DS 2.

5-20. FULL OPERATIONAL TEST

5-21. The full operational test checks approximately 85 percent of the contents of the ROM's on the logic PCA. It should be performed at either the end of component-level service of the logic PCA or at the end of assembly-level service of the calculator. During troubleshooting of the logic PCA, it can be used also to isolate and identify a ROM failure.

5-22. To perform the full operational test during assembly-level service:

a. Switch: ON   PRGM (switches set to ON and PRGM)

b. Press: f f CLEAR PRGM.

c. Enter the program listed in table 5-6. The program functions are listed under "FUNCTION"; however, to save the time required to scan the keyboard searching for prefixed functions printed above or on the lower faces of the keys, the faces of the keys to be pressed are listed under "ACTUAL KEYS". After entering each program step, compare the displayed keycode to that in the entry under "DISPLAY, PRGM MODE". If they do not agree, press g DEL, then press the correct keys indicated for the program step until the calculator display shows the correct keycode. All keystrokes of the 103 steps in the test must be entered correctly.

d. Switch to: RUN.

e. Press:

CLX f FIX 3
GTO · 14 R/S

f. *The resulting display when execution of the test program* is completed should agree with the last display shown in table 5-6. If they are not the same, *and it is certain that all program steps have been entered correctly,* the calculator has failed the test and the logic PCA should be replaced.

g. To double-check that all program steps have been entered correctly:

(1) Switch to: PRGM.

(2) Press: GTO · 00.

(3) Press SST repeatedly to single-step through the 98 steps of the program, checking each time that the display for the program step is correct. If one is not, press g DEL, then press the correct keys indicated for the program step until the calculator display shows the correct keycode. If pressing the correct keys does not result in the correct keycode, the logic PCA should be replaced. If the correct keycode is obtained, return to step *d*.

Table 5-6. Full Operational Test

TEST STEP	FUNCTION	ACTUAL KEYS	DISPLAY, *PRGM MODE*	DISPLAY, *RUN MODE*	MOST PROBABLE *IC FAILURE*
1	LBL 0	g GTO 0	01 15 13 00		
2	5	5	02 05		
3	STO − i	STO − R↓	03 23 41 22		
4	1	1	04 01		
5	GTO 1	GTO 1	05 13 01		
6	ISZ	g RCL	06 15 24		
7	STO + 0	STO + 0	07 23 51 00		
8	ISZ	g RCL	08 15 24		
9	GSB i	GSB R↓	09 12 22		
10	RTN	g GSB	*10 15 12	1.00	ROM 3
11	LBL 1	g GTO 1	11 15 13 01		
12	GSB i	GSB g R↓	12 12 22		
13	RTN	g GSB	*13 15 12	1.00	ROM 3
14	CLEAR REG	f EEX	14 14 33	0.000	ROM 0; DS 0; DS 1
15	FIX 2	f SST 2	15 14 11 02	0.00	ROM 3; DS 2
16	GSB i	GSB R↓	*16 12 22	1.00	ROM 3; ACT
17	RCL 0	RCL 0	17 24 00	0.00	ROM 3; DS 0
18	x≠0	g ×	18 15 61	0.00	ROM 3
19	GTO 2	GTO 2	19 13 02	†	ROM 3
20	2	2	20 02	2.	ROM 3; DS 1
21	9	9	21 09	29.	ROM 3; DS 1
22	STO i	STO g R↓	22 23 22	29.00	ROM 3; DS 0
23	LBL 9	g GTO 9	23 15 13 09	29.00	ROM 3; ROM 0
24	RCL 0	RCL 0	24 24 00	29.00	ROM 3; DS 0
25	10^x	g 8	25 15 43	1.00 29	ROM 1; ROM 2
26	STO + i	STO + g R↓	26 23 51 22	1.00 29	ROM 3; ROM 1; DS 0 or DS 1
27	RCL i	g R↓	27 24 22	‡ 1.00 29	ROM 3; ROM 1; DS 0 or DS 1
28	x≠y	f ×	28 14 61	1.00 29	ROM 3
29	GTO 2	GTO 2	29 13 02	†	ROM 3.
30	DSZ	g STO	30 15 23	1.00 29	ROM 1; DS 0
31	GTO 9	GTO 9	31 13 09	1.00 29	ROM 3
32	R↓	R↓	32 22	10.00	ROM 3
33	log	f 8	33 14 43	1.00	ROM 1; ROM 2
34	GRD	g CHS	34 15 32	1.00	ROM 2; DS 2
35	→R	f 9	35 14 44	0.00	ROM 2; DS 2
36	e^x	g 7	36 15 42	1.00	ROM 1; ROM 2

Table 5-6. Full Operational Test (Continued)

TEST STEP	FUNCTION	ACTUAL KEYS	DISPLAY, PRGM MODE	DISPLAY, RUN MODE	MOST PROBABLE IC FAILURE
37	[RAD]	[g] [EEX]	37 15 33	1.00	ROM 2; DS 2
38	[→P]	[g] 9	38 15 44	1.41	ROM 2; DS 2
39	[x^2]	[g] 2	39 15 63	2.00	ROM 1
40	[ln]	[f] 7	40 14 42	0.69	ROM 2; ROM 1
41	[x<0]	[g] [−]	41 15 41	0.69	ROM 3
42	[GTO] 2	[GTO] 2	42 13 02	†	ROM 3
43	[→H.MS]	[f] 0	43 14 72	0.41	ROM 1
44	[cos^{-1}]	[g] 5	44 15 53	1.14	ROM 2; DS 2
45	[→H]	[g] 0	45 15 72	1.25	ROM 1
46	[INT]	[f] 1	46 14 62	1.00	ROM 3
47	[x≤y]	[f] [−]	47 14 41	1.00	ROM 3
48	[GTO] 2	[GTO] 2	48 13 02	†	ROM 3
49	[$\sqrt{x}$]	[f] 2	49 14 63	1.00	ROM 1
50	[DEG]	[g] [CLx]	50 15 34	1.00	ROM 2; DS 2
51	[sin^{-1}]	[g] 4	51 15 52	90.00	ROM 2; DS 2
52	8	8	52 08		
53	[cos]	[f] 5	53 14 53	§	
54	[BST]	[g] [SST]	52 08		
55	[DEL]	[g] [Σ+]	51 15 52		
56	[SST]	[SST]	52 14 53	0.00	ROM 2; DS 2
57	[x>0]	[g] [+]	53 15 51	0.00	ROM 3
58	[GTO] 2	[GTO] 2	54 13 02	†	ROM 3
59	[LAST X]	[f] [·]	55 14 73	90.00	ROM 3; DS 1
60	[ENG] 4	[f] [GTO] 4	56 14 13 04	90.000 00	ROM 3; DS 2
61	CLEAR [Σ]	[f] [CLx]	57 14 34	90.000 00	ROM 0
62	9	9	58 09	9.	ROM 3; DS 1
63	[Σ+]	[Σ+]	59 25	1.0000 00	ROM 1; DS 0
64	[RCL] [Σ+]	[RCL] [Σ+]	60 24 25	9.0000 00	ROM 1; DS 0
65	[Σ+]	[Σ+]	61 25	2.0000 00	ROM 1; DS 0
66	7	7	62 07	7.	ROM 3; DS 1
67	[ENTER↑]	[ENTER↑]	63 31	7.0000 00	ROM 3
68	3	3	64 03	3.	ROM 3; DS 1
69	[Σ+]	[Σ+]	65 25	3.0000 00	ROM 1; DS 0
70	7	7	66 07	7.	ROM 3; DS 1
71	[LAST X]	[f] [·]	67 14 73	3.0000 00	ROM 3; DS 1
72	[Σ−]	[f] [Σ+]	68 14 25	2.0000 00	ROM 1; DS 0
73	[$\bar{x}$]	[f] [x⇄y]	69 14 21	9.0000 00	ROM 1; DS 0
74	[x>y]	[f] [+]	70 14 51	9.0000 00	ROM 3
75	[GTO] 2	[GTO] 2	71 13 02	†	ROM 3
76	CLEAR [PREFIX]	[f] [ENTER↑]	71 13 02		
77	[x⇄y]	[x⇄y]	72 21	90.000	ROM 3
78	[STO] [÷] 1	[STO] [÷] 1	73 23 71 01	90.000 00	ROM 3; ROM 1; DS 0
79	[sin]	[f] 4	74 14 52	1.0000 00	ROM 2; DS 2
80	[π]	[g] [·]	75 15 73	3.1416 00	ROM 2
81	[%]	[g] [x⇄y]	76 15 21	31.416 −03	ROM 1
82	[R↓]	[R↓]	77 22	1.0000 00	ROM 3
83	[−]	[−]	78 41	8.0000 00	ROM 1
84	[STO] [×] 1	[STO] [×] 1	79 23 61 01	8.0000 00	ROM 3; ROM 1; DS 0

Table 5-6. Full Operational Test (Continued)

TEST STEP	FUNCTION	ACTUAL KEYS	DISPLAY, PRGM MODE	DISPLAY, RUN MODE	MOST PROBABLE IC FAILURE
85	[x=0]	[g] [÷]	80 15 71	8.0000 00	ROM 3
86	[GTO] 2	[GTO] 2	81 13 02	†	ROM 3
87	3	3	82 03	3.	ROM 3; DS 1
88	[1/x]	[g] [R/S]	83 15 74	333.33 -03	ROM 1
89	[y^x]	[f] 3	84 14 64	2.0000 00	ROM 1; ROM 2
90	[x=y]	[f] [÷]	85 14 71	2.0000 00	ROM 3
91	[GTO] 2	[GTO] 2	86 13 02	†	ROM 3
92	[RCL] 1	[RCL] 1	87 24 01	888.89 -03	ROM 3; DS 0
93	[ABS]	[g] 3	88 15 64	888.89 -03	ROM 3
94	[CHS]	[CHS]	89 32	-888.89 -03	ROM 3
95	[SCI] 9	[f] [GSB] 9	90 14 12 09	-8.8888888-01	ROM 3; DS 2
96	[EEX]	[EEX]	91 33	1. 00	ROM 3; DS 1
97	8	8	92 08	1. 00	ROM 3; DS 1
98	7	7	93 07	1. 87	ROM 3; DS 1
99	[CHS]	[CHS]	94 32	1. -87	ROM 3
100	[×]	[×]	95 61	-8.8888888-88	ROM 1
101	[LBL] 2	[g] [GTO] 2	96 15 13 02	-8.8888888-88	ROM 3; ROM 0
102	[PAUSE]	[f] [R/S]	97 14 74	-8.8888888-88	ROM 2; ROM 1
103	[R/S]	[R/S]	98 74	-8.8888888-88	ROM 0; ROM 3

* Refer to paragraph 5-23a.

† Refer to paragraph 5-23b.

‡ Refer to paragraph 5-23c.

§ The keys shown at *test* steps 52 through 55 are pressed when the program is entered to test the [BST], [DEL], and [SST] operations. When single-stepping through the program, skip over these program steps. Note that the result of the program modification performed here is that program step 52 contains the function [cos]—which was originally entered into program step 53—and program step 53 contains the function [x>0].

5-23. To perform the full operational test during component-level service of the logic PCA, follow the procedures shown in figure 5-1. If it is necessary to single-step through the operational test program to isolate failure of an IC, the following characteristics of the program should be checked.

a. Execution of program step 16 begins execution of nested subroutines comprising program steps 1 through 13. Since each of these subroutines is executed entirely with only one pressing of [SST], tests for proper operation of the subroutines are given in tables 5-8 through 5-10. When single-stepping through the program, the program step numbers shown with [SST] down should be displayed in the following order: 14 (first program step executed in test), 15, 16 (begin execution of nested subroutines), 10, 13, 17 (execution of nested subroutines completed), 18, 20, and then on through the rest of the test program. If the program steps are not accessed in the proper order, failure of an IC is indicated. This IC can be identified as follows:

(1) If step 10 is not shown after step 16, test the subroutines using the procedures beginning at point F in figure 5-1, and the steps given in tables 5-10, 5-9, and 5-8 (in that order). If each of the subroutines are executed correctly when single-stepping through them, replace successively ROM 3 and the ACT until the program steps listed above are accessed in the proper order. After each replacement of an IC, return to step *a* of paragraph 5-22 and perform the test in automatic RUN mode to check whether replacing the IC has resulted in a successful test. If not, single-step through the program again as directed in figure 5-1.

(2) If step 13 is not shown after step 10, or step 17 is not shown after step 13, replace ROM 3 and return to step *a* of paragraph 5-22 as above.

b. During a successful test, none of the program steps 19, 29, 42, 48, 54, 71, 81, or 86—which each contain [GTO] [2]—is executed. If one of these program steps is executed, as signified by a display of its step number while [SST] is down, an IC failure is indicated. To ascertain which IC has failed, consider the numbers in the X- and Y-registers together with the particular functions executed prior to the test immediately preceding the [GTO] [2]. The IC's most likely to have failed are indicated under the "IC FAILURE" column of table 5-7. (For the special case of step 29, refer to paragraph 5-23d.) Replace these IC's successively until the [GTO] [2] is not executed when running the test again.

Table 5-7. IC Failure If GTO 2 Is Executed

PROGRAM STEP	IC FAILURE
19	*
42	ROM 2 or ROM 1
48	ROM 3
54	ROM 2 or DS 2
71	DS 0, DS 1, or ROM 1
81	ROM 1 or ROM 3
86	ROM 1 or ROM 2

*To determine the IC failure, test the subroutines using the procedures beginning at point F in figure 5-1, and the steps given in tables 5-8, 5-9, and 5-10 (in that order).

c. Program steps 23 through 31 comprise an iterative loop, which is passed through 29 times. The entries under "DISPLAY, RUN MODE" for these program steps are *those for the first pass through the loop. If the correct* displays are obtained for this pass, it is likely that the microinstructions for implementing the operations performed in this section of the program are working properly. Therefore, to save the time required to single-step through each of the 28 remaining passes through the loop, press R/S to start automatic execution, then a short time later press R/S again to halt execution. (R/S may have to be pressed more than once to halt execution.) When the end of the loop is reached—when the display shows, say, ***1000.00***, ***100.00***, or ***10.00***—resume single-stepping to monitor exit from the loop and execution of each remaining step of the program. Note, however, that if during automatic execution of the loop the program abruptly halts at the end of the program, step 29 has been executed. In this situation, refer to paragraph 5-23d.

d. If program step 29 is executed, a failure has occurred in a storage register. To ascertain which register, press R↓ ; the exponent of the number then displayed is the indirect address of the register. (See figure 1-1.) Recall that registers R_0 through $R_{.5}$ are located in DS 0 and *registers $R_{(16)}$ through $R_{(29)}$ are located in DS 1.* (Refer to table 4-3.) Therefore, an exponent of 0 through 15 signifies a failure in DS 0, while an exponent of 16 through 29 signifies a failure in DS 1.

Table 5-8. Subroutine Test, GSB at Program Step 9

KEYSTROKE	DISPLAY, SST DOWN	DISPLAY, KEY UP	IC FAILURE
3		3.	ROM 3; DS 1
CHS		-3.	ROM 3
STO		-3.	
0		-3.00	ROM 3; DS 0
GTO		-3.00	
.		-3.00	
0		-3.00	
6		-3.00	ROM 0
1		1.	ROM 3; DS 1
SST	06 15 24	1.00	ROM 1; DS 0
SST	07 23 51 00	1.00	ROM 3; ROM 1; DS 0
SST	08 15 24	1.00	ROM 1; DS 0
SST	10 15 12	1.00	ROM 3
RCL		1.00	
0		0.00	ROM 3; DS 0

Table 5-9. Subroutine Test, GSB at Program Step 12

KEYSTROKE	DISPLAY, SST DOWN	DISPLAY, KEY UP	IC FAILURE
5		5.	ROM 3; DS 1
CHS		-5.	ROM 3
STO		-5.	
0		-5.00	ROM 3; DS 0
GTO		-5.00	
⊡		-5.00	
0		-5.00	
7		-5.00	ROM 0
1		-5.00	ROM 3; DS 1
SST	07 23 51 00	1.00	ROM 3; ROM 1; DS 0
SST	08 15 24	1.00	ROM 1; DS 0
SST	09 12 22	1.00	ROM 3; ACT
SST	10 15 12	1.00	ROM 3
SST	11 15 13 01	1.00	ROM 3; ROM 0
RCL		1.00	
0		0.00	ROM 3; DS 0
SST	12 12 22	1.00	ROM 3; ACT
SST	10 15 12	1.00	ROM 3
SST	13 15 12	1.00	ROM 3
RCL		1.00	
0		0.00	ROM 3; DS 0

Table 5-10. Subroutine Test, GSB at Program Step 16

KEYSTROKE	DISPLAY, SST DOWN	DISPLAY, KEY UP	IC FAILURE
9		9.	ROM 3; DS 1
STO		9.	
0		9.00	ROM 3; DS 0
GTO		9.00	
0		9.00	ROM 0
SST	01 15 13 00	9.00	ROM 3; ROM 0
SST	02 05	5.	ROM 3; DS 1
SST	03 23 41 22	5.00	ROM 3; ROM 1; DS 0
SST	04 01	1.	ROM 3; DS 1
SST	05 13 01	1.00	ROM 3
RCL		1.00	
0		9.00	ROM 3; DS 0
RCL		9.00	
9		-5.00	ROM 3; DS 0

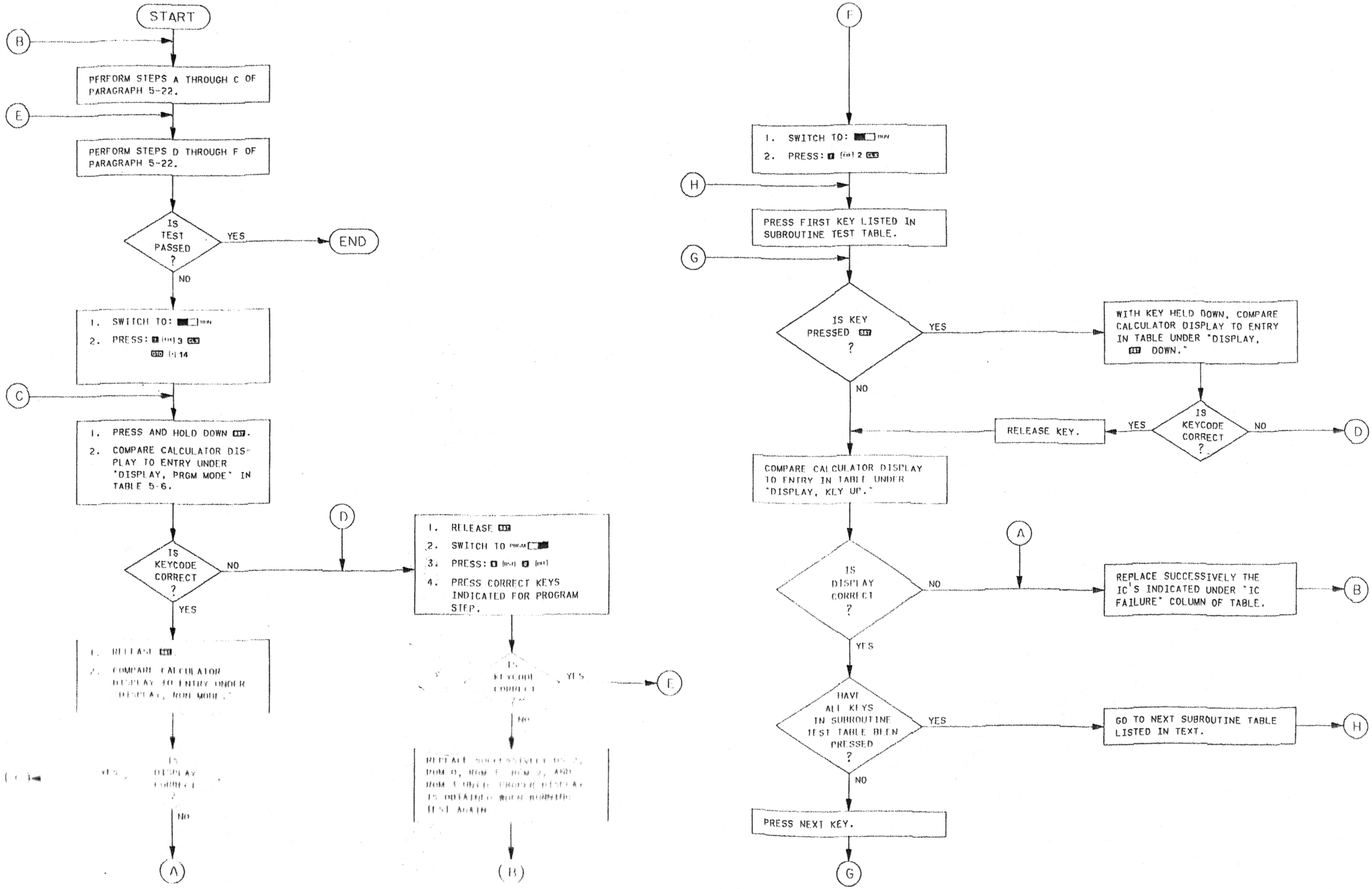


Figure 5-1. Full Operational Test

Accessories

6-1. INTRODUCTION

6-2. This section identifies the accessories available for use with the HP-29C. Replacement of accessories is recommended rather than repair, since the cost of a new unit is usually less than the cost of repair.

6-3. HP 82019A BATTERY PACK

6-4. Figure 6-1 shows the HP 82019A Battery Pack. If the calculator is received from the customer with a complaint related to the performance of the battery pack, discard the pack and insert a new one. From all other calculators having blank displays at turn-on, remove (but do not discard) the battery pack and replace it with a new one. To determine whether the removed battery pack is faulty or merely needs charging, perform the following procedures when time permits:

a. Charge the battery pack for at least 8 hours in an HP 82028A Reserve Power Pack or in a calculator (HP-21, HP-22, HP-25, HP-25C, HP-27, or HP-29C) known to be operating properly.

b. At the end of the charging period, remove the battery pack and connect a 5-ohm, 10W, 10% resistor across its contacts.

c. After 45 minutes, disconnect the resistor and measure the voltage between the contacts of the battery pack. If the voltage is less than 2.2 Vdc, discard the battery pack. If the voltage is at least 2.2 Vdc, the battery pack is good; in this case, charge it again for at least 5 hours, then store the pack for later use.

Figure 6-1. HP 82019A Battery Pack

6-5. AC ADAPTER/RECHARGERS

6-6. Table 6-1 lists the various ac adapter/rechargers available for use with the HP-29C. Figures 6-2 through 6-7 show the plug configuration and location of the part number.

Table 6-1. AC Adapter/Rechargers

HP MODEL NUMBER	VOLTAGE*	IDENTIFICATION
82024A	115/230	European
82025A	230	UK
82025A Opt 001	230	UK with Australian Plug
82025A Opt 002	230	UK with RSA Plug
82026A	115/230	US
82041A	115	US

*Indicates nominal voltage; acceptable ranges are 200 to 254 Vac and 90 to 127 Vac.

6-7. To determine whether the ac adapter/recharger is functioning properly, perform the procedures below:

> **Note:** The calculator should remain switched *OFF, and the battery pack should be removed* from the calculator, during steps *a* through *d*.

a. Plug the ac adapter/recharger into the calculator.

b. Plug the ac adapter/recharger into an outlet of the proper voltage. (Refer to table 6-1.)

c. Connect a 10-ohm, 5W to 10W, 5% resistor across the battery terminals of the calculator.

d. With a dc voltmeter, measure the voltage V_{OUT} across the load. If V_{OUT} is between 2.0 and 4.0 Vdc, the recharger is functioning properly. If not, proceed with step *e*.

e. Unplug the recharger from the calculator.

f. With an ac voltmeter, measure the voltage at the power outlet (V_{IN}) and the voltage at the output of the recharger (V_{OUT}).

g. Calculate V_{MIN} and V_{MAX} as follows:

(1) If V_{IN} is approximately 230 Vac, $V_{MIN} = V_{IN}/25.70$ and $V_{MAX} = V_{IN}/21.80$.

(2) If V_{IN} is approximately 115 Vac, $V_{MIN} = V_{IN}/12.85$ and $V_{MAX} = V_{IN}/10.90$.

h. If V_{OUT} is not between V_{MIN} and V_{MAX}, the recharger is defective and should be replaced.

i. If V_{OUT} is within the proper range, connect a 12-ohm, 5W, 5% resistor across the output of the recharger, and measure V_{OUT} across the load with an ac voltmeter. If V_{OUT} is between 4.1 and 4.7 Vac, the problem is in the charging circuitry on the logic PCA: otherwise, the recharger is defective and should be replaced.

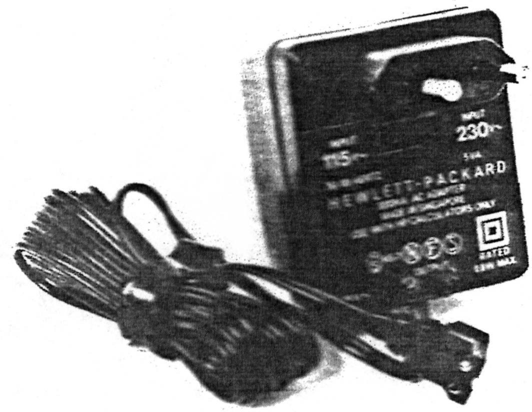


Figure 6-2. HP 82024A AC Adapter/Recharger

Figure 6-4. HP 82025A Opt 001 AC Adapter/Recharger

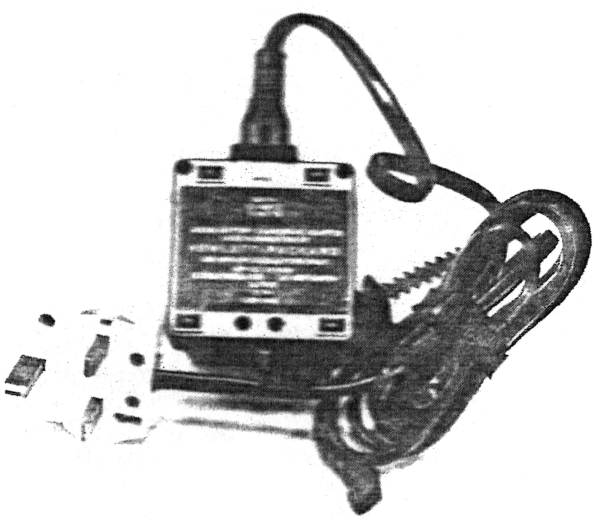


Figure 6-3. HP 82025A AC Adapter/Recharger

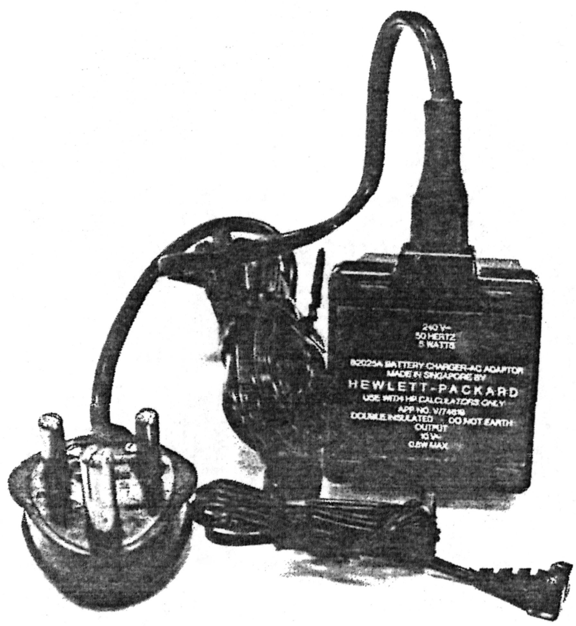


Figure 6-5. HP 82025A Opt 002 AC Adapter/Recharger

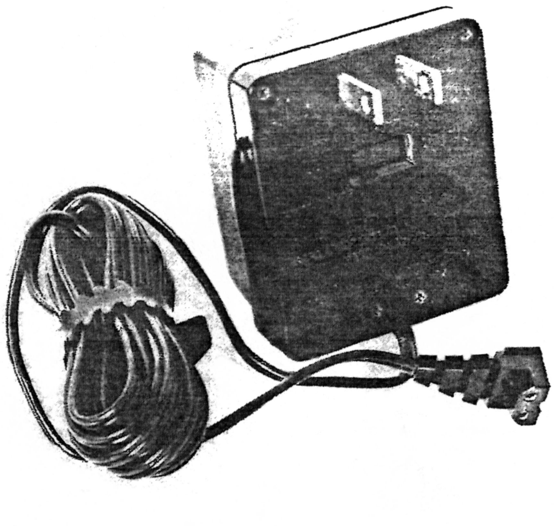


Figure 6-6. HP 82026A AC Adapter/Recharger

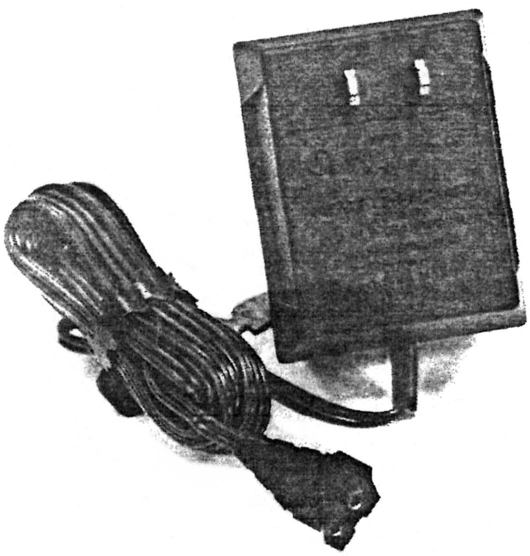


Figure 6-7. HP 82041A AC Adapter/Recharger

6-8. HP 82028A RESERVE POWER PACK

6-9. Description

- Allows spare battery to recharge while calculator is in use.
- Especially useful where calculator is in constant field use.
- Attaches to standard ac adapter/recharger.
- Built-in indicator shows battery is charging. Uses standard battery pack (one supplied).
- Allows charging extra packs for extended usage of calculator.
- Provides extra portability around the user's facility.

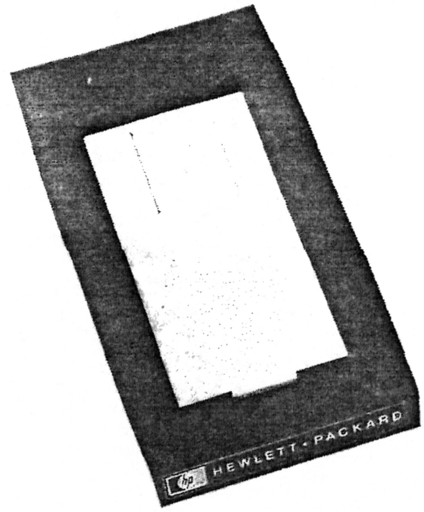


Figure 6-8. HP 82028A Reserve Power Pack

6-10. Specifications

- Dimensions: length 4.0 inches, width 2¼ inches, height 0.850 inch.
- Weight: 3½ ounces (including battery pack).
- Material: High-impact plastic.
- Battery Charging Indicator: Light-emitting diode (LED).
- *Temperature Operating Range 15° to 40°C (59° to* 104°F).
- Power Input: From ac adapter/recharger.

6-11. Operation

6-12. Guide battery pack into reserve power pack so that the exposed metal battery contacts face the metal contacts in the reserve power pack. Plug the two-prong female connector from an ac adapter/recharger into the bottom of the reserve power pack. Then plug the ac adapter/recharger into a wall socket. A red light (LED) will glow when the proper connections have been made and the batteries are charging. The light *does not* go out when charging is complete.

6-13. HP 82029A SECURITY CRADLE

6-14. Description

- For the security of larger office equipment.
- *Stranded stainless steel cable (plastic-sheathed)* or permanent table-top mounting, with screws or high-adhesive tape.
- Handsome, molded, glass-filled polycarbonate top and aluminum base.
- Lightweight for desk-top usage.

- Coded key for personalized security—two keys provided.
- Contoured and aesthetically matched to HP pocket calculators.

Figure 6-9. HP 82029A Security Cradle

6-15. Specifications

- Dimensions: length 7¼ inches, width 3½ inches, height $1^{27}/_{32}$ inches.
- Weight: 10 ounces (excluding cable).
- Material: Aluminum base, molded glass-filled polycarbonate.
- Screw Mounting: Four wood screws ($^3/_{16}$-inch diameter by ¾-inch long) in corners or one screw in center which allows 360° rotation.
- Security Cable: ¼-inch diameter stainless steel stranded cable, plastic sheathed, 6 feet long. Loop-ended cable allows attachment to convenient mounting point.
- Security Tape: Two strips, length 6 inches, width ¾ inch.
- Security Keys: Two coded keys.

6-16. Performance Check

a. Turn the key to the right until it releases the cradle top from the bottom. Separate the two parts.

b. If you are unable to turn the key or insert the key into the lock, the lock is defective.

c. To separate the cradle, use a flat-bladed screwdriver. Insert the screwdriver between the bottom case and the base plate at the top end of the cradle, and pry it apart. If damage is caused to the cradle, a replacement cradle is recommended.

d. You may have a situation where the lock is defective and replacement is required. The procedure to remove a lock follows:

(1) Remove hex nut with a $^9/_{16}$-inch wrench. (When reinstalling use only a *little* more than finger-tight pressure.)

(2) Remove washer.

(3) Remove lock camplate 82015-00001.

(4) Remove large hex nut with a ¾-inch socket.

(5) Remove spring washer 3050-0800.

(6) Remove defective lock and install new lock.

(7) Reverse order of above procedure to reinstall.

6-17. Security Cradle and Keylock Problems

6-18. Some customers have had problems with their security cradle locks and keys. All cradles are checked at the factory prior to shipment. It is possible that some linkage changes do occur within this lock during shipment. However, there are some other things which you can recommend to the customer prior to having him send the unit in for repair:

a. *I cannot get my key into the lock.*

Be sure to insert the key at right angles to the surface of the lock, parallel to the key slot. If that does not work, try some lock lubricant, which may be obtained from most hardware stores.

b. *Once my key is in the lock, the lock will not work.*

Take the calculator out of the cradle and then try locking it. If it works, then the calculator was in crooked or the base did not align with the top.

c. *I can't get my key out of the lock.*

- Try squeezing the key where it meets the key slot cylinder and squeeze it slowly, gently out.
- Sometimes the key slot cylinder is not in its slot exactly. Try wiggling the key around the different angles to see if it frees up.

d. *I have lost my keys–what should I do?*

Contact a locksmith. HP does not keep any duplicate keys. Future advice is to have several made.

Replaceable Parts

7-1. INTRODUCTION

7-2. This section contains information pertaining to the parts used in the *HP-29C*. Parts descriptions, quantities, HP stock numbers, reference designations (where applicable) and assembly breakdowns are given.

7-3. Replaceable parts for the logic PCA (table 4-5) are listed for convenience alongside its component location diagram in section IV.

7-4. ORDERING INFORMATION

7-5. To order replacement parts or assemblies, address order or inquiry to Corporate Parts Center, Parts Center Europe, or International Operations. Specify the following information for each part ordered:

a. Calculator model and serial number.
b. HP part number.
c. Description.
d. Complete reference designation (if applicable).

Table 7-1. HP-29C Replaceable Parts

FIGURE & INDEX NUMBER	HP PART NUMBER	DESCRIPTION	QTY
7-1-			
1	00029-60001	PCA (L), logic (refer to table 4-5)	1
2	00029-60902	ASSEMBLY, keyboard service	1
3	00021-60005	ASSEMBLY, battery pack	1
4	1990-0559	DISPLAY, numeric	1
5	5040-8960	CASE, bottom	1
6	5040-8957	FOOT	4
	7100-0594	COVER, battery terminal	1
	7120-6344	LABEL, nameplate	1
	7120-4464	LABEL, rear (US)	1
7	0624-0303	SCREW, 2-28, 0.312 inch	2

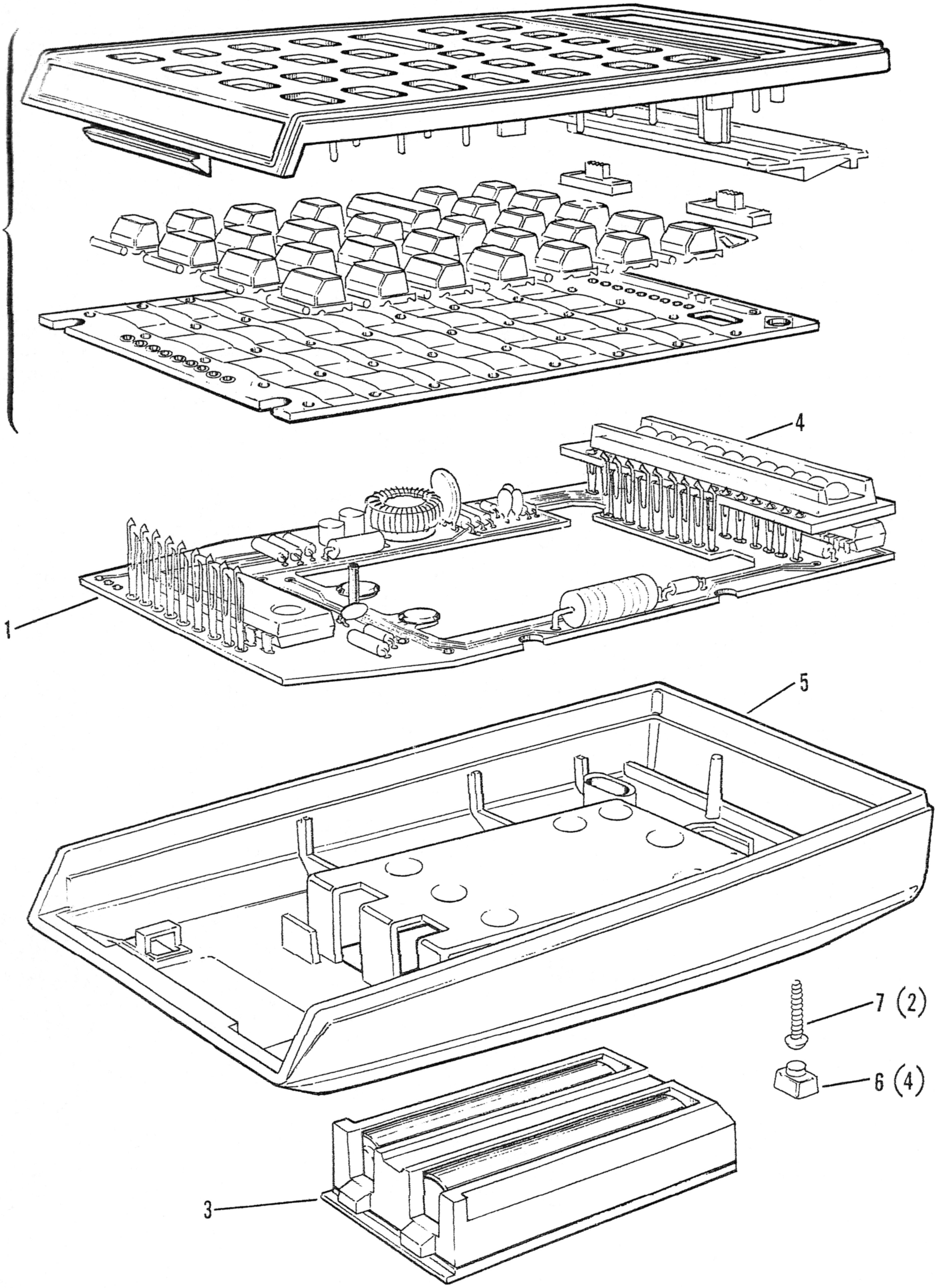


Figure 7-1. HP-29C Exploded View