HEWLETT hp PACKARD

HP-19C
Advanced Scientific Programmable Handheld Printing Calculator

SERVICE MANUAL

00019-90003

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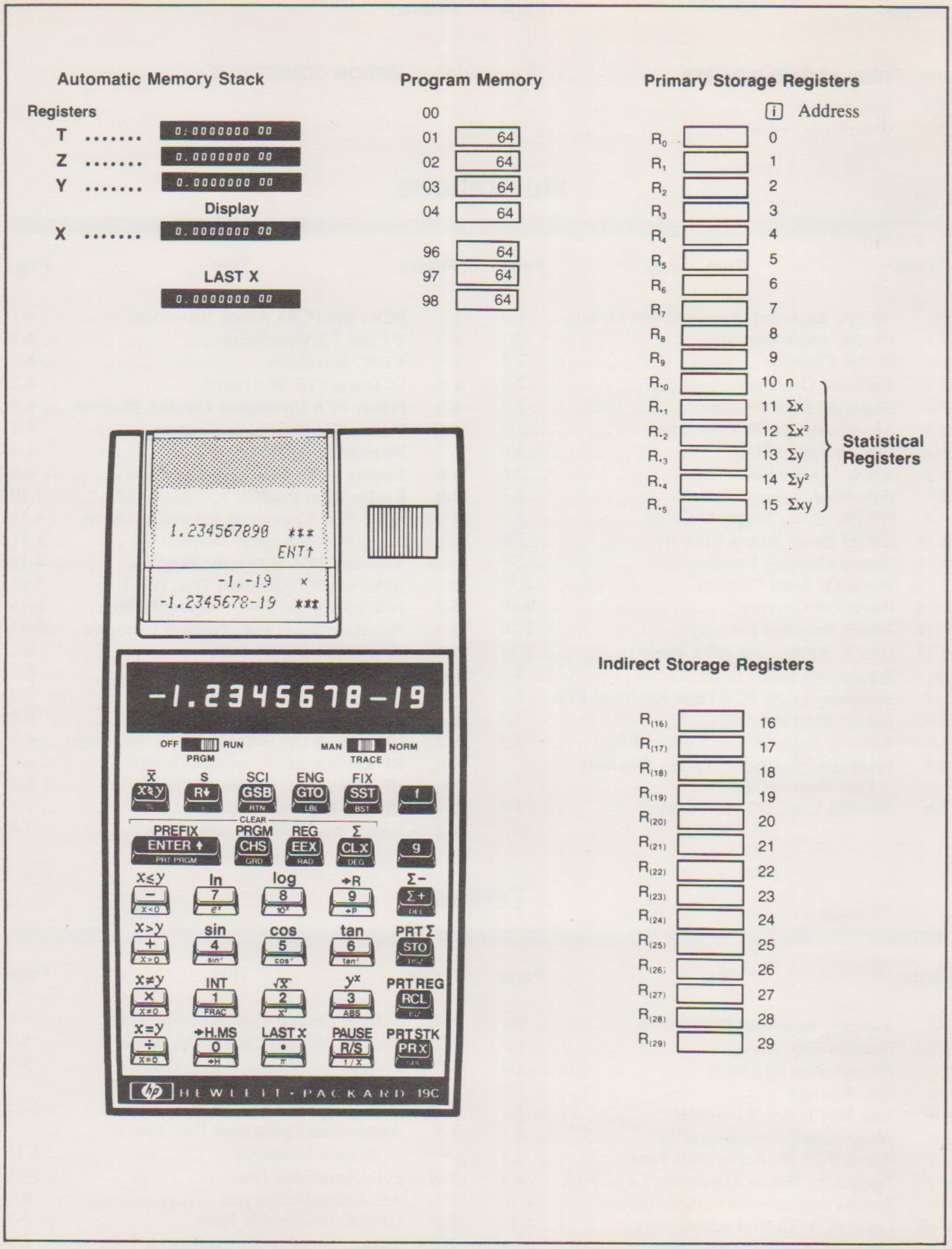


Figure 1-1. HP-19C Keyboard, Registers, and Memory

General Information

1-1. INTRODUCTION

1-2. This service manual presents the information needed to troubleshoot, disassemble, repair, reassemble, and test the HP-19C.

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, information on accessories, 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
P	Printer Assembly and Printer PCA
K	Keyboard Assembly and Keyboard PCA
R	AC Adapter/Recharger
B	Battery Pack

1-6. DESCRIPTION

1-7. The HP-19C is a handheld, advanced scientific, programmable printing calculator with a nonvolatile memory. (See figure 1-1.) The features and operation of the HP-19C are summarized in tables 1-2 and 1-3; its specifications are given in table 1-4. Operations under conditions leading to an error display are listed in appendix A.

1-8. Mechanically, the HP-19C is virtually identical to the HP-10, except that a cable connecting the logic PCA to the keyboard PCA has been added to facilitate reassembly of the calculator. Electrically, the power supply circuitry and printer drive circuitry of the HP-19C is similar to that of the HP-91, HP-92, and HP-97. Functionally, the HP-19C is similar to the HP-97, with the following major differences:

a. Nonvolatile storage contained in CMOS memory instead of on a magnetic card.

b. Ten conditional test operations instead of 14.

c. A maximum of 10 rather than 20 labels.

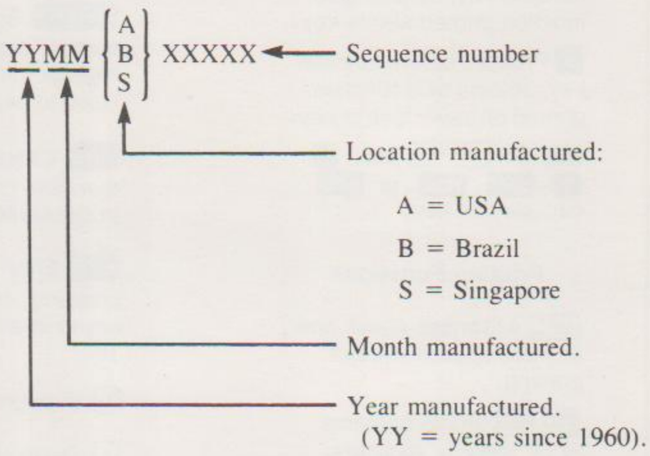
d. No user-definable keys.

e. No flags.

1-9. IDENTIFICATION

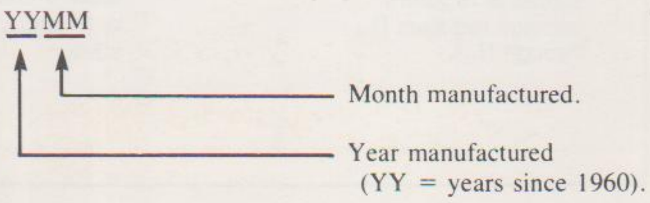
1-10. The serial number of the calculator is used for identification and determination of warranty status. It is located on the bottom case just below the battery door. Its format is explained below:

Calculator Serial Number



1-11. The serial number located on the ac adapter/recharger indicates the date of manufacture. Its format is described below:

AC Adapter/Recharger Manufacture Date



1-12. ACCESSORIES

1-13. The HP-19C is packaged with:

- Carrying Case.
- AC Adapter/Recharger.
- *HP-19C/HP-29C Owner's Handbook and Programming Guide.*
- *HP-19C/HP-29C Applications Book.*
- *HP-19C/HP-29C Quick Reference Card.*
- Thermal Paper (two rolls).

1-14. Neither a reserve power pack nor a security cable is available for use with the HP-19C.

Table 1-2. Function Key Index

Manual RUN Mode. OFF-PRGM-RUN Switch OFF [switch] RUN set to RUN.
PRGM

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 [switch] RUN
PRGM
OFF-PRGM-RUN Switch.

MAN [switch] NORM
TRACE
Print Mode switch. Selects printing option.

[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.

Printing Functions

[SPC] Advances paper one or more spaces without printing.

[PRTREG] Prints contents of all storage registers.

[PRTSTK] Prints contents of automatic memory stack.

[PRx] Prints contents of displayed X-register.

[PRTΣ] Prints contents of statistical registers (storage registers $R_{.0}$ through $R_{.5}$).

[PRTPRGM] Print program. Prints contents of program memory, beginning with current step and continuing until two consecutive [R/S] instructions are encountered or step 98 is printed.

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.

Table 1-2. Function Key Index (Continued)

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

√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.

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 OFF-PRGM-RUN switch set to PRGM. OFF RUN PRGM All function keys except the functions shown below are loaded into program memory when pressed.	**Automatic RUN Mode** OFF-PRGM-RUN Switch OFF RUN PRGM set to 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≠y] [x=y] [x>y] [x≤y] [x≠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. Stops program execution.	[R/S] Run/stop. Begins execution from current step of program memory. Stops execution if program is running.
[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.	
[PRT PRGM] Print program. Prints contents of program memory beginning with current step and continuing until two consecutive [R/S] instructions are encountered or step 98 is printed.	[PRT PRGM] Print program. Prints contents of program memory beginning with current step and continuing until two consecutive [R/S] instructions are encountered or step 98 is printed.	
	Any key. Pressing any key on the keyboard stops execution of a running program.	

Table 1-4. Specifications

Dimensions

- Length: 6.5 inches (16.5 centimeters).
- Width: 3.45 inches (8.8 centimeters).
- Height: 1.60 inches (4.0 centimeters).

Weight

- Calculator with battery pack and paper: 346 grams (12.2 ounces).
- U.S. Recharger: 6 ounces (170 grams).

Power

- Rechargers

	HP Part Number	
United States	82059A	90-127 Vac, 50-60 Hz, 7 watts
Australian	82068A	200-254 Vac, 50-60 Hz, 7 watts
European	82069A	90-127 Vac, 50-60 Hz, 7 watts
	82066A	200-254 Vac, 50-60 Hz, 7 watts
Desktop	82067A	200-254 Vac, 50-60 Hz, 7 watts

- Battery

  Four cell, 4.4 to 6.0 volts, quick-charge, nickel-cadmium battery pack.

  - Operating time: 4 to 7 hours.

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

  - Recharging time: 6 to 10 hours, calculator OFF; 17 hours, calculator ON.

Output

- Display module with 13 character positions, each consisting of eight light-emitting diode segments.
- Printer capable of printing up to 18 characters.
- Numbers are shown with a maximum of 10 digits, or 8 digits in the mantissa and 2 digits in the exponent, plus separate character positions for the mantissa sign, exponent sign, and decimal point.
- Minimum/maximum displayed/printed number: $\pm 1 \times 10^{-99}$ to $\pm 9.9999999 \times 10^{99}$.
- Rounding to last displayed/printed digit; calculations performed internally with at least 10 digits.
- 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 attempted. (Refer to appendix A.)
Overflow:	Overflow of the X-register results in a display of the number (±**9.9999999 99**). Overflow of a storage register results in a display of ***Error***.
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)

- Twenty seconds to 10 minutes, depending on:
  a. State of battery charge before power interrupt.
  b. Capacitor LC5.
  c. Data storage IC's.

Environmental Specifications

- Operating: 0° to 45°C (32° to 113°F); with paper, 5% to 95% relative humidity.
- Charging: 15° to 40°C (59° to 104°F).
- Calculator Storage: −40° to 55°C (−40° to 131°F).
- Paper Storage: −40° to 30°C (−40° to 86°F); less than 60% relative humidity.

Note: Avoid exposing paper to direct sunlight or artificial light sources for extended periods; keep in box or suitable container.

Principles of Operation

2-1. HP-19C ARCHITECTURE

2-2. The HP-19C architecture (see figure 2-1) is based on nine MOS (metal-oxide-semiconductor) integrated circuits (IC's):

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

b. Five 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.

d. The PIK (Printer Interface Control and Keyboard Buffer).

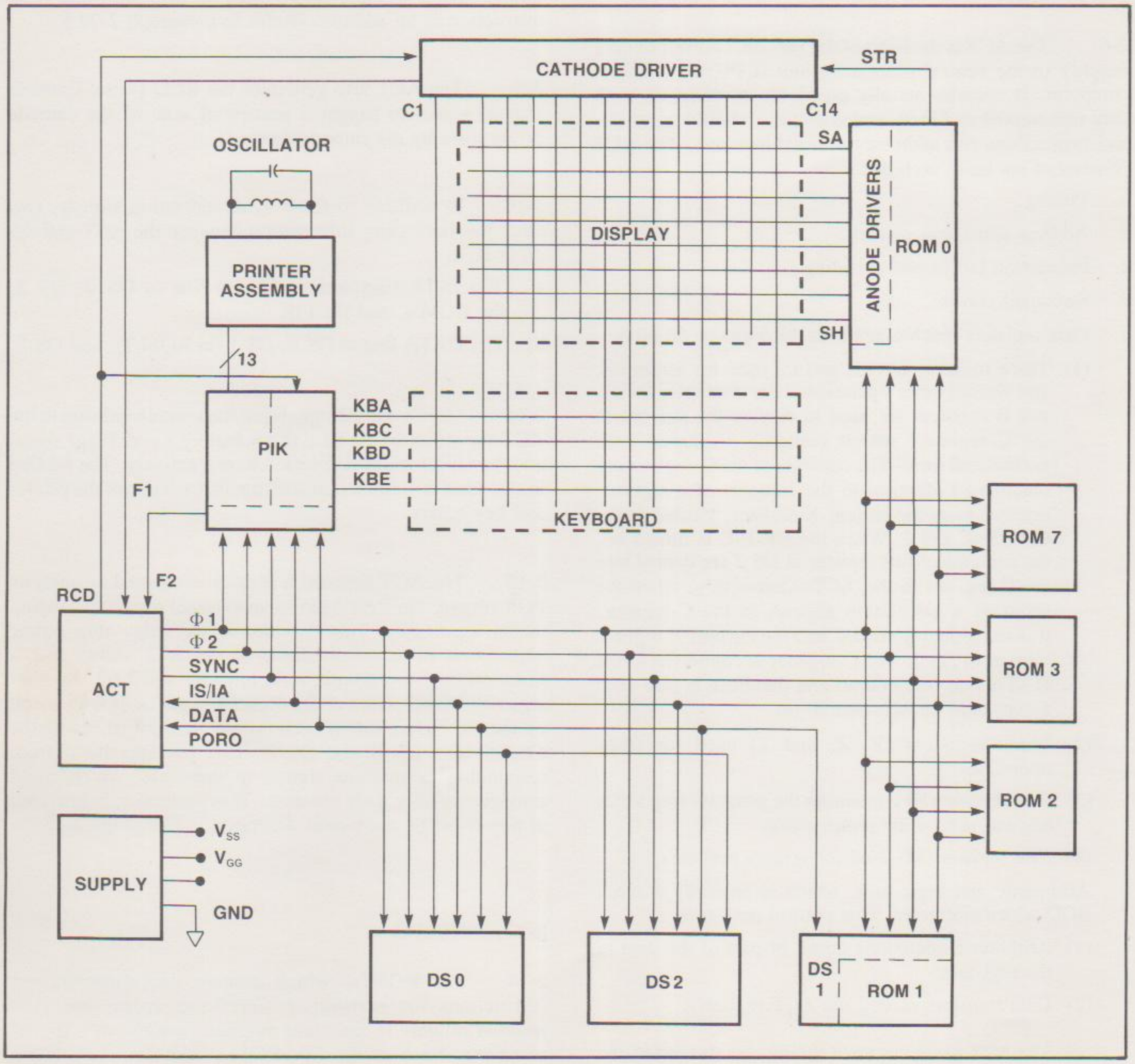


Figure 2-1. HP-19C Block Diagram

2-3. Input to the calculator is through a keyboard with 31 keys. Output is through an LED (Light-Emitting Diode) display module with 13 character positions, or a moving-head, thermal printer capable of printing up to 18 characters on a line.

2-4. In addition to the MOS IC's listed above, the HP-19C circuitry includes a bipolar IC containing cathode drivers used by the keyboard and display. All of these IC's are located on the logic PCA. The remaining circuitry, located on the printer PCA, consists primarily of the power supply, recharger interface, and printer drive circuitry.

2-5. ACT

2-6. The ACT is the heart of the HP-19C, 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 CMOS IC DS 2. When the HP-19C 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.

2-7. The ACT generates three timing signals used by the various IC's in the calculator: $\Phi 1$, $\Phi 2$ 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 740 KHz. The ACT generates pulses on the $\Phi 1$ and $\Phi 2$ lines at one-fourth the oscillator frequency, with $\Phi 2$ trailing $\Phi 1$ by approximately two pulse widths. (See figure 4-2.) Bits of information on the IS/IA and DATA bus lines (see below) extend between successive trailing edges of $\Phi 2$ pulses.

2-8. 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 the PIK and DS 0 through DS 2 whether information on the IS/IA line is an instruction or an address. (Refer to paragraph 2-72.)

2-9. 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.

2-10. 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, the ROM's, and the PIK.

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

2-11. The F1 and F2 signals are flags which indicate to the ACT the status of the LLF (Low battery Level Flag) signal and the OFF/PRGM/RUN switch, respectively. The F2 flag is also used in conjunction with the PIK to control the printer and key buffer.

2-12. 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. For a description of this circuit, refer to paragraph 2-60. Another signal—PORO (Power-On-Reset-Output)—is generated by the ACT 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 circuit described in paragraph 2-63.

2-13. ROM'S

2-14. 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 five ROM's contains 1024 10-bit words in read-only-memory.

2-15. 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.

2-16. 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.

2-17. 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.

2-18. 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 letters ***E***, ***r***, or ***o***.

2-19. 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.

2-20. CMOS DATA STORAGE

2-21. 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).

2-22. PIK

2-23. The PIK IC consists of two independent sections—printer interface control, and keyboard buffer—plus associated control and timing logic.

2-24. Printer Interface Control

2-25. This portion of the PIK interfaces between the ACT and the printer. After the PIK receives a print instruction from the ACT over the IS/IA line, information to be printed is sent over the DATA line from the C-register of the ACT to a 56-bit print register in the PIK. The PIK then pulls the FWD signal high, causing the print head to travel across the paper. Logic within the PIK decodes the information in the print register to address read-only-memory within the PIK, which contains 64 characters (including a special end-of-line character), each represented by a 5-by-7 matrix. As the print head moves across the paper, logic within the PIK, using these character codes and the STB signal from the printer drive circuitry (which regulates print intensity), selectively energizes output lines R_1 through R_7. These output lines are fed to the printer drive circuitry, where they control the current supplied to the print head resistors. To minimize power loss, the printed characters are slanted by logic within the PIK. (See figure 2-2.) This reduces the instantaneous current required for printing, thereby prolonging battery life.

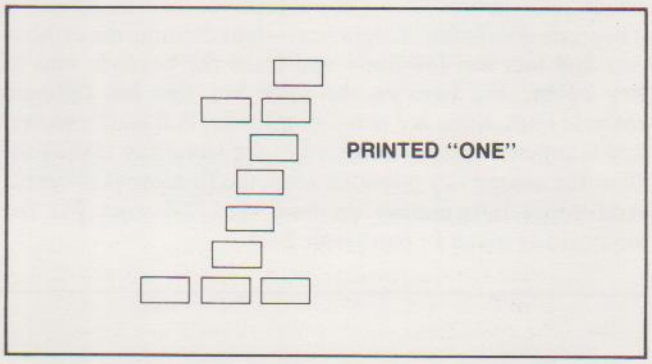


Figure 2-2. Printed Character

2-26. The ACT controls the printer via five print instructions and two interrogation instructions. If there is more data to be printed on the same line after a print instruction is issued, the ACT repeatedly sends an interrogation instruction asking if the PIK is ready for more data. The PIK ignores this instruction until it has finished printing the character string (terminated by an end-of-line character) in its print register. When the printing of the character string is completed, the PIK pauses for about 4.7 milliseconds and waits for the interrogation instruction from the ACT. It responds to the inquiry by pulling high the FLG line, which is connected to the F2 port of the ACT. The ACT then issues another print instruction to continue printing on the same line. The ACT adds at least two blank characters at the left of each line so that each line contains 20 characters, including blanks. It sends these characters and print instructions to the PIK until a line of 20 characters (including the two blanks at the left) has been printed.

2-27. When there are not more characters (or blanks) to be printed on the same line following the previous print instruction, the ACT does not issue the interrogation instruction. At the end of its 4.7 millisecond pause, the PIK, since it did not receive another print instruction, lets the FWD signal float low and pulls the REV signal high, which speeds the print head carrier back to its home position. (Refer to paragraph 2-47.) When it reaches this position (the right-hand wall of the printer), it closes a switch which grounds the HOM signal fed to the PIK. The PIK then lets the REV signal float low and pulls the BRK signal high, which brakes the motor rotation. If the ACT has data to be printed on the next line, it sends its other interrogation instruction to the PIK, asking whether the print head carrier has reached its home position. The PIK ignores this instruction until its HOM signal is grounded, but thereafter responds by pulling high the FLG line. The ACT then issues its print instruction for the next line.

2-28. Keyboard Buffer

2-29. So that the user can continue to enter keystrokes while the ACT is busy controlling calculations or printing, a keyboard buffer is provided to interface between the keyboard and the ACT. Eight cathode lines (C1, C2, C3, C5, C7, C8, C11, and C14) from the cathode driver IC and four key lines (KBA, KBC, KBD, and KBE) from the PIK run to the keyboard. By monitoring which key is connected to which cathode line when a key is pressed, the PIK generates a keycode consisting of eight bits—four defining the cathode line and four the key line—and loads the keycode into its key buffer. For keys on the same key line but different cathode lines, there is a two-key rollover; that is, if a second key is pressed that is connected to the same key line as the first, the second key is loaded when the first key is released. Additional information on how the PIK manages the keyboard is given in paragraph 2-34.

2-30. Since each keycode consists of eight bits, up to seven keycodes can be stored in the 56-bit key buffer. When the ACT is ready to process a keycode, it interrogates the PIK to determine if there is a keycode in the key buffer. If there is, the PIK signifies so by pulling its FLG line high, which is fed to the F2 port of the ACT. The PIK then transmits the keycode over the DATA line to the C-register in the ACT, where it is processed.

2-31. CATHODE DRIVER

2-32. The bipolar cathode driver IC consists of:

a. Fourteen cathode drivers, each capable of sinking up to 200 mA of current.

b. A 14-bit shift register that turns on the cathode drivers one at a time.

c. Timing control gating.

d. Low battery detection and indication. When the battery voltage falls to between 4.5 and 4.75 Vdc (depending on the particular cathode driver IC), an open collector output is turned on, enabling the LLF pin to sink current. This pin is connected to the F1 flag of the ACT. Instructions from ROM 0 and ROM 3 cause the decimal point to blink, indicating that the battery voltage is low.

2-33. KEYBOARD

2-34. Data is input to the calculator through the keyboard. It consists of 31 keys mounted over the keyboard PCA, from which eight cathode lines (C1, C2, C3, C5, C7, C8, C11, and C14) run to the cathode driver IC and four key lines (KBA, KBC, KBD, and KBE) run to the PIK. 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 2-3.) Since each cathode line is scanned by the cathode driver IC once every 15 word times, this key

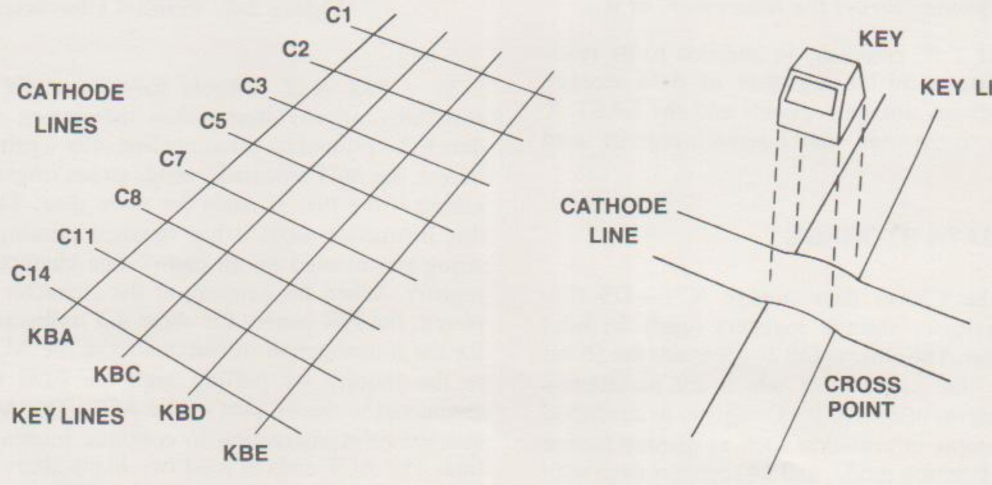


Figure 2-3. Keyboard Operation

line is brought low by the cathode line at the same rate. During one word time, no cathode lines are scanned by the cathode driver. The PIK waits 56 word times (approximately 18 ms) after the low key line is first detected to insure that a key is actually pressed. It then waits another 4.5 to 12 ms to negate the effects of key bounce, which results in multiple entries. Finally, it loads into its key buffer an eight-bit keycode corresponding to the key line and cathode line which are simultaneously low. Up to seven keys can be entered before the key buffer is full; keys pressed after that are simply "lost"—that is, not stored in the key buffer—until a key has been processed and there is room for another.

2-35. DISPLAY

2-36. Data is output from the calculator through a display module consisting of 13 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 2-4.) 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.

2-37. At each character position, all eight LED segments share a common cathode. (See figure 2-5.) Every 15 word times, the RCD pulse sent by the ACT to the cathode driver IC triggers a scan of the cathode lines. (See figure 2-6.)

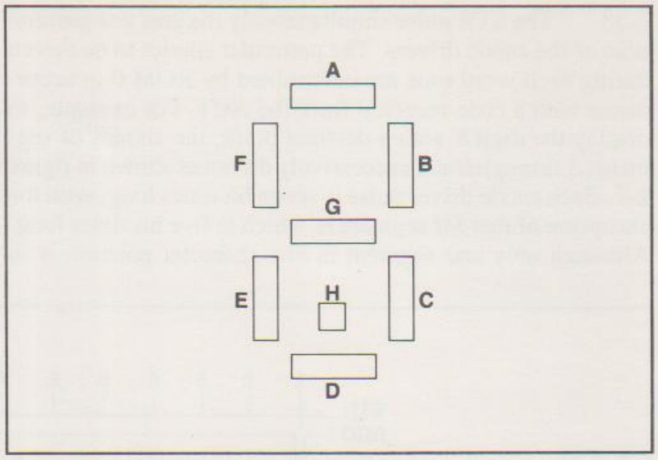


Figure 2-4. Displayed Digit Structure

This scan successively grounds the common cathode at each character position, so that every 15 word times, all eight LED segments at each character position have their cathode grounded for 1 word time. During the first word time of every 15-word-time cycle, cathode line C1 is grounded; but since this cathode line does not go to the display, no character position is lit during this word time. During the last word time of every 15-word-time cycle, there is no cathode line at ground potential; hence for this word time also, no character position is lit. 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.

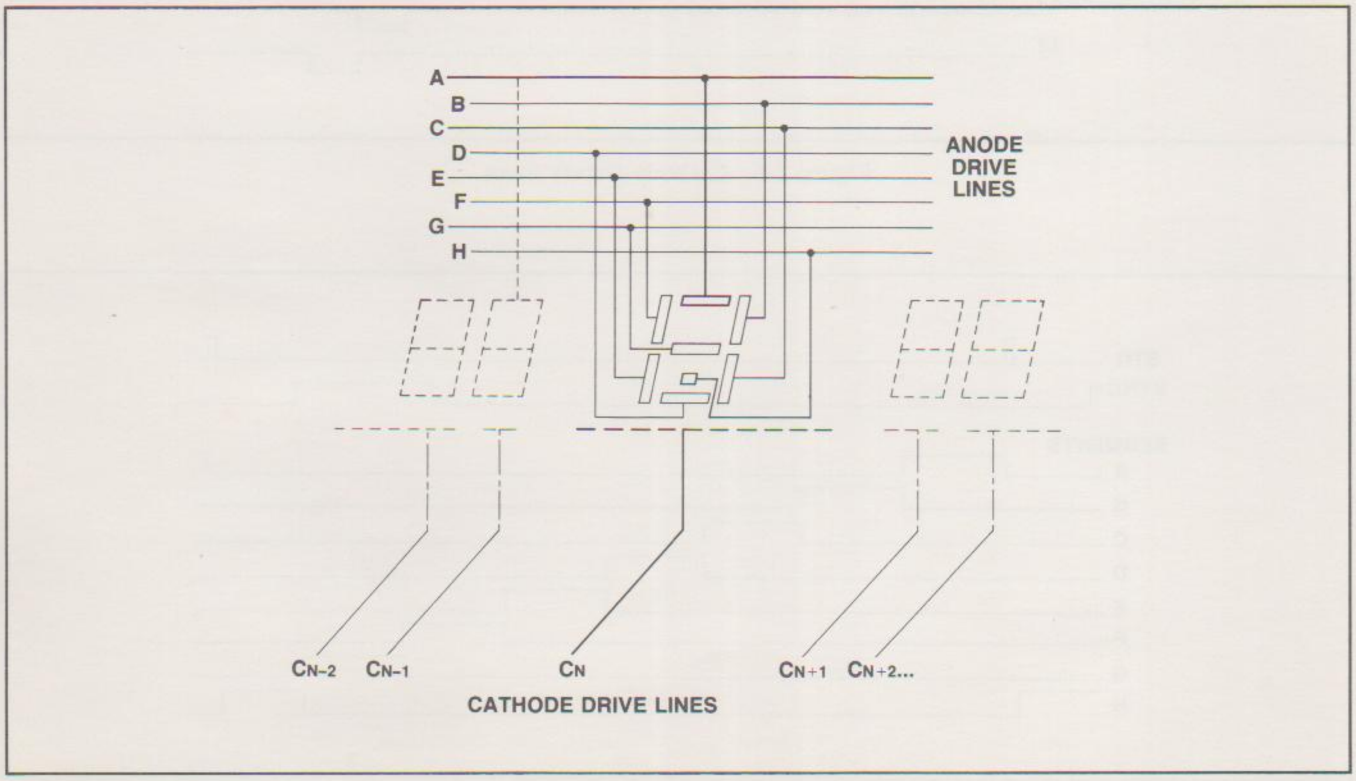


Figure 2-5. Anode and Cathode Drive Lines

2-38. 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 2-7. 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 cannot be seen, since the eye cannot detect flicker at refresh rates greater than about 100 per second. Current to drive the LED's is provided by V_B through Q1. The intensity of the display is governed by the values of R2 and R3, which constitute a voltage divider across Q1. By changing the value of R3, the display intensity can be adjusted dimmer (larger value) or brighter (smaller value).

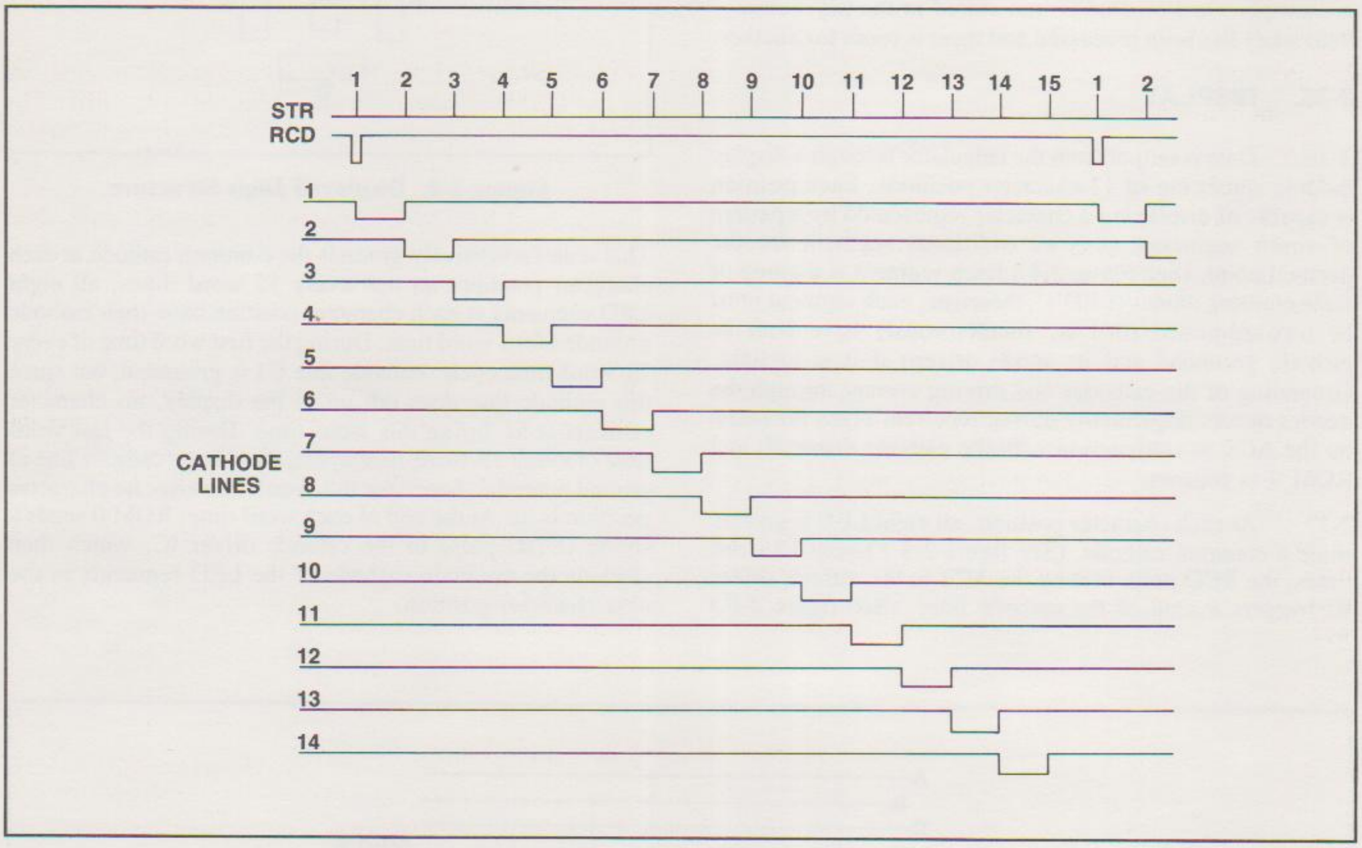


Figure 2-6. Cathode Driver Scan

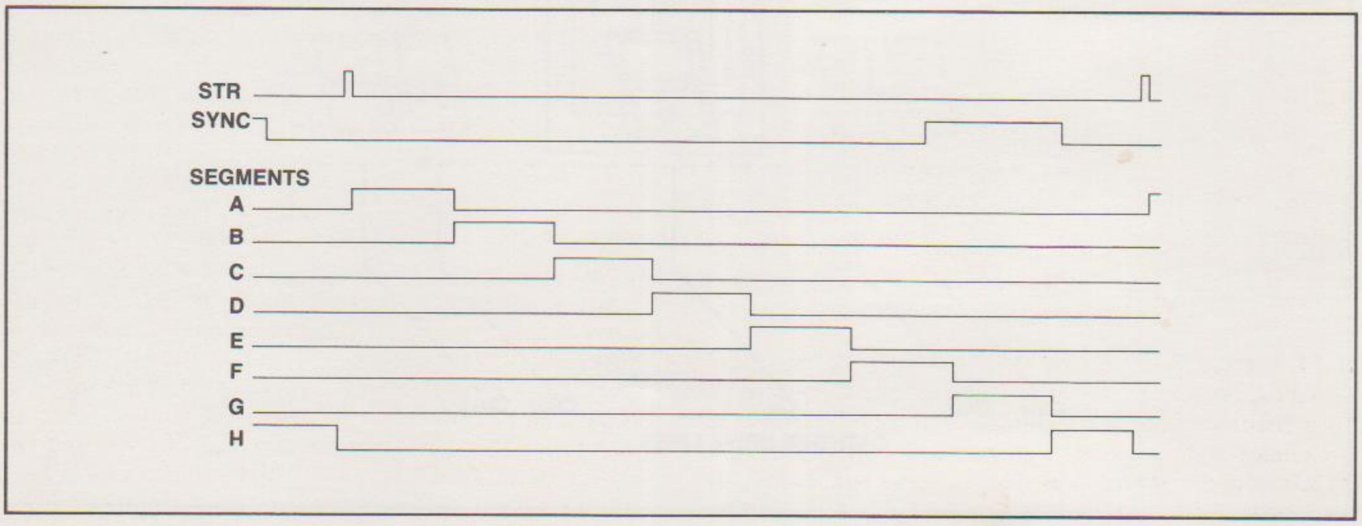


Figure 2-7. Anode Driver Scan

2-39. PRINTER

2-40. The HP-19C contains a moving-head, thermal printer. Appropriate printer drive circuitry, interfacing between the printer and the PIK, is provided also.

2-41. Printer Mechanism

2-42. The printer mechanism consists of three major portions:

a. Paper drive mechanism.

b. Print head.

c. Print head drive mechanism.

2-43. Print Head. The print head consists of a column of seven 10-ohm, thin-film resistors deposited on a ceramic substrate. (See figure 2-8.) When energized by electrical pulses, the resistors heat to 350°C, then cool to below a certain temperature threshold within 5.1 milliseconds. As the print head travels across the heat-sensitive paper, the selectively pulsed resistors leave a trail of dots. Each dot, approximately 0.3 mm on a side, is the result of a chemical reaction in the paper, which is coated with two types of pulverized thermo-reaction compounds plus a binder. The chemical reaction changes the color of the paper at the point of heat application. Codes contained in the PIK regulate the pulsing of the resistors, so that the dots are arrayed in patterns seven high by five wide, each representing an alphanumeric character. Spacing between character patterns is two dots wide.

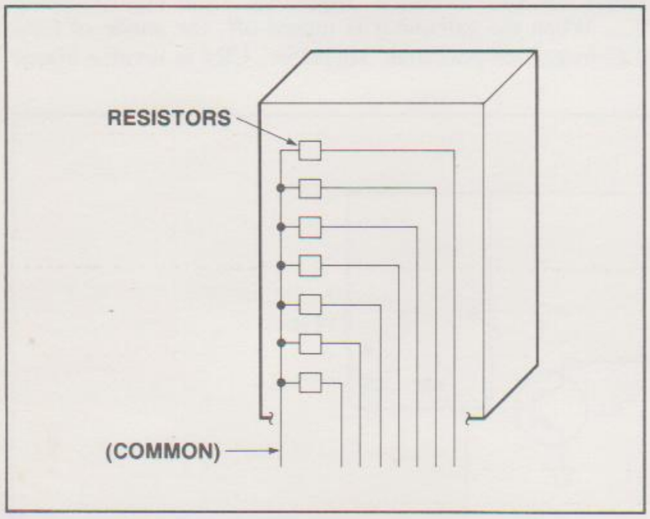


Figure 2-8. Print Head

2-44. Print Head Drive Mechanism. The print head travels along a drive screw with a double helix thread, driven by a fast-response, ironless-armature, dc motor. Characters are printed, right-justified, as the print head moves from right to left; paper is advanced as the print head returns right to its "home" position (the right-hand wall of the printer mechanism). A printed line contains up to 18 characters.

2-45. Printer Drive Circuitry

2-46. The printer drive circuitry, located on the printer PCA, consists of five major portions:

a. Motor drive.

b. Motor speed control.

c. Print head current control.

d. Power regulator.

e. Voltage reference.

2-47. Motor Drive. The printer motor drive is regulated by the FWD, REV, and BRK signals from the PIK. The FWD (forward) signal turns on Q5 and Q4, sending current supplied by V_B into the positive terminal of the motor and out of the negative terminal. This drives the motor clockwise and the print head to the left. When a distance equivalent to 20 characters is reached (approximately the left-hand wall of the printer), the PIK drops the FWD signal and then pulls the REV (reverse) signal high. This turns on Q3 and Q4, again sending current into the positive terminal of the motor, which therefore continues rotating in the same direction. However, because the drive screw has a double rather than single-helix thread, after the print head carrier reaches the left-hand wall of the printer it follows the other helix thread back to its home position. Thus, the necessity of reversing the direction of motor rotation is avoided. When the print head carrier reaches its home position, it closes a switch which grounds the HOM line fed to the PIK. The PIK then drops the REV signal and applies the BRK (brake) signal, which turns on a transistor within U1, for approximately 100 milliseconds. This transistor shorts the motor leads, thereby braking motor rotation.

2-48. Motor Speed Control. The speed of the motor is regulated only while the FWD signal is applied, using a combination of analog and digital techniques. During sample periods of about 1.5 milliseconds FWD is allowed to float low, so the motor is a free-running generator during these intervals. The back emf (electromotive force) generated by the motor in this condition, which is linearly proportional to the speed of the motor, is sampled by a comparator within U4 which compares it to a constant 1V reference provided by the voltage reference circuitry. The output of the comparator (V_M) is fed to the PIK, which uses it to gate the FWD signal. If the back emf is less than the reference voltage, the motor speed is too slow, so FWD is restored by the PIK at the end of the sample period. If the back emf is greater than the reference voltage, the motor speed is too fast, so FWD is not restored by the PIK at the end of the sample period. Since the mechanical response time of the motor is much longer than the sample period (the sample rate is a relatively high 660 per second), the pulsed power input to the motor is averaged out, resulting in a steady motor speed. Unlike FWD, which is applied intermittently as a result of the technique described above, REV is applied over the entire interval between the dropping of FWD and the application of BRK. Therefore REV functions as a fast-forward signal, and the print head carrier moves left-to-right more quickly than it does right-to-left.

2-49. Capacitor C6 eliminates high-frequency noise spikes that could cause differential input to the comparator not related to motor speed. Resistors R5 and R6 constitute a voltage divider to scale the back emf down to approximately 1V. By adjusting trimmer R5, the motor speed can be varied (within certain limits). Since the time during which printing occurs is determined only by the number of characters to be printed, this adjustment of the motor speed varies the length of the printed line.

2-50. Print Head Current Control. Seven high-current NPN transistors, located within U1 and U2, act as switches to allow current to flow through the print head resistors when energized by the R_1 through R_7 outputs from the PIK. When the base of a transistor is energized by the source current of 12 mA, the transistor turns on, allowing about 500 mA to flow from V_B through the print head resistor and the transistor to ground.

2-51. Power Regulator. To maintain uniform print contrast, the print head resistors must develop approximately the same temperature each time they are energized, independent of fluctuations in V_B. This is accomplished through power regulation circuitry, consisting of the thick-film resistor-capacitor-diode network U3 and comparators located within U4. This essentially constitutes a pulse-width modulation control circuit.

2-52. The power regulation circuit ensures a constant rms voltage at the R_1 through R_7 outputs of the PIK by varying the duty cycle of the STB (strobe) signal, which is fed to the PIK, in inverse proportion to the square of V_B. The STB signal is generated by an oscillator consisting of portions of U3 and a comparator within U4. Its frequency is fixed, with a nominal value of 10 kHz. Another comparator within U4, fed by the oscillator output and a 3.95V offset voltage, acts as an inverter to insure proper switching. The output of the inverter is fed to a third comparator within U4 which, together with resistor R4 and a capacitor within U3, determine the duty cycle of the STB signal. By adjusting trimmer R4, the print intensity can be varied.

2-53. Voltage Reference. The 1V reference used by the motor speed control circuit, and the 3.95V offset used by the power regulator, are supplied by a tapped voltage divider across a zener diode located within U3.

2-54. POWER SUPPLY

2-55. Quick-charge nickel-cadmium batteries are the primary power source for the HP-19C. The +5.0 Vdc nominal battery voltage is converted to +6.25 Vdc and to −12.0 Vdc by a transistor inverter circuit located on the printer PCA and shown in figure 2-9.

2-56. Transistor Q1 and toroidal transformer T1 form the basic inverter circuit. With feedback from winding A, Q1 oscillates at a frequency of 30 to 200 kHz, depending on the state of battery charge. Winding B of T1 forms the transformer primary from which V_{SS} is derived; CR1 rectifies and C2 filters the voltage from winding B. The voltage from winding C is rectified, filtered, and doubled by the combined actions of CR2, CR3, and C4 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 CR4 and transistor Q2.

2-57. The CMOS IC's are powered by V_S, which is obtained from either V_{SS} or V_{BAT} via circuitry located on the logic PCA. (See figure 2-10.) During normal calculator operation, V_{SS} is greater than V_B. Therefore, CR5 is reverse-biased and CR4 conducts, supplying V_S at approximately V_{SS}. When the calculator is turned off, the anode of CR4 goes to ground potential. Therefore, CR4 is reverse-biased

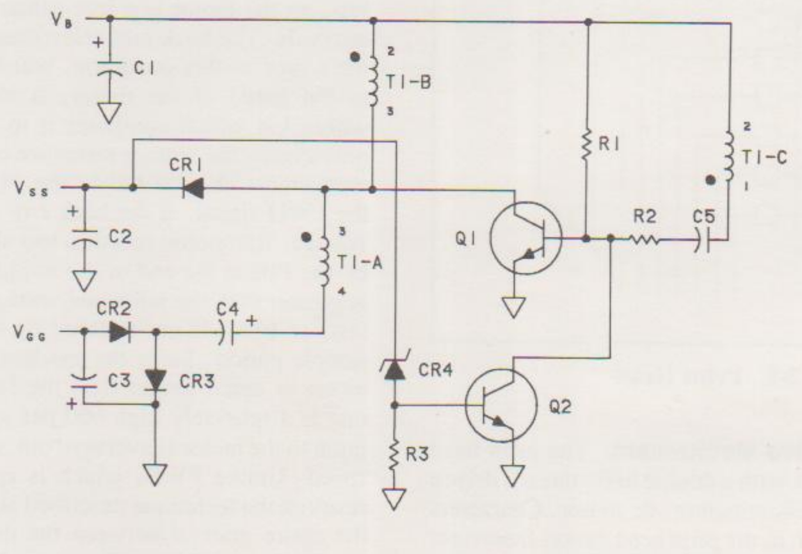


Figure 2-9. HP-19C Power Supply Circuitry

and CR5 conducts, supplying V_S at approximately V_{BAT}. While no power is applied—as when batteries are being changed—V_S is supplied by stored charge in C5.

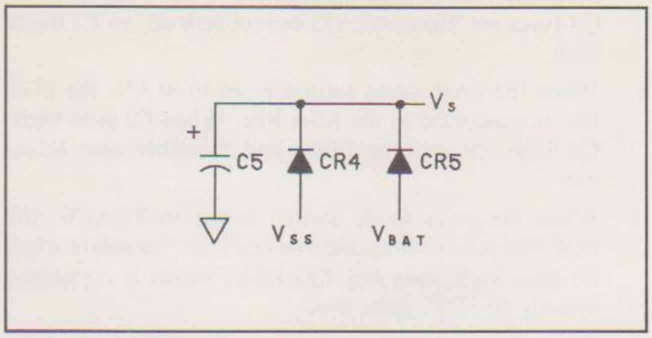


Figure 2-10. CMOS Power Supply Circuitry

2-58. BATTERY CHARGING

2-59. Figure 2-11 illustrates the battery charging circuitry, which is located on the printer PCA. The ac adapter/recharger is a transformer that drops the line voltage to about 12.8 Vac at the recharger input terminals of the calculator. Diodes CR5 through CR8 rectify the alternating current. When the calculator is off, the RCHR line is connected to the V_{BAT} line at the OFF/PRGM/RUN switch (see figure 4-12), and the battery is charged through R9 and R10. When the calculator is on, the CHG line is connected to the V_{BAT} line at the OFF/PRGM/RUN switch, and the battery is charged through R10.

Note: With batteries removed, the calculator will not be damaged by connecting the ac adapter/recharger to the input terminals; however, it will not operate correctly until the batteries have been reinstalled.

2-60. POWER-ON RESET

2-61. Circuitry located on the logic PCA (see figure 2-12) ensures that the logic contained within the ACT comes up in the correct logic state when power is applied to the calculator.

2-62. Basically, when power is applied, Q6 is turned off; V_{SS} rises and the voltage across C4 also rises, resetting the ACT. If V_B drops a certain level below V_{SS}, Q6 turns on and discharges C4, forcing the ACT to reset again. This can occur a number of times until V_B and V_{SS} are stable. The effect of switch contact noise at turn-on is counteracted by this circuit.

2-63. POWER-OFF

2-64. Circuitry located on the logic PCA (see figure 2-13) ensures that the CMOS IC's are disabled before V_{SS} drops below 5.5V. This protects their contents from being altered or destroyed. When power is turned off, C1 discharges through R4 and Q2 to V_B, which is dropping below V_{BAT}. Q2 turns on, pulling PORO low through CR2.

2-65. SWITCH DECODING

2-66. Circuitry located on the logic PCA (see figure 2-14) is used by the ACT, in conjunction with its F0 output flag, F2 input flag and its KSA, KSC, and KSE lines, to decode the OFF/PRGM/RUN and print mode switches as follows.

a. When the OFF/PRGM/RUN switch is set to PRGM, the PRGM line from the logic PCA is connected to V_{BAT}. This turns on Q3, which pulls the emitter of Q5 low. When flag F0 goes high, Q4 turns on. This turns on Q5 (since its emitter is near ground) which pulls flag F2 low.

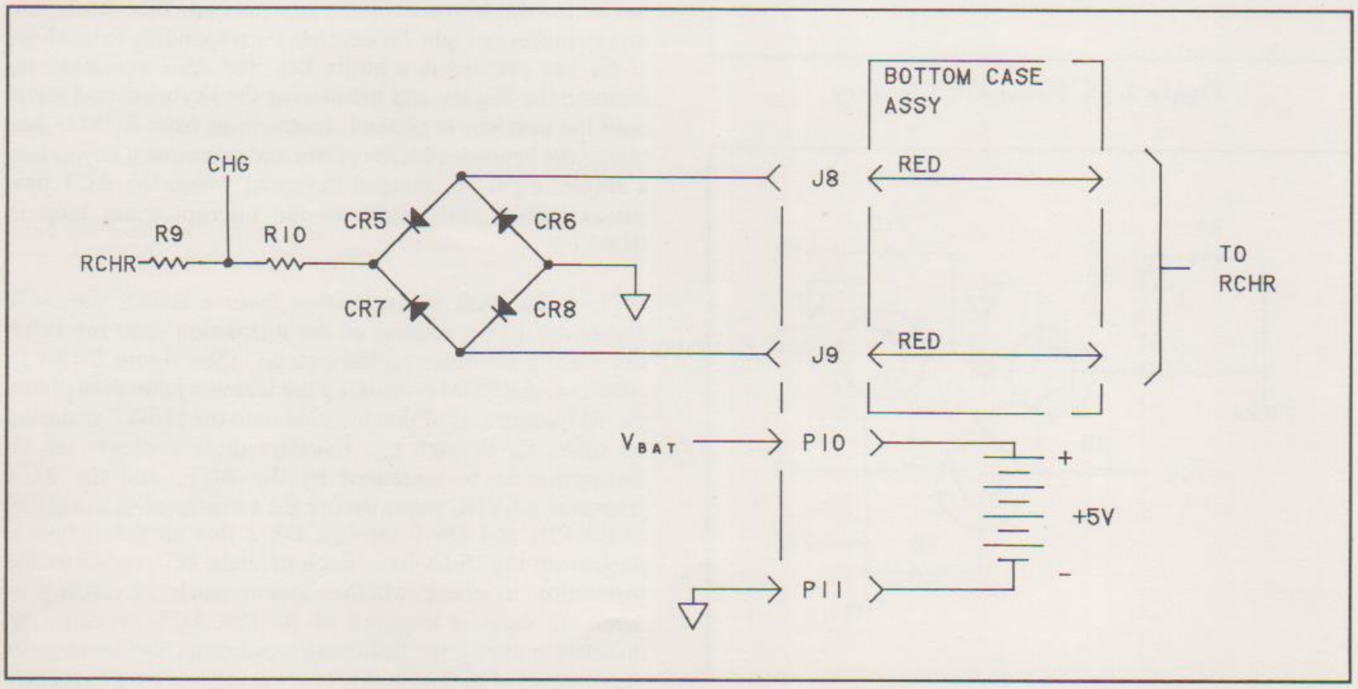


Figure 2-11. Battery Charging Circuitry

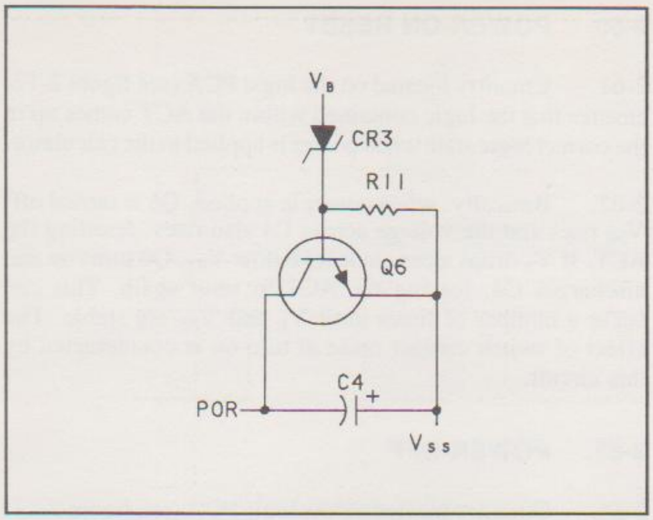


Figure 2-12. Power-On Reset Circuitry

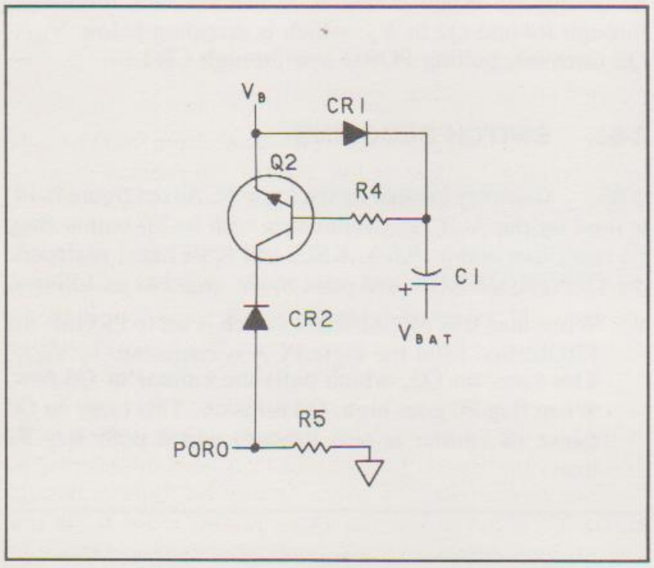


Figure 2-13. Power-Off Circuitry

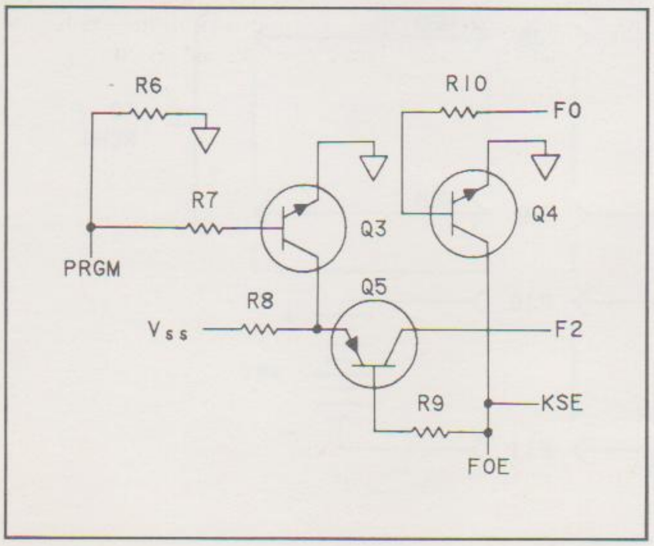


Figure 2-14. Switch Decoding Circuitry

b. When the OFF/PRGM/RUN switch is set to RUN, the PRGM line from the logic PCA floats. The base of Q3 is held low through R6, so Q3 is turned off. V_{SS} pulls the emitter of Q5 high through R8. When F0 goes high, Q4 turns on. However, Q5 cannot turn on, so F2 floats high.

c. When the print mode switch is set to MAN, the FOE line is connected to the KSA line. When F0 goes high, Q4 turns on, pulling FOE, and therefore also KSA, low.

d. When the print mode switch is set to TRACE, the FOE line is not connected to a key line. Therefore when F0 goes high, only key line KSE, which is connected directly to FOE, goes low.

e. When the print mode switch is set to NORM, the FOE line is connected to the KSC line. Therefore when F0 goes high, both KSE and KSC go low.

2-67. In addition to its use for switch decoding in the circuit described above, R10 is used for chip enable. When flag F0 goes high, R10 keeps it at a level that causes ROM 3 to turn off and ROM 7 to turn on during switch interrogation.

2-68. SYSTEM OPERATION

2-69. 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:

a. Check its flag lines to determine whether a low battery level has been detected (F1) or the position of the OFF/PRGM/RUN switch has been changed (F2).

b. Interrogate the PIK to determine whether a key has been pressed.

2-70. If a key has been pressed, the ACT asks the PIK key buffer for the keycode of the key pressed, then loads into its key buffer an eight-bit keycode corresponding to that key. 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(s) into a single, eight-bit, merged keycode, which the ACT processes before going back to the microprogram loop in ROM 0.

2-71. To fetch an instruction from a ROM, the ACT places the 12-bit address of the instruction onto the IS/IA line during bit times t_{16} through t_{27}. (See figure 2-15.) 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 the PIK and DS 0 through 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 sending or receiving 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.

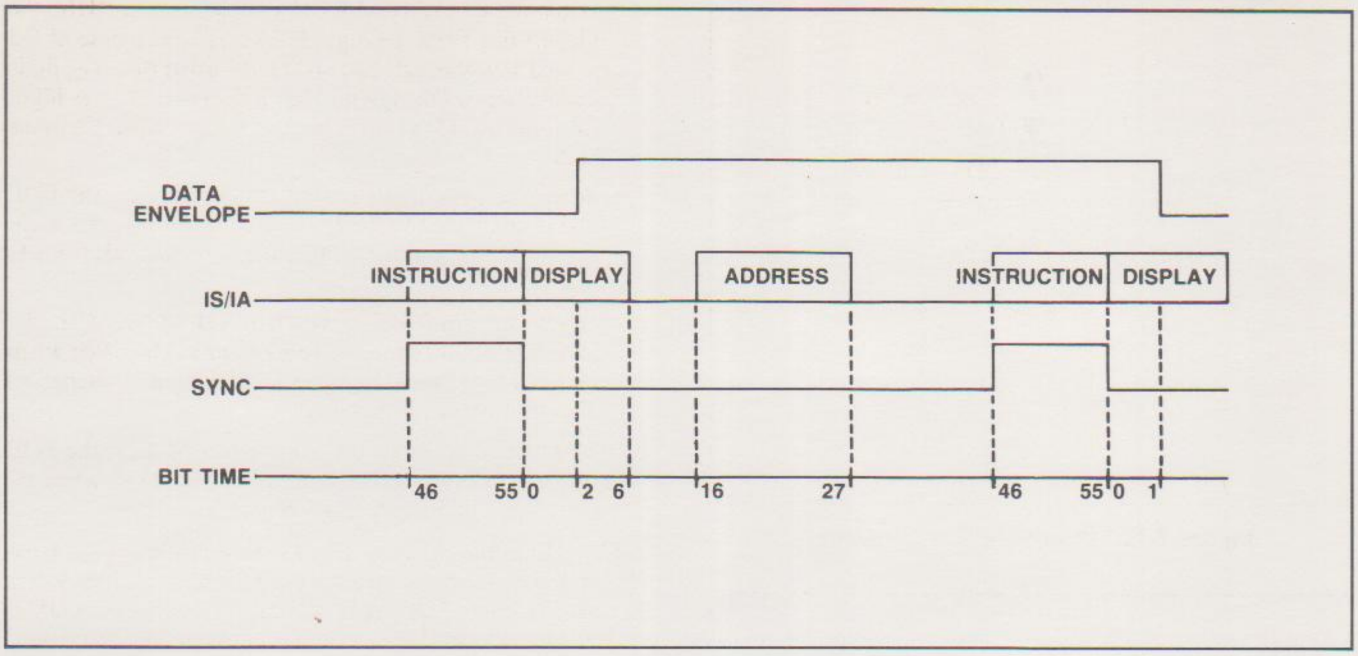


Figure 2-15. DATA, SYNC, and IS/IA Timing

2-72. 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 the PIK and DS 0 through 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.

2-73. 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.

2-74. 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 13 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-19C consist of the following:

a. Isolate the cause of a problem to a malfunction in a particular assembly: refer to table 3-1.

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 3-3.

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.

Table 3-1. Assembly Failure Symptoms

FAILURE SYMPTOM \ ASSEMBLY FAILURE*	LOGIC PCA	PRINTER PCA	PRINTER ASSEMBLY	KEYBOARD/TOPCASE ASSEMBLY	DISPLAY	BATTERY PACK	AC ADAPTER/RECHARGER
Calculator inoperative; no display.	1	4	5	2		3 (1)	
Calculator operative on battery pack only.		2					1
Calculator operative on ac adapter/ recharger only.		2				1 (1)	
Printer not operating correctly. (Refer also to table 4-6.)	1	3	2				
Print functions cause blank display.	1		2				
Printer burns hole in paper or turns paper dark blue.	1	2	4	3			
Functions inoperative or give incorrect results.	1			2	3		
Low battery indication not operating correctly.	1						
No key entry.	1 (2)			2 (1)			
Numbers cannot be stored and recalled.	1						
Digit(s) and/or segment(s) missing or added in display.	2 (3)			3 (2)	1 (1)		

*The numbers in the columns indicate the recommended order of replacement. The order for each symptom is based on the probability of assembly failure plus the relative ease of replacement.

3-3. DISASSEMBLY AND REASSEMBLY

3-4. The following procedures describe in detail the disassembly and reassembly of the HP-19C. The procedures are presented in the following order:

a. Paper Removal: paragraph 3-6.
b. Battery Pack Removal: paragraph 3-8.
c. Case Separation: paragraph 3-10.
d. Logic PCA and LED Display Removal: paragraph 3-12.
e. Keyboard/Topcase Assembly Parts Replacement: paragraph 3-14.
   (1) Display Window Replacement: paragraph 3-15.
   (2) Slide Latch Replacement: paragraph 3-16.
   (3) Top/Bottom Case Connector Replacement: paragraph 3-17.
f. Printer Removal: paragraph 3-18.
g. Printer PCA Removal: paragraph 3-20.
h. Rubber Foot Removal and Replacement: paragraph 3-22.
i. Flex-Cable Disconnection: paragraph 3-25.
j. Flex-Cable Reconnection: paragraph 3-27.
k. Printer PCA Replacement: paragraph 3-29.
l. Printer Replacement: paragraph 3-31.
m. LED Display Replacement: paragraph 3-33.
n. Logic PCA Replacement: paragraph 3-35.
o. Case Reattachment: paragraph 3-37.
p. Battery Pack Replacement: paragraph 3-39.
q. Paper Replacement: paragraph 3-41.

3-5. For addiitonal aid in disassembly and reassembly, see the HP-19C Exploded View, figure 7-1.

3-6. Paper Removal

3-7. Remove the paper from the calculator as follows:

> **CAUTION**
>
> Do not attempt to remove the paper from the printer by pulling it in a direction opposite to its normal travel. To do so could damage the paper advance mechanism.

a. Open the paper cover by sliding the paper cover latch to the right.

b. Tip the calculator over so that the paper roll drops out of the printer, then tear off and discard the roll.

c. Switch the calculator ON. Press [g] [SPC] and hold until the paper no longer advances, then pull the remaining paper in the same direction until it is free of the printer. Switch the calculator OFF.

3-8. Battery Pack Removal

3-9. Remove the battery door and battery pack as follows:

a. Hold the calculator in one hand and place your thumb or forefinger in the recess in the battery door. Press toward the bottom of the calculator until the door snaps free. Remove the door by tilting its top toward you.

b. Turn the calculator over and gently shake until the battery pack falls into your hand.

3-10. Case Separation

3-11. Separate the keyboard/topcase assembly from the bottom case as follows:

a. Place the calculator face down. With a small, flat-blade screwdriver, lift up the **upper** edge of the rubber foot at the **upper right** corner of the bottom case. With a small Phillips screwdriver, unscrew the screw underneath. Turn the calculator over, hold the rubber foot open with your finger, and gently shake the screw out. Discard the screw.

b. Lift up the **lower** edge of the rubber foot at the **upper left** corner of the bottom case, and unscrew the screw in the well underneath. Shake out and discard the screw as above.

c. Unscrew, remove, and discard the two screws at the top of the battery well and the one screw near the ac adapter/recharger pins.

d. Hook your left thumbnail between the bottom case and top case at the left of the printer, then separate the cases until resistance is felt.

e. Hold the calculator as shown in figure 3-1, grasping the edges of the logic PCA with your thumb and middle finger. Lift the keyboard/topcase assembly, with the logic PCA connected to it, straight up from the bottom case.

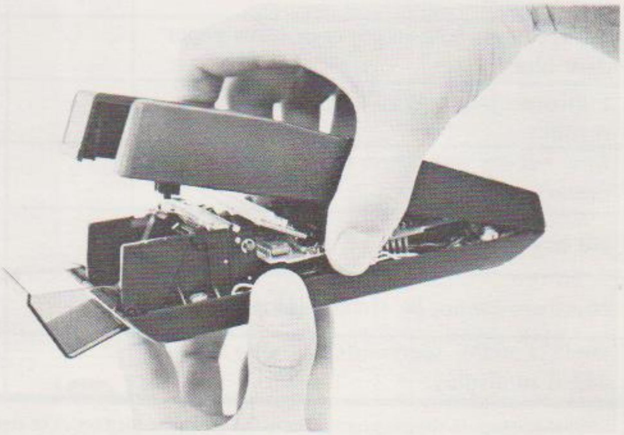


Figure 3-1. Separating Cases

3-12. Logic PCA and LED Display Removal

3-13. When the keyboard/topcase assembly has been separated from the bottom case, the logic PCA—with the LED display connected to it—will be found connected to the keyboard PCA via a cable soldered to the logic PCA. To disconnect the logic PCA from the keyboard PCA, grasp the keyboard/topcase assembly and logic PCA as shown in figure 3-2. Gently but firmly pull the logic PCA straight out from the keyboard PCA until the wires in the cable disengage from the connector on the keyboard PCA. The LED display can then be removed by grasping its ends and carefully pulling it free of the connector pins on the logic PCA.

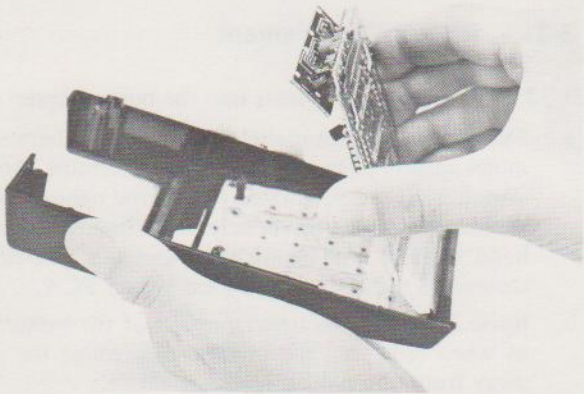


Figure 3-2. Separating Logic PCA From Keyboard PCA

3-14. Keyboard/Topcase Assembly Parts Replacement

3-15. Display Window Replacement. If the display window is scratched or otherwise damaged, replace it with a new window as follows:

a. Place the keyboard/topcase assembly face down. Insert a small flat-blade screwdriver between the rib on the display window and one of its retaining tabs. Pry them apart slightly and gently press downward on the window until the window is free of the tab. This should require only a very small movement.

b. While holding the window disengaged from its retaining tab with your thumb, with the screwdriver pry the window free of the other retaining tab, and with your thumb push the window out.

c. Place the new display window tilted into the cut-out in the top case with its short, hooked lip engaged around the top edge of the cut-out.

Note: The top edge of the display window should *not* be touching the chrome strip above the cut-out.

d. While keeping the window engaged in the slot by maintaining forward pressure with your thumbs, press down with your forefingers until the window snaps secured into the cut-out. Ensure that both sides of the window are securely shut.

3-16. Slide Latch Replacement. If the paper cover slide latch is damaged, remove it from the rest of the keyboard/topcase assembly and insert a new latch as follows:

a. Pull up on the catch until the ears snap free of their retaining stubs in the top case.

b. Grasp the latch from below and push it up through the square hole until it is free of the topcase.

c. Insert a new latch into the hole from the inside of the topcase.

d. Hold the latch flush with the top surface of the topcase with your finger below, and gently pull the two latch ears toward the printer cut-out until they snap over their retaining stubs.

3-17. Top/Bottom Case Connector Replacement. If the top/bottom case connector (9, figure 7-1) is damaged, remove it and replace with a new connector as follows:

a. Carefully note its configuration with respect to the top case.

b. Remove the screw securing the connector to the top case, and discard the screw and connector.

c. Place a new screw in a new connector. Its threads will freely pass through the proper hole.

d. Place the connector in the proper psoition, with its largest face engaged in the slot in the bottom case rib. Tighten the screw, being careful not to apply excessive torque.

3-18. Printer Removal

3-19. Remove the printer as follows:

a. With long-nose pliers, carefully disconnect the red and black motor leads and two white home switch leads from the long side of the printer PCA. Remove both sets of leads from behind the connectors on the printer PCA, then position the motor leads over the battery well.

b. Manually rotate the drive screw (14, figure 7-2) until the head carrier is positioned against the right side of the printer mainframe.

c. Unscrew the three screws securing the printer to the bottom case, being careful not to touch the printer drive screw or oscillator stabilizer (8, figure 7-2) with the shaft of the screw-driver when loosening the screw below.

d. Orient the calculator with the printer to your right. Lift up the printer with your right hand and remove the three screws and grommets, then raise the top of the printer PCA with your left forefinger under the printer cable connector.

CAUTION

In the following step, do not sharply bend the flex-cable. To do so can damage it.

e. Hold the printer PCA in this raised position by placing your second finger under the 12-pin connector, then move the printer away from the bottom case, uncurling the flex-cable until it lies straight and flat between the printer and the connector on the printer PCA.

3-20. Printer PCA Removal

3-21. Remove the printer PCA from the bottom case as follows:

a. Disconnect the two red ac adapter/recharger leads from the lower corner of the printer PCA.

b. With a small, flat-blade screwdriver, raise the lower portion of the printer PCA until it clears the small bosses in the lower corners of the bottom case, then with your right thumb and forefinger lift up the upper portion of the printer PCA until it clears the large boss on the battery well.

c. Slide the flexed printer PCA to the left until the four tabs on the lower portion of the printer PCA clear the slots in the battery well and the printer PCA is free of the bottom case.

3-22. Rubber Foot Removal and Replacement

3-23. If the rubber foot adjacent to the ac adapter/recharger pins is damaged, discard the bottom case and use a new case when reassembling the calculator.

3-24. If any of the other three rubber feet is damaged:

a. Lift its upper end with a small, flat-blade screwdriver.

b. Grasp the foot firmly with long-nose pliers and pull it free of the bottom case.

c. Insert the tail of a new rubber foot through the slot in the bottom case from the outside, configured such that the foot will rest it its recess in the bottom case.

d. With long-nose pliers, pull the tail through the slot until its shoulder passes through the slot, locking the foot in the bottom case.

e. With diagonal cutters, cut off the tail above the shoulder inside the bottom case.

3-25. Flex-Cable Disconnection

3-26. To detach the flex-cable from the connector on the printer PCA, insert the small end of the cable connector tool (part number T-155435) into the connector, positioned between the connector contacts and the cable contacts, then pull the cable and tool together out of the connector.

3-27. Flex-Cable Reconnection

3-28. To reconnect the flex-cable to the printer PCA:

a. Check whether the end of the cable is folded. If not, fold it 1.5 millimeters (1/16 inch) from the beginning of the exposed contact area.

b. Place the connector tool in the fold of the cable.

c. Carefully insert them together, with the exposed contact area of the cable end facing up, into the connector on the printer PCA.

d. Remove the connector tool.

3-29. Printer PCA Replacement

3-30. To return the printer PCA into the bottom case:

a. Place the printer PCA in position on the bottom case.

b. Press the tabs on the printer PCA down and slide the printer PCA to the right until the four tabs enter the slots in the battery well.

c. Continue to slide the printer PCA to the right until the tabs are fully engaged in the slots, the upper portion of the printer PCA clears the battery well, and the two small bosses in the bottom case are engaged in their mating holes in the printer PCA.

d. With long-nose pliers, connect the two red ac adapter/recharger leads to the printer PCA.

3-31. Printer Replacement

3-32. To return the printer into the bottom case:

a. Ensure that the motor leads are positioned between the motor adapter plate and the printer mainframe, the home switch leads are positioned toward the opposite side of the mainframe, the head carrier is positioned at the right-hand wall of the mainframe, and the flex-cable is secured in the connector on the printer PCA.

b. Raise and hold the upper portion of the printer PCA as when removing the printer, then rotate the printer away from you until it is upside down.

c. Move the printer directly toward you in a straight line so that the flex cable passes beneath the printer PCA, being careful not to sharply bend the cable.

d. Release the printer PCA, rotate the printer 180° away from you, and place the three grommets, with screws inserted, into the slots on the printer.

e. Place the printer in position, ensuring that the stubs on the lower front of the printer are above the printer PCA and the cable connector on it.

f. Ensure that free opening of the paper window is not impeded by its heat-staked pin rubbing against the bottom case assembly. If it is, trim off the excess or heat-stake again until the paper cover opens freely.

g. Tighten the three screws securing the printer to the bottom case, being careful not to touch the printer drive screw or oscillator stabilizer with the shaft of the screwdriver when tightening the screw below.

h. With long-nose pliers, insert the red and black motor leads into their connectors in the printer PCA.

i. Position the motor leads first between the 12-pin connector and the battery well, then between the 10-pin connector and the battery well, and pull any slack up against the side of the printer mainframe.

j. Position the two white home switch leads between the 12-pin connector and the battery well, above the motor leads.

k. Insert the home switch leads into their connectors in the printer PCA, and pull any slack up against the side of the printer mainframe.

3-33. LED Display Replacement

3-34. To connect the LED display to the logic PCA:

> **CAUTION**
> Avoid touching the lens of the display with your fingers.

a. Ensure that the 3/16-inch rubber shim is in position on U7 and is not loose. (See figure 3-3.)

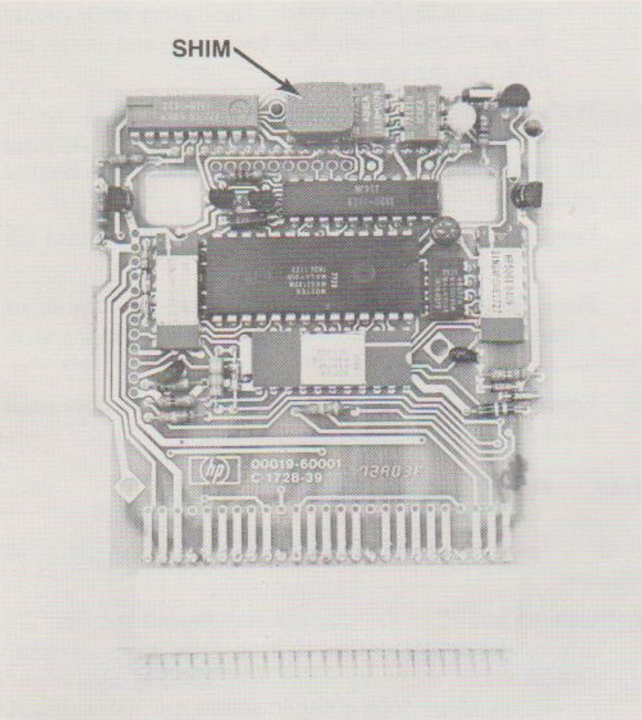


Figure 3-3. Rubber Shim Position

b. Hold the display by its ends and align its holes over the 21-pin connector on the logic PCA.

c. Press down on the display until it is secured to the pins.

Note: These pins have stops designed to prevent over-insertion and to ensure proper display location.

3-35. Logic PCA Replacement

3-36. To connect the logic PCA to the keyboard PCA:

a. Ensure that the abrasion shield is in position on the circuit side of the logic PCA and is not damaged or loose. (Refer to paragraph 4-25.)

b. Hold the keyboard/topcase assembly upside down, then position the logic PCA over it such that the wires in the cable enter the holes in the connector on the keyboard PCA.

> **CAUTION**
> In the following step, be careful not to severely bend or otherwise damage the wires in the cable. To do so could impede proper operation of the calculator.

c. With your thumb, carefully press a few wires at a time firmly into their sockets. (See figure 3-4.) If necessary, push individual wires carefully with needle-nose pliers until each wire is secured in its socket.

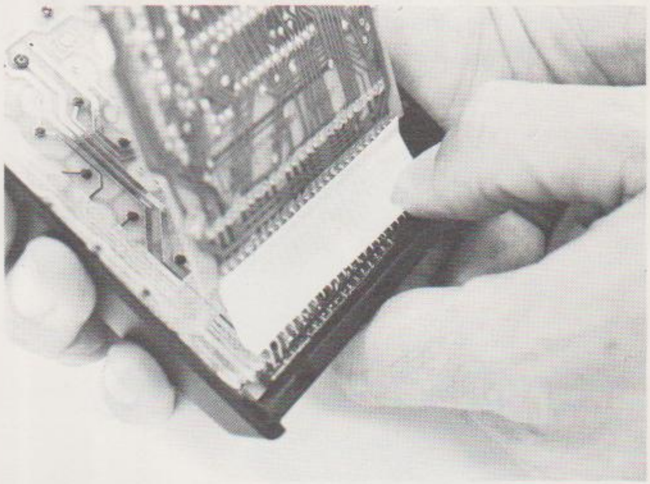


Figure 3-4. Securing Logic PCA to Keyboard PCA

3-37. Case Reattachment

3-38. Reattach the keyboard/topcase assembly to the bottom case as follows:

a. Ensure that the display window, slide latch, and top/bottom case connector are in place, as described in paragraphs 3-15, 3-16, and 3-17, respectively.

b. Hold the keyboard/topcase assembly, with the logic PCA hanging out from it, over the bottom case as shown in figure 3-5.

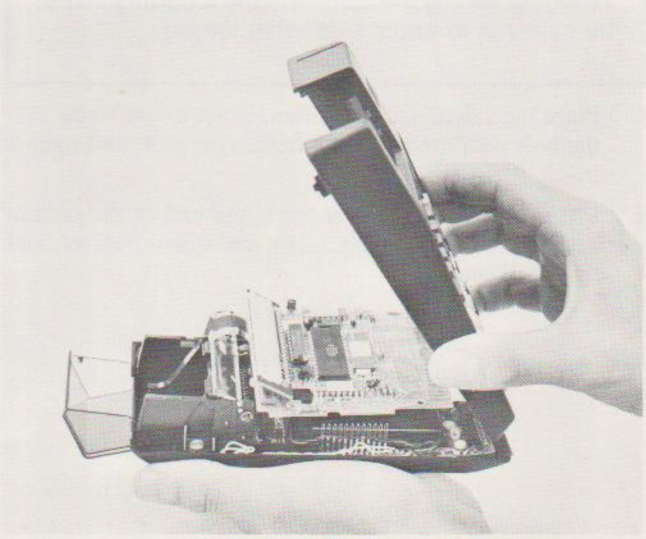


Figure 3-5. Positioning Keyboard/Topcase Assembly Over Bottom Case

c. Lower the keyboard/topcase assembly slowly until the tips of the 10- and 12-pin connectors from the printer PCA begin to protrude through their mating holes in the logic PCA.

d. Engage the lip on the inside-bottom of the topcase, in the catch on the inside-bottom of the bottom case. With your thumb, press down on the PIK until the connector pins are secured in their mating holes. (See figure 3-6.)

Note: These pins have stops designed to prevent over-insertion into the holes. Do not press so hard that the pins enter the holes further then their stops allow.

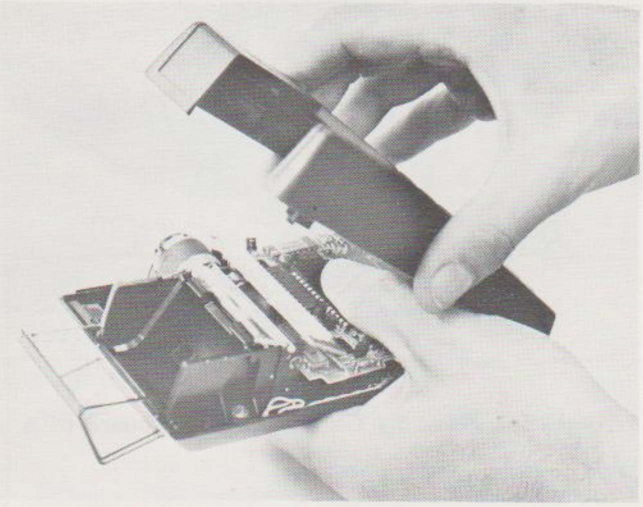


Figure 3-6. Securing Logic PCA to Printer PCA

e. Ensure that the right-side wall of the topcase is not caught on the printer motor. Check whether the top/bottom case connector is caught on the edge of the bottom case. If so, press the top case inward near the printer until the top case closes onto the bottom case.

CAUTION

When tightening the screws in the following steps, be sure not to apply excessive torque.

f. Place the calculator face down, insert a new screw into the hole near the ac adapter/recharger pins, and tighten it.

g. Lift up the rubber feet at the upper end of the bottom case (refer to paragraph 3-10), insert new screws, and tighten them.

h. Insert new screws into the two holes in the top of the battery well, and tighten them.

3-39. Battery Pack Replacement

3-40. Replace the battery pack and door as follows:

a. Place the calculator face down. Note that the battery pack can be inserted only if it is positioned as follows:
   (1) The springs contacting each of the four battery cells must be toward the printer end of the calculator.
   (2) The two center holes in the other end of the battery pack are slightly offset to one side, as are the tabs which are to go into them. The battery pack should be positioned such that both tabs and holes are offset to the same side.

b. With the battery pack positioned as described above, insert it into the battery well so that the four tabs from the printer PCA engage into the holes in the battery pack.

c. Press the spring end of the battery pack down into the battery well.

d. Place the battery door in place with the two tabs on its lower edge (adjacent to the finger recess) engaged in the slots in the bottom case (adjacent to the feet).

e. Press down on the top corners of the battery door until it snaps shut.

3-41. Paper Replacement

3-42. Insert a new rool of paper into the calculator as follows:

a. Using a straightedge, tear off and discard the first 2/3 turn of the roll to ensure that no glue, tape, or other foreign matter is on the paper. The leading edge of the paper should be torn straight across so that it is not crooked or jagged. Do not fold the paper; if this is done, the double thickness of the paper edge may impede the paper advance.

b. Place the paper roll in the paper cover so that it unrolls into the printer from below.

c. With the eraser end of a pencil, push the leading edge of the paper beneath the two guides at the bottom rear of the printer. Continue to push the paper until it stops.

d. Switch the calculator ON, then press g SPC and hold until the paper passes above the tear bar.

e. Tear off the excess paper, then switch the calculator OFF and close the paper cover.

Component-Level Service

4-1. INTRODUCTION

4-2. This section presents information to assist in troubleshooting and repairing the HP-19C to the component level. Included are the following:

a. Power supply troubleshooting: paragraph 4-6.
b. System timing troubleshooting: paragraph 4-8.
c. Component failure symptoms for the logic PCA: paragraph 4-14 and table 4-3.
d. Troubleshooting hints for the logic PCA: paragraph 4-16.
e. Display troubleshooting: paragraph 4-18.
f. Printer problems and solutions: table 4-6.
g. Replaceable parts lists for the:
   (1) Printer PCA: table 4-2.
   (2) Logic PCA: table 4-5.
h. Component location diagrams for the:
   (1) Printer PCA: figure 4-5.
   (2) Logic PCA: figure 4-10.
i. Schematic diagrams for the:
   (1) Printer PCA: figure 4-6.
   (2) Logic PCA: figure 4-11.
   (3) Keyboard PCA: figure 4-12.

4-3. Component-level service of the HP-19C should begin with checking the power supply voltages (refer to paragraph 4-6) and then the system timing waveforms (refer to paragraph 4-8). If the power supply is functioning properly and all system timing waveforms are present, refer to Printer Assembly Troubleshooting (paragraph 4-26) for printer problems or Component-Level Troubleshooting (paragraph 4-10) for all other problems.

4-4. After all repairs have been made to the calculator, 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.

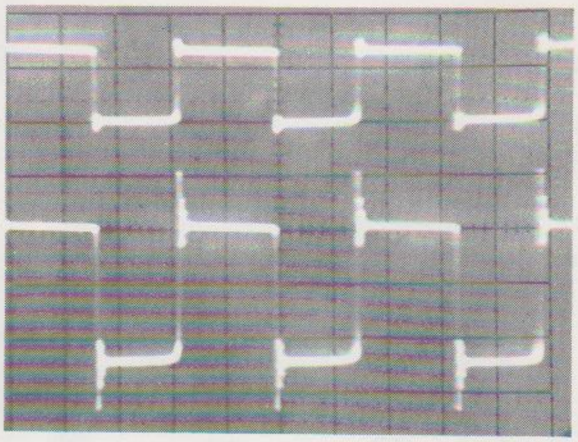
4-5. When the above tests show that all components on the logic PCA are functioning properly, ensure that the rubber shim and abrasion shield are properly located and secured on the logic PCA. (Refer to Logic PCA Mechanical Parts, paragraph 4-23.)

4-6. POWER SUPPLY TROUBLESHOOTING

4-7. Specifications for the various power supply voltages are given in table 4-1. If V_{SS} and V_{GG} are within specifications but V_S is not, the cause is probably failure of one of the following components (all located on the logic PCA): CR4, CR5, C5. If either V_{SS} or V_{GG} is not within specifications, the cause is probably failure of one or more of the components on the printer PCA. To isolate the faulty component(s), begin by checking the anodes of CR1 and CR3 to determine if the oscillator is working properly. (See figure 4-1.)

Table 4-1. Power Supply Troubleshooting

VOLTAGE	SPECIFICATIONS	
	VDC	RIPPLE (MV)
V_B	4.4 to 5.8	
V_{SS}	5.5 to 6.5	250 max
V_{GG}	−11.0 to −13.0	250 max
V_S	5.5 to 6.5	250 max



TEST POINTS: ANODES OF PCR1 AND PCR3
OSCILLOSCOPE TIME BASE: 2 μS/DIV
VERTICAL GAIN: 5 V/DIV

Figure 4-1. PCR1 and PCR3 Anode Waveforms

a. If the oscillator is working and:
   (1) V_{SS} is high, it is likely that either CR4 or Q2 is faulty. If Q2 is found to be faulty, this may be due to failure of CR4. Therefore, CR4 should be replaced whenever Q2 is replaced.

(2) V_{GG} is low, it is likely that either CR3, CR2, or C3 is faulty. If CR3 is found to be faulty, this may be due to failure of C4. Therefore, C4 should be replaced whenever CR3 is replaced.

b. If the oscillator is not working, measure the voltage at the base of Q1.

(1) If the voltage is approximately 0.275V, it is likely that either CR1, CR2, or R1 is faulty, and that Q1 is not faulty. If CR1 is found to be faulty, this may be due to failure of C2. Therefore, C2 should be replaced whenever CR1 is replaced. If replacing these components does not result in the oscillator working, a faulty IC could be causing excessive loading on the V_{SS} line, bringing V_{SS} low.

(2) If the voltage is not approximately 0.275V, it is likely that Q1 is faulty. If replacing Q1 does not solve the problem and the new transistor is destroyed when power is applied, it is likely that one of the following components is faulty: CR4, C1, C3, C5, R1, R2. Q1 should again be replaced in addition to whichever of these components is found to be faulty.

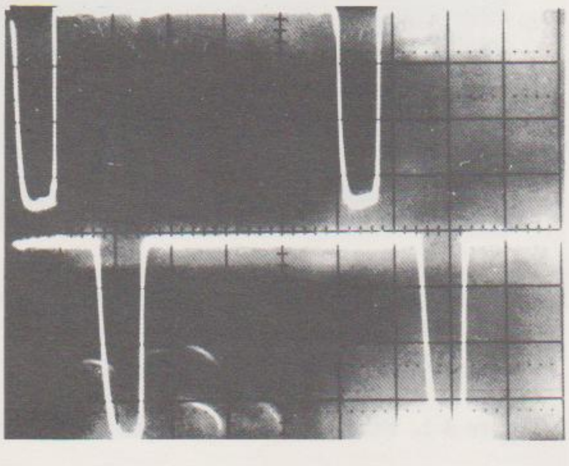
c. If the ripple on V_{SS} is too high, it is likely that either CR1 or C2 is faulty. Since failure of CR1 can be caused by failure of C2, C2 should be replaced whenever CR1 is replaced. If replacing these components does not reduce the ripple to an acceptable level, check for a short between V_{SS} and some other line.

d. If the ripple on V_{GG} is too high, it is likely that either CR2, CR3, C3, or C4 is faulty. Since failure of CR3 can be caused by failure of C4, C4 should be replaced whenever CR3 is replaced.

4-8. SYSTEM TIMING TROUBLESHOOTING

4-9. Figures 4-2 through 4-4 show the timing waveforms Φ1, Φ2, SYNC, RCD, and STR. If Φ1, Φ2, SYNC, or RCD is not present, check whether POR is held high. If so, replace successively (on the logic PCA) Q6, CR3, R11, and C4 until POR goes low. If POR does not go low after replacing these components, or if Φ1, Φ2, SYNC, and RCD are all not present, replace successively the ACT, L1, and C3 until all waveforms are present. If necessary, replace the remaining IC's until all waveforms are present. If only STR is not present, replace ROM 0.

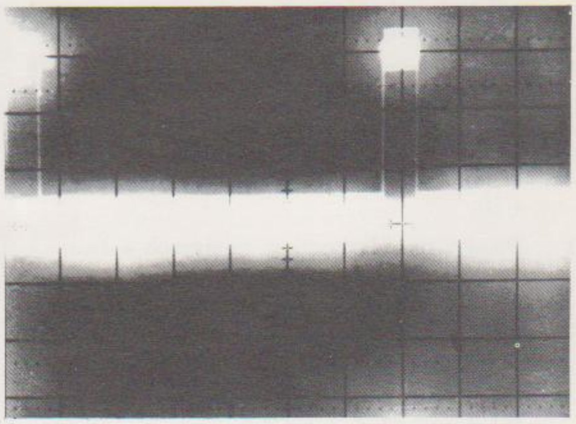
Φ1
0-
Φ2
0-



TEST POINTS: PINS 16 (Φ2) AND 17 (Φ1) OF ACT (LU4)
OSCILLOSCOPE TIME BASE: 1 μS/DIV
VERTICAL GAIN: 5 V/DIV

Figure 4-2. Φ1 and Φ2 Waveforms

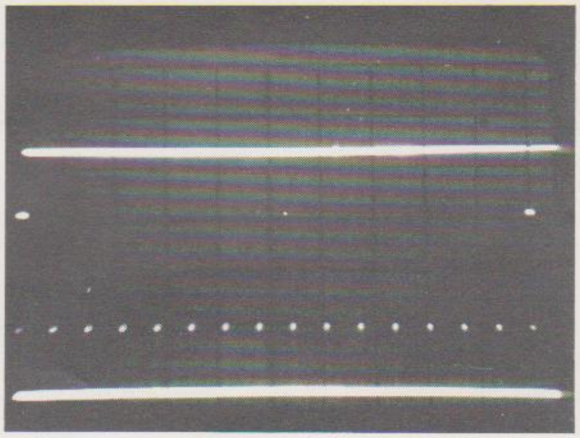
SYNC
0-



TEST POINT: PIN 20 OF ACT (LU4)
OSCILLOSCOPE TIME BASE: 0.1 MS/DIV
VERTICAL GAIN: 2 V/DIV

Figure 4-3. SYNC Waveform

RCD
0-
STR
0-

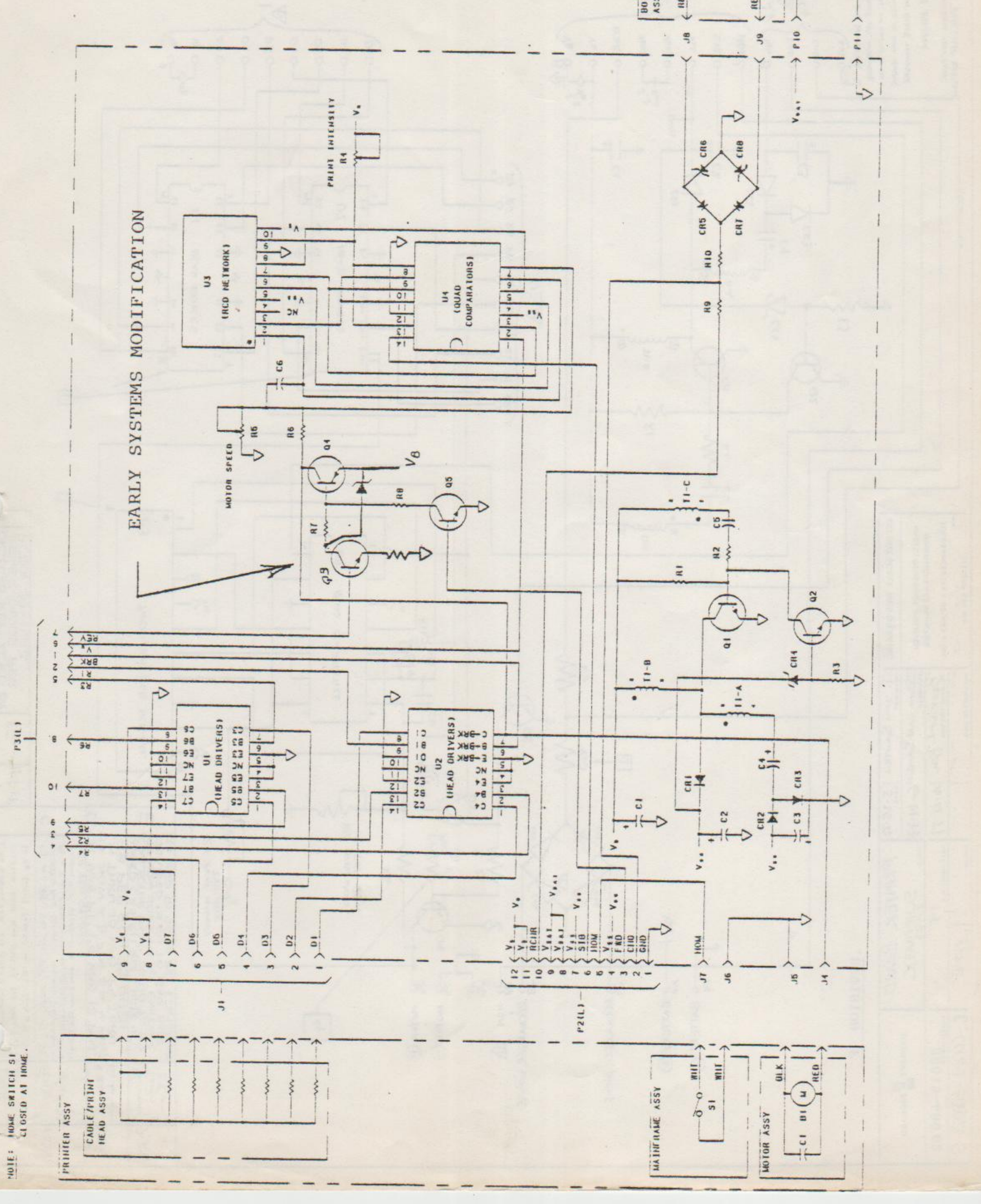


TEST POINTS: RCD: PIN 21 OF ACT (LU4)
STR: PIN 11 OF ROM 0 (LU1)
OSCILLOSCOPE TIME BASE: 5 MS/DIV
VERTICAL GAIN: 2 V/DIV

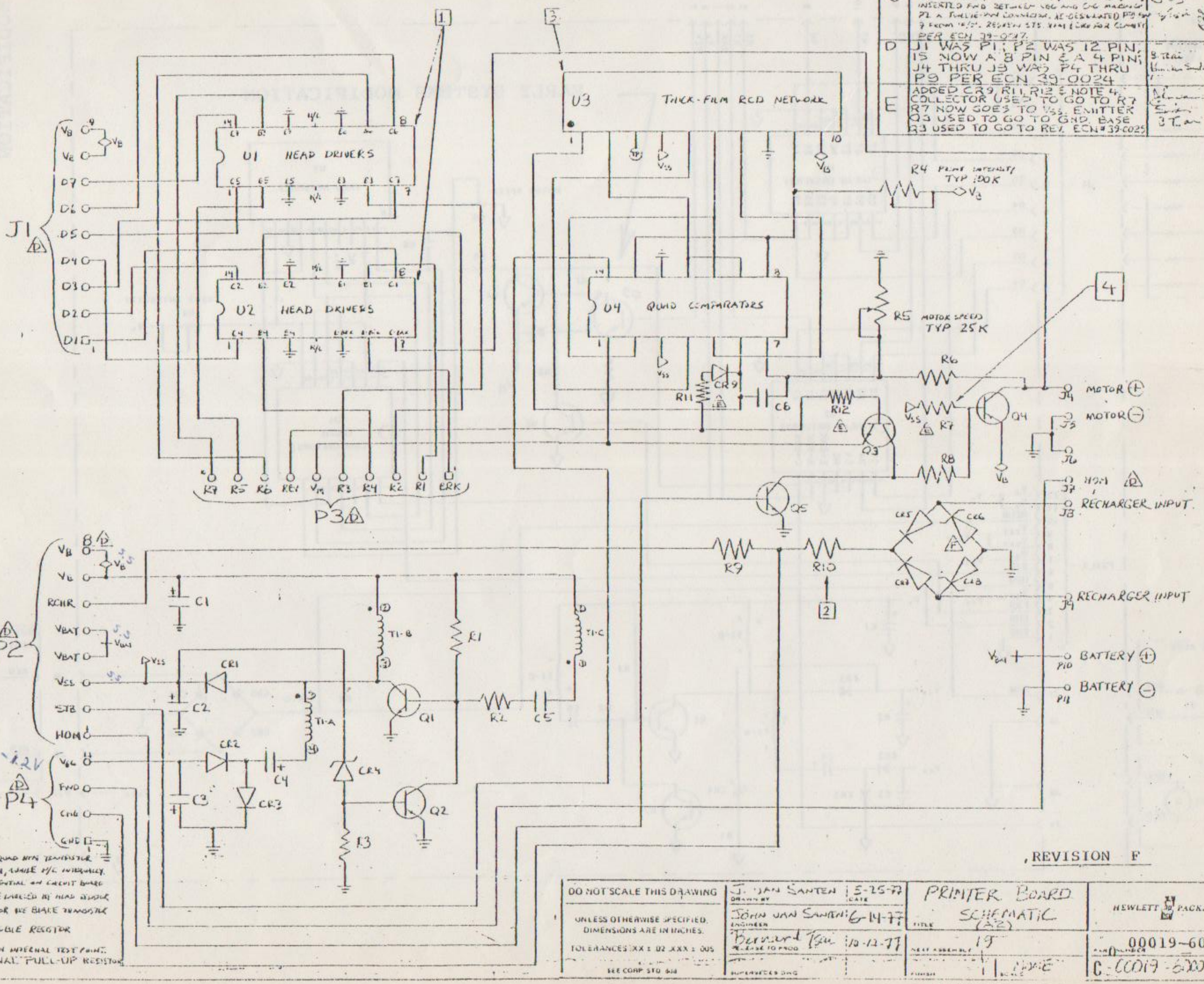
Figure 4-4. RCD and STR Waveforms

PRINTER SCHEMATIC 00019-60002

MODIFICATION



SYM	REVISIONS	APPROVED	DATE
A	AS ISSUED		5-14-77
B	P2 PIN 2 CHANGED FROM 'GND' TO ... CHG CONNECTED TO R8/R9 JUNCT. DELETED ... TO V_B SHUNT TRANSISTOR Q5 ECN 39-0014		7-6-77
C	R9 WAS 'R8', R10 WAS 'R9', ADDED R9 & Q5 INSERTED ... PER ECN 39-0017.	JVS	7-22-77
D	J1 WAS P1; P2 WAS 12 PIN, IS NOW A 8 PIN & A 4 PIN; J4 THRU J9 WAS P4 THRU P9 PER ECN 39-0024		9/9/77
E	ADDED CR9, R11, R12 & NOTE 4. COLLECTOR USED TO GO TO R7. R7 NOW GOES TO VSS. EMITTER Q3 USED TO GO TO GND. BASE R3 USED TO GO TO REV. ECN#39-0025		9-12-77
F	CR6 & CR8 REPLACED BY ZENER DIODE PER PCO # 39-1482		11-8-77



, REVISION F

NOTE: 1. U1 AND U2 ARE QUAD NPN TRANSISTOR PACKS. PINS 4 AND 11, WHICH ARE INTERNALLY ARE AT GROUND POTENTIAL ON CIRCUIT BOARD. THE TRANSISTORS ARE LABELED BY HEAD RESISTOR NUMBER, EXCEPT FOR THE BLADE THERMISTOR.

2. R10 IS A 2W FUSIBLE RESISTOR

3. PIN 3 OF U3 IS AN INTERNAL TEST POINT.

4. R7 IS OPTIONAL PULL-UP RESISTOR

DO NOT SCALE THIS DRAWING	J. VAN SANTEN (DRAWN BY)	5-25-77	PRINTER BOARD SCHEMATIC (A2)
UNLESS OTHERWISE SPECIFIED. DIMENSIONS ARE IN INCHES.	JOHN VAN SANTEN (ENGINEER)	6-14-77	HEWLETT PACKARD
TOLERANCES .XX ± .02 .XXX ± .005	Bernard Tsai (RELEASE TO PROD)	10-12-77	NEXT ASSEMBLY 19
SEE CORP STD 610	SUPERSEDES DWG		00019-60002
			C-00019-60002-S

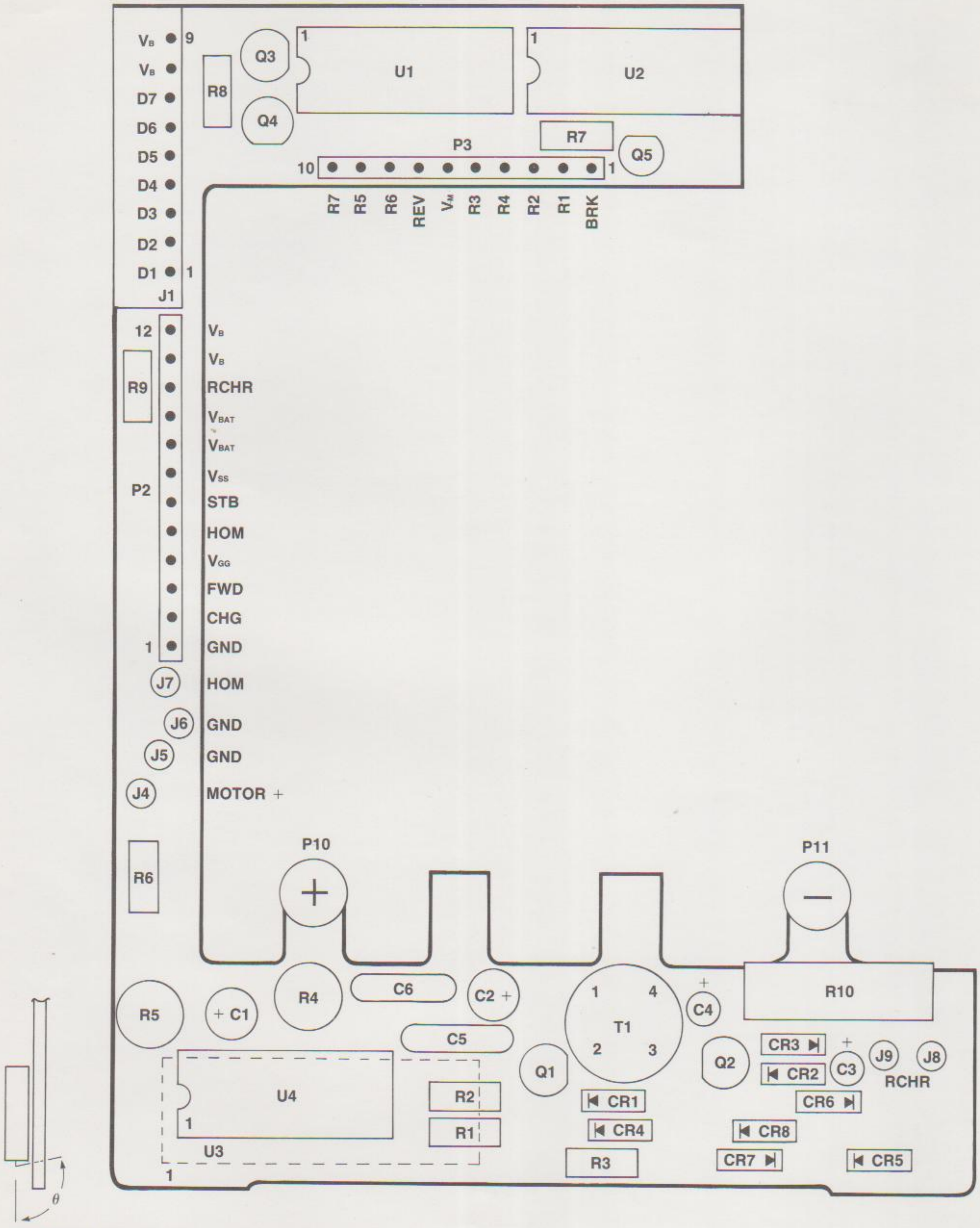
Table 4-2. Printer PCA (P) Replaceable Parts

REFERENCE DESIGNATION	HP PART NUMBER	DESCRIPTION
C1	0180-2616	CAPACITOR, 60 μF, 20%, 6V
C2	0180-2615	CAPACITOR, 22 μF, 20%, 10V
C3, 4	0180-2664	CAPACITOR, 3.3 μF, 20%, 15V
C5*	0160-3995	CAPACITOR, 3900 pF, 10%, 250V
C6†	0160-3456	CAPACITOR, 1000 pF, 10%, 1 KV
CR1 thru CR3	1901-1098	DIODE, switching
CR4	1902-1314	DIODE, zener, 5.62V
CR5 thru CR8	1901-0704	DIODE, silicon rectifier
J1	1251-4143	CONNECTOR, cable, 9-contact
J4 thru J9	1251-0691	CONNECTOR, single socket
P2	1600-0580	CONNECTOR, 8-pin
P2	1600-0691	CONNECTOR, 4-pin
P3	1600-0583	CONNECTOR, 10-pin
Q1	1854-0668	TRANSISTOR, npn
Q2, 3, 5	1854-0071	TRANSISTOR, npn
Q4	1853-0393	TRANSISTOR, pnp
R1	0683-1525	RESISTOR, 1.5K, 5%, ¼W
R2	0683-1515	RESISTOR, 150Ω, 5%, ¼W
R3	0683-1025	RESISTOR, 1K, 5%, ¼W
R4	2100-3697	RESISTOR, trmr, 200K, 10%
R5	2100-3699	RESISTOR. trmr, 50K, 10%
R6	0698-3157	RESISTOR, 19.6K, 1%, ⅛W
R7‡	0698-0085	RESISTOR, 2.61K, 1%, ⅛W
R7‡	0757-0279	RESISTOR, 3.16K, 1%, ⅛W
R7‡	0698-3153	RESISTOR, 3.83K, 1%, ⅛W
R8	0683-2015	RESISTOR, 200Ω, 5%, ¼W
R9	0683-1005	RESISTOR, 10Ω, 5%, ¼W
R10	0811-3517	RESISTOR, fusible, 15Ω, 5%, 2W
T1	9100-3594	TRANSFORMER, toroidal
U1, 2	1858-0044	INTEGRATED CIRCUIT, quad transistor, npn
U3	1810-0236	NETWORK, passive
U4	1826-0287	INTEGRATED CIRCUIT, quad comparator

*If C5 is replaced, bend the new capacitor over R2 before soldering it in place.

†If C6 is replaced, bend the new capacitor over C5 before soldering it in place.

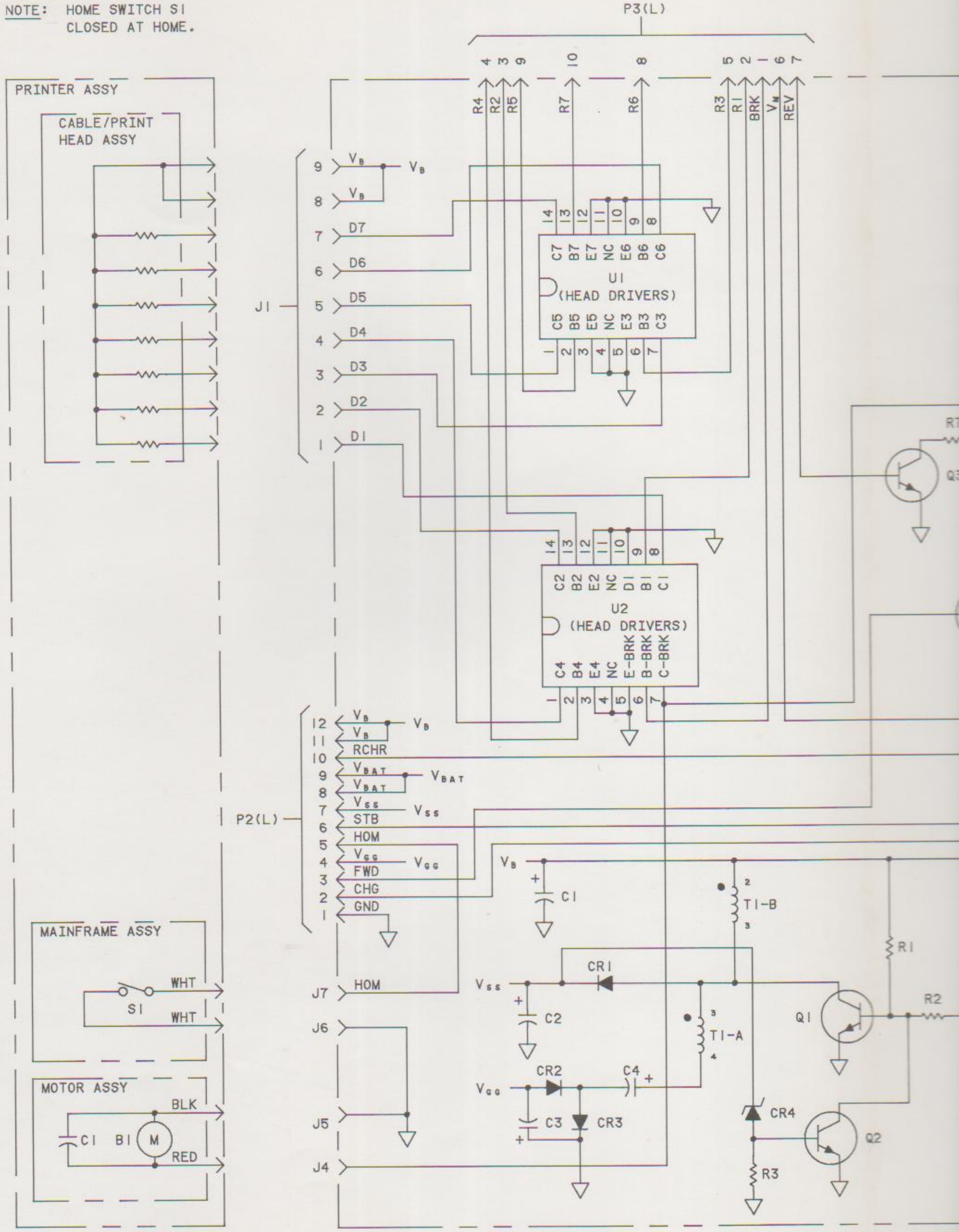
‡The value of R7 is selected to achieve the proper motor speed when the head carrier is moving in the reverse direction (left to right). The nominal value of R7 is 3.16K. If during service the travel of the head carrier in the reverse direction is found to be too slow (for example, slower than that in the forward direction), replace R7 with a 2.61K resistor. If the travel in the reverse direction is too fast, the head carrier may not stop in its home position but instead move continuously left and right. In this case, replace R7 with a 3.83K resistor. For more information on these abnormal conditions, refer to table 4-6.



NOTE: U3 IS BACKLOADED WITH LEADS BENT AS CLOSE AS POSSIBLE TO BODY AS SHOWN. ANGLE θ IS APPROXIMATELY 125°.

Figure 4-5. Printer PCA Component Location Diagram

NOTE: HOME SWITCH S1 CLOSED AT HOME.



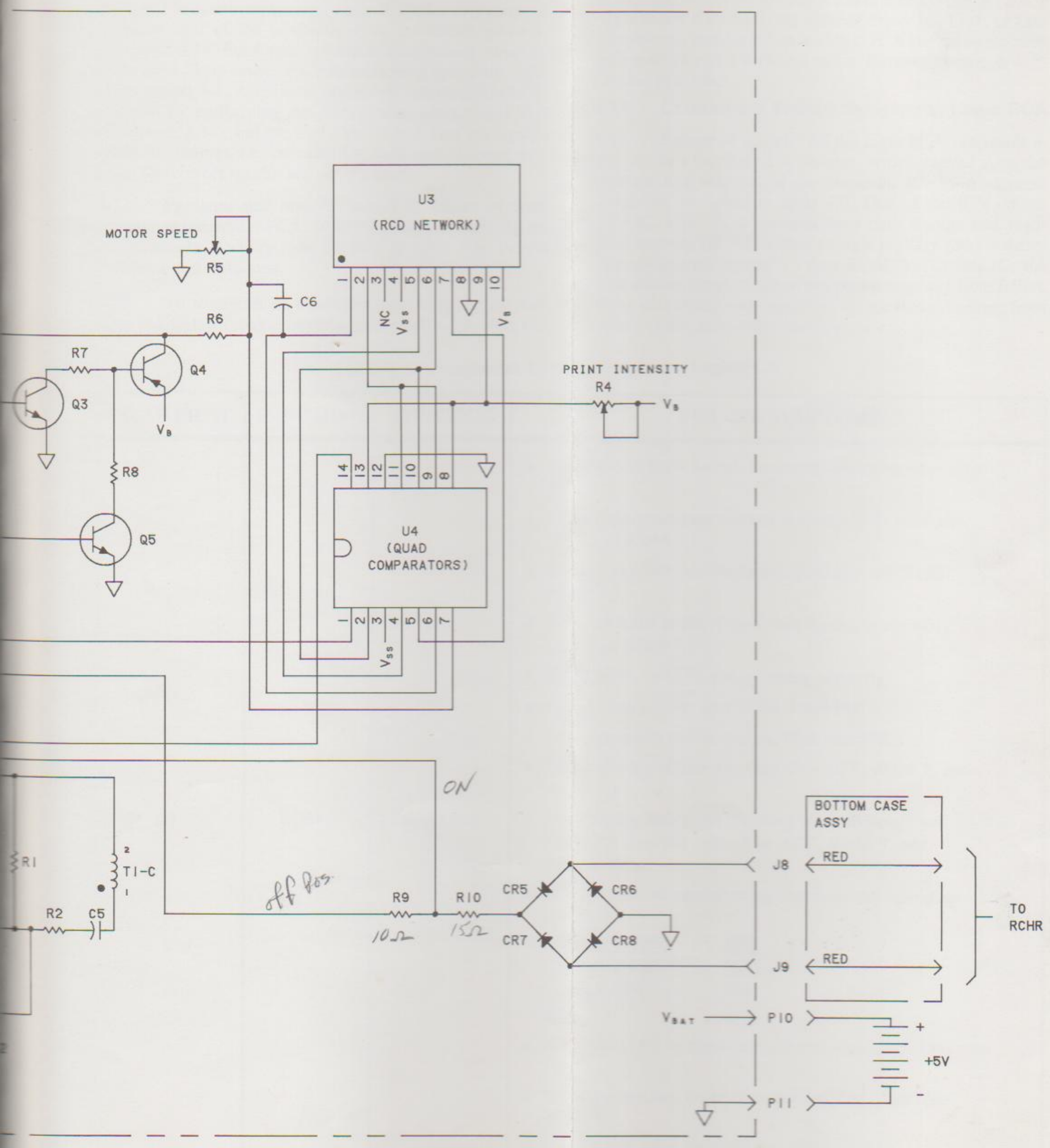


Figure 4-6. Printer PCA Schematic Diagram

4-10. COMPONENT-LEVEL TROUBLESHOOTING

4-11. To troubleshoot a problem that may be caused by failure of a component on the logic PCA, consider the contents and failure symptoms of each IC (refer to paragraph 4-14) in light of the troubleshooting guidelines given in paragraph 4-16. For further information regarding which IC is the most likely cause of 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.

4-12. Problems that may be caused by failure of components on the printer PCA, other than those comprising the power supply circuitry, are covered in table 4-6, Printer Problems and Solutions.

4-13. To troubleshoot a problem involving the display, refer to Display Troubleshooting, paragraph 4-18. Note that if it is necessary during the course of repair to replace the cathode driver IC, it might also be necessary to replace R1 on the logic PCA. Refer to paragraph 4-21 for this procedure. In addition, when the display is too dim or too bright (which might result if ROM 0, the cathode driver IC, LQ1, or LR2 is replaced), resistor R3 on the logic PCA should be replaced with a resistor of a different value. Refer to paragraph 4-22 for this procedure.

4-14. Component Failure Symptoms, Logic PCA

4-15. 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-19C 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, Logic PCA

COMPONENT	FUNCTION	CONTENTS	FAILURE SYMPTOMS
U1	ROM 0	Overhead	• OFF/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 DS 2 and ROM 7.) • Program trace in RUN mode not operating correctly. (See also ROM 7.) • SST, BST, or R/S not operating correctly. • No key entry. (See also ROM 3 and PIK.) • No response to function keys. (See also PIK.) • 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 cathode driver.) • One or more of the following functions not operating correctly: CLEAR PREFIX SST CLEAR PRGM BST CLEAR REG R/S PRX SPC • Asterisks (***) in printout incorrect or missing. (See also PIK.) • Executes function other than that selected. (See also ROM 3.) • No printout. (See also PIK and ROM 7.) • Prefix key(s) ignored. (See also ACT.)

Table 4-3. Component Failure Symptoms, Logic PCA (Continued)

COMPONENT	FUNCTION	CONTENTS	FAILURE SYMPTOMS
U1	Anode Drivers		• Missing digits, incorrect or missing segments in display. • Incorrect character(s) in display of ***Error***.
U8	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 ln − 10^x $\bar{x}$ × y^x s ÷ log Σ+ x^2 % Σ- $\sqrt{x}$ →H RCL Σ+ 1/x →H.MS DSZ GTO · nn Overflow not operating correctly. • Indirect label search skipping or not finding labels. (See also ROM 3.) • Correct program step number not displayed. (See also ACT and ROM 0.) Blank display at turn-on. (See also ACT, ROM 0, and ROM 3.) • Incorrect character(s) in display and printout of ***Error***. • Unable to switch from one print mode to another.
	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.
U7	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 delection 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, Logic PCA (Continued)

COMPONENT	FUNCTION	CONTENTS	FAILURE SYMPTOMS
U6	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. • Illegal number displayed. • 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 cathode driver.) • Digit or [.] entry, EEX, or CHS not operating correctly. • No key entry. (See also ROM 0 and PIK.) • 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.) CL X 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 • ***Error*** displayed when print operation attempted. • Printhead does not stop at home position; moves continuously left and right across paper. (See also PIK.)
U5	ROM 7	Printer Labels	• Incorrect or absent labels in printout. (See also PIK.) • Correct keycode not displayed. (See also ROM 0.) • Program trace in RUN mode not operating correctly. (See also ROM 0.)

Table 4-3. Component Failure Symptoms, Logic PCA (Continued)

COMPONENT	FUNCTION	CONTENTS	FAILURE SYMPTOMS
U3	PIK	Printer Interface Control & Keyboard Buffer	• Seven keystrokes not retained in key buffer. • No key entry. (See also ROM 0 and ROM 3.) • Incorrect printout. • Bright blue spot burned on paper. • Print head does not return to home position with motor on. (See also ROM 3.)
U4	ACT	Arithmetic, Control, and Timing	• Blank display at turn-on. (See also ROM 0, ROM 1, 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. • OFF/PRGM/RUN switch incorrectly decoded. (See also ROM 0.) • Unable to switch from one print mode to another. (See also ROM 1.) • Low battery indication (blinking decimal point) not operating correctly. (See also ROM 0, ROM 3, and cathode driver.) • Keys ignored. • Correct program step number not displayed. (See also ROM 0 and ROM 1.)
U10	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. • Statistics functions operate incorrectly. (See also ROM 3 and ROM 1.)
U9	DS 2	Program Storage Current X Status Registers (Display Format &Trigonometric Mode)	• Program steps 0 through 98 not recorded properly; display shows ***64*** or ***25 14 .5*** in blocks of seven; printout shows ***R/S*** or ***ΣXY*** 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 to FIX mode or 1 in SCI mode. • Unable to change from DEG or RAD trigonometric mode. • Incorrect formatting. (See also ROM 1.)
U2	Cathode Driver	Cathode Drivers	• Digit too bright or dim. • Digit has tendency to turn on another digit, causing ghost image to appear. • Single digit missing.
		Low Level Detection	• Low battery indication (blinking decimal point) not operating correctly. (See also ACT, ROM 0, and ROM 3.)

4-16. Troubleshooting Hints, Logic PCA

4-17. Given below are general guidelines, specific operating characteristics, and failure modes. Several of them are based on idealistic assumptions and educated guesses; nevertheless, they can greatly help in 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. This makes it difficult to be certain that an inoperative operation is due to failure of one particular ROM rather than some other ROM. Fortunately, however, when a failure occurs in read-only-memory, it generally affects the entire ROM portion of the IC, rather than affecting only one or a few bits, or one or a few 10-bit words. (Such a failure is frequently termed a "catastrophic failure.") 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 ***64*** (in display) and ***R/S*** (in printout) when the register is filled with 0's; it appears as ***25 14 .5*** (in display) and Σ***XY*** (in printout) 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 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. During turn-on of the calculator, the ACT calls instructions from ROM 0 and ROM 3, checks status information stored in DS 2, and clears the indirect storage registers in DS 1. Therefore, if the calculator appears to turn on improperly or not at all, the failure is probably in the IC containing one of the following, listed in decreasing order of probability: ACT, ROM 0, ROM 3, DS 1, DS 2.

f. When an operation is attempted that uses instructions contained in ROM 1, ROM 2, or ROM 7 (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.

g. ROM 0 and ROM 3 contain the instructions used for key entry. Therefore, a totally inoperative keyboard may be caused by failure of one of these ROM's. If the calculator turns on properly, however, the cause is more likely to be failure of the PIK.

h. All operations except stack manipulation, digit entry, printing, 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. All numbers displayed or printed 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 or printout could be caused by a failure either of ROM 1 or in DS 2.

j. If a program appears to be entered correctly in PRGM mode, but when executed results in a display of ***64*** 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.

k. 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.

l. If pressing [$\bar{x}$] or [s] results in a display of ***Error***, and there has been at least one ([$\bar{x}$]) or more than one ([s]) statistical entry, 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.

m. When a failure occurs in a particular section of micro-instructions, the section which would normally be executed following it will probably not be executed properly, if at all. Therefore, since printing of labels occurs before actual execution, failure to obtain the correct label with the print mode set to TRACE will probably result in an incorrect answer; however, obtaining the correct label does not guarantee a correct answer.

n. ROM 7 contains the instructions used for setting up the labels in the printout (except for the indicator ***, which is set up by instructions in ROM 0). Therefore, incorrect labels indicate failure of ROM 7. The actual printing is then initiated by instructions contained in ROM 0, and uses character codes contained in the PIK. Therefore, missing printouts indicate failure of ROM 7, ROM 0, or the PIK.

o. With the print mode set to TRACE, if no label is printed or if the printed label is absent for any operation, switch the print mode to MAN and test the operation again. If the answer displayed is incorrect, the keycode for a key other than that pressed has been used; therefore, the failure is probably in the PIK. If the answer displayed is correct, the failure is probably in the PIK, ROM 7, or—if no label at all is printed—ROM 0. To distinguish in such a case between a failure in the PIK and a failure in ROM 7, check whether the character(s) misprinted are so in other labels that normally contain the character(s). If the character(s) are misspelled or otherwise incorrect in more than one label, a failure in the PIK is probably responsible. On the other hand, if character(s) are misprinted in only one label, a failure in ROM 7 is probably responsible. For example, if the label for COS is printed as Σ***OS***, and the label for CHS is printed as Σ***HS***, it is likely that there is a failure in the PIK.

p. If ***Error*** is displayed as a result of a print operation, there is probably an electrical failure in the printer drive circuitry.

q. If an ***Error*** indication cannot be cleared by pressing a key, the cause may be failure of the ACT, or an open or grounded printed-circuit trace (such as the DATA line) between the ACT and any ROM.

4-18. Display Troubleshooting

4-19. To test the LED display module and display circuitry (see the displayed digit structure in figure 4-7):

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 4-8:

(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.

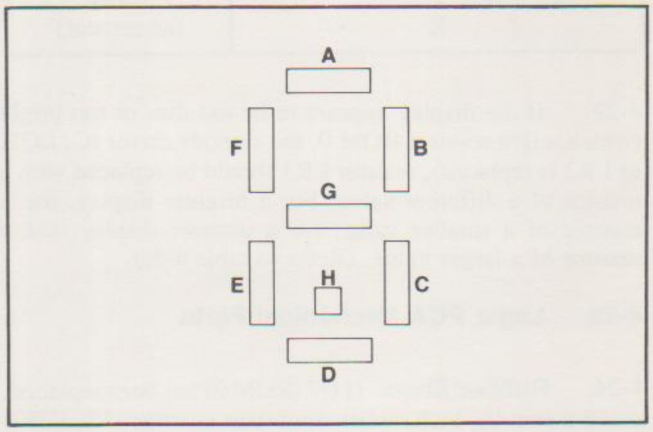


Figure 4-7. Displayed Digit Structure

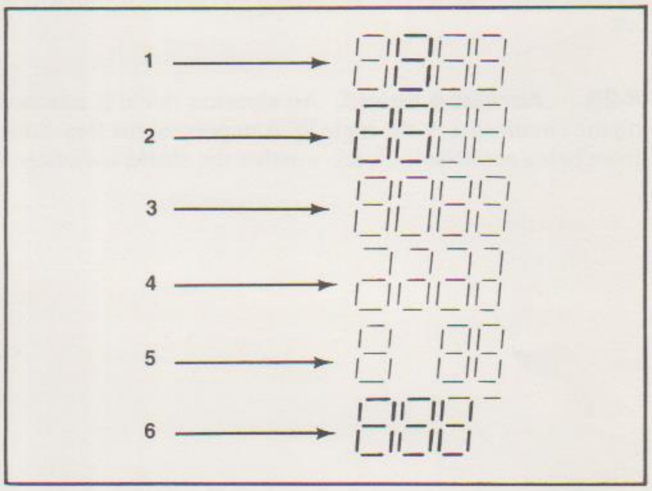


Figure 4-8. Display Problems

4-20. Probable causes for the problems listed above are:

Problem	Caused By
4, 6	ROM 0.
1, 2, 5	Cathode Driver. (Refer to paragraph 4-21.)
3, 4, 5	LED Module.
4, 5	Bad connection at connector P1.

4-21. The value of LR1 is selected to match the characteristics of the particular cathode driver IC (LU2) 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 LR1 with a resistor of the proper value.

Table 4-4. Resistor Selection for Cathode Driver

CATHODE DRIVER CATEGORY CODE	R1
I	200K
J	330K
K	(no resistor)

4-22. If the display appears to be too dim or too bright (which might result if ROM 0, the cathode driver IC, LQ1, or LR2 is replaced), resistor LR3 should be replaced with a resistor of a different value. For a brighter display, use a resistor of a smaller value; for a dimmer display, use a resistor of a larger value. (Refer to table 4-5.)

4-23. Logic PCA Mechanical Parts

4-24. Rubber Shim. If U7 (ROM 2) has been replaced, attach a new $^{3}/_{16}$-inch rubber shim (part number 4320-0297) to it, positioned against the 21-pin connector as shown. (See figure 4-9.) If U7 has not been replaced, check to ensure that the rubber shim on it is not loose; if it is, replace it with a new one.

4-25. Abrasion Shield. An abrasion shield is attached on the circuit side of the logic PCA to prevent the flex-cable from being scratched. Check whether the shield is damaged or loose; if it is, remove it and insert a new one. To do so, insert first the hook on the end of the shield, then the hook on the center, then press the catch on the other end until it locks into the hole in the logic PCA.

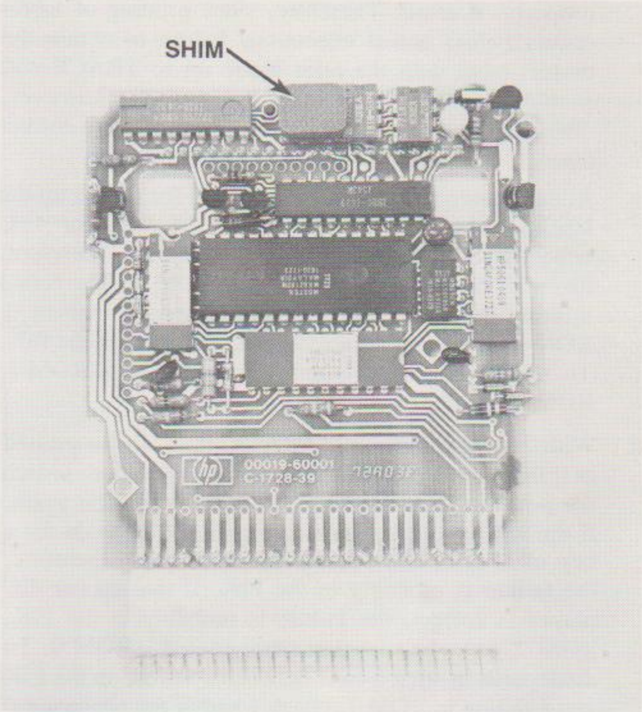


Figure 4-9. Rubber Shim Position

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

REFERENCE DESIGNATION	HP PART NUMBER	DESCRIPTION
C1, 4	0180-0575	CAPACITOR, 2.2 μF, 20%, 15V
C2	0180-2615	CAPACITOR, 22 μF, 20%, 10V
C3	0160-4292	CAPACITOR, 330 pF, 5%, 50V
C5	0180-2602	CAPACITOR, 47 μF, 20%, 8V
CR1, 2, 4, 5	1901-1098	DIODE, switching
CR3	1902-1324	DIODE, zener, 3V
L1	9100-3850	INDUCTOR, 140 μH
P1	1600-0581	CONNECTOR, 21-pin
Q1 thru Q3	1854-0071	TRANSISTOR, npn
Q4	1854-0757	TRANSISTOR, npn
Q5	1853-0058	TRANSISTOR, pnp
Q6	1853-0395	TRANSISTOR, pnp
R1*	0683-2045	RESISTOR, 200K, 5%, ¼W
R1*	0683-3345	RESISTOR, 330K, 5%, ¼W
R2, R3†	0683-6825	RESISTOR, 6.8K, 5%, ¼W
R3†	0683-3925	RESISTOR, 3.9K, 5%, ¼W
R3†	0683-5625	RESISTOR, 5.6K, 5%, ¼W
R4	0683-2725	RESISTOR, 2.7K, 5%, ¼W
R5	0683-1045	RESISTOR, 100K, 5%, ¼W
R6	0683-1035	RESISTOR, 10K, 5%, ¼W
R7	0683-1545	RESISTOR, 150K, 5%, ¼W
R8	0683-2025	RESISTOR, 2K, 5%, ¼W
R9	0683-4745	RESISTOR, 470K, 5%, ¼W
R10	0683-3035	RESISTOR, 30K, 5%, ¼W
R11	0683-1025	RESISTOR, 1K, 5%, ¼W
U1	1818-0432	INTEGRATED CIRCUIT, ROM 0
U2	1820-1629	INTEGRATED CIRCUIT, cathode driver
U3	1820-1952	INTEGRATED CIRCUIT, PIK
U4	1820-2028	INTEGRATED CIRCUIT, ACT
U5	1818-0387	INTEGRATED CIRCUIT, ROM 7
U6	1818-0376	INTEGRATED CIRCUIT, ROM 3
U7	1818-0377	INTEGRATED CIRCUIT, ROM 2
U8	1818-0379	INTEGRATED CIRCUIT, ROM 1 & DS 1
U9	5061-0469	INTEGRATED CIRCUIT, DS 2
U10	5061-0469	INTEGRATED CIRCUIT, DS 0
W3	8120-2571	CABLE, 25-lead
	5040-9744	SHIELD, abrasion
	4320-0297	SHIM, rubber, 3/16 inch

*The value of R1 is selected according to the display brightness category of the cathode driver IC. (Refer to paragraph 4-21.)

†The value of R3 is selected to achieve the desired display brightness. (Refer to paragraph 4-22.)

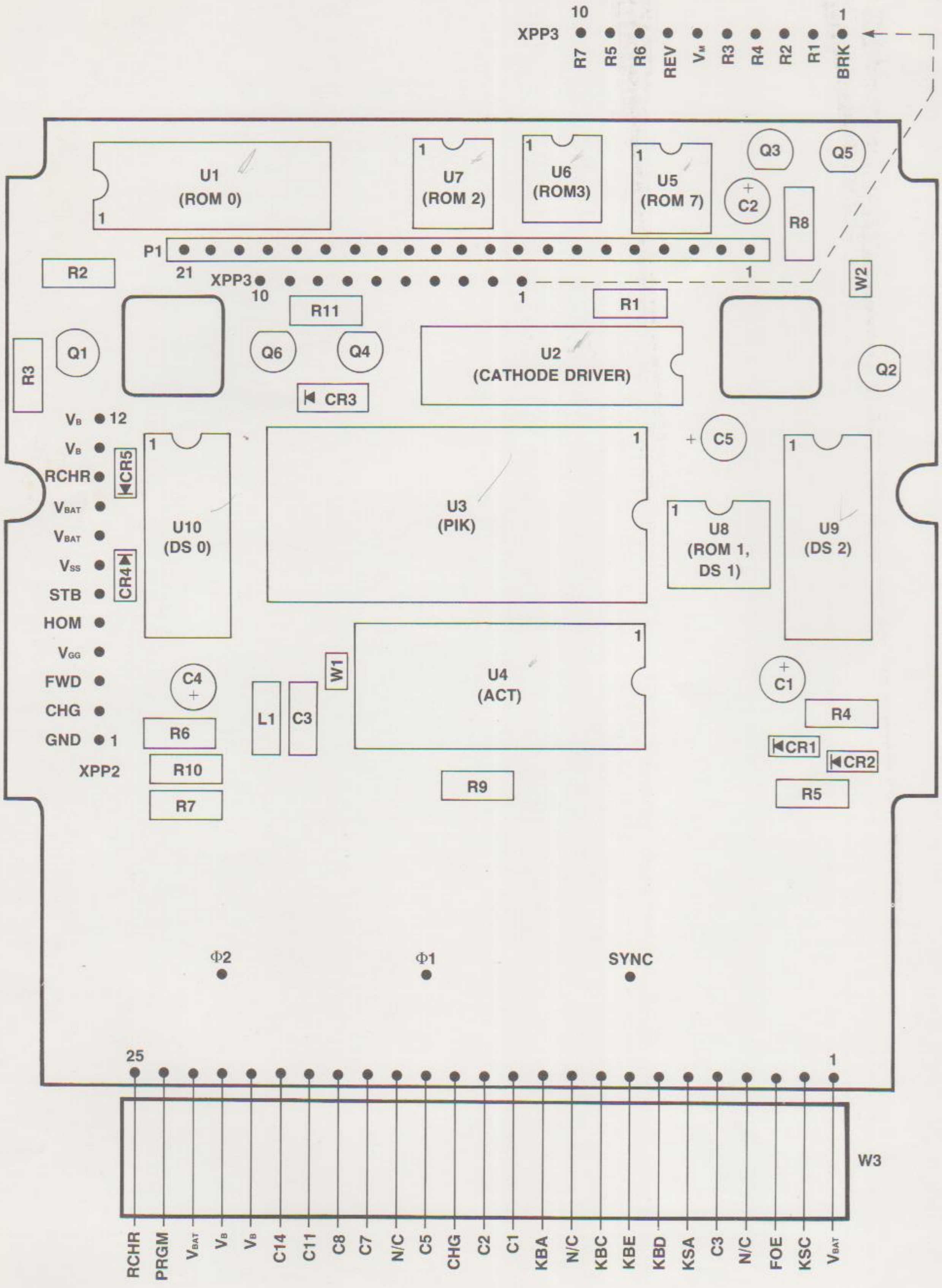
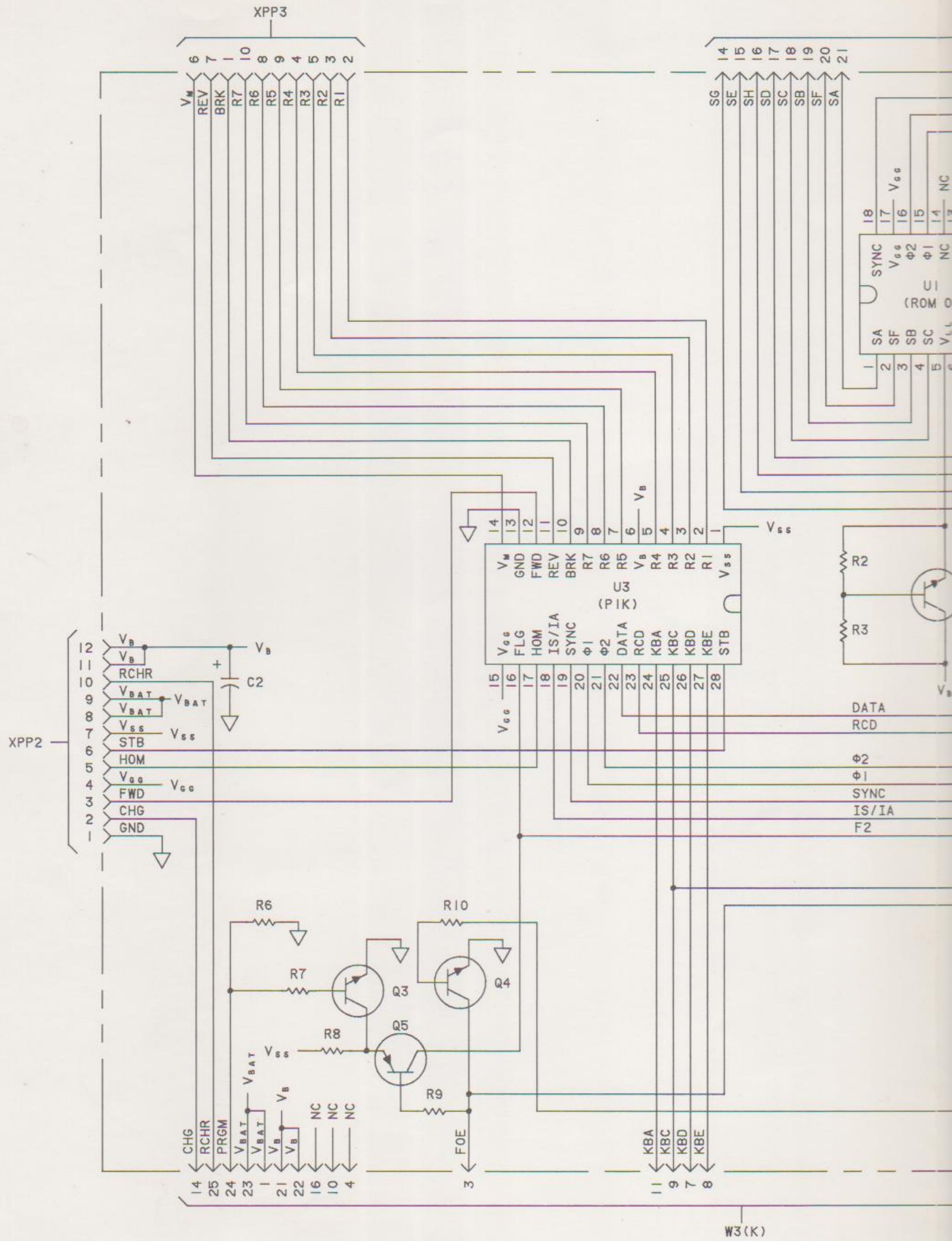


Figure 4-10. Logic PCA Component Location Diagram



XPP3
XPP2
W3(K)
U3
(PIK)
U1
(ROM O
R2
R3
C2
R6
R7
R8
R9
R10
Q3
Q4
Q5
DATA
RCD
Φ2
Φ1
SYNC
IS/IA
F2
FOE
CHG
RCHR
PRGM
KBA
KBC
KBD
KBE
NC
STB
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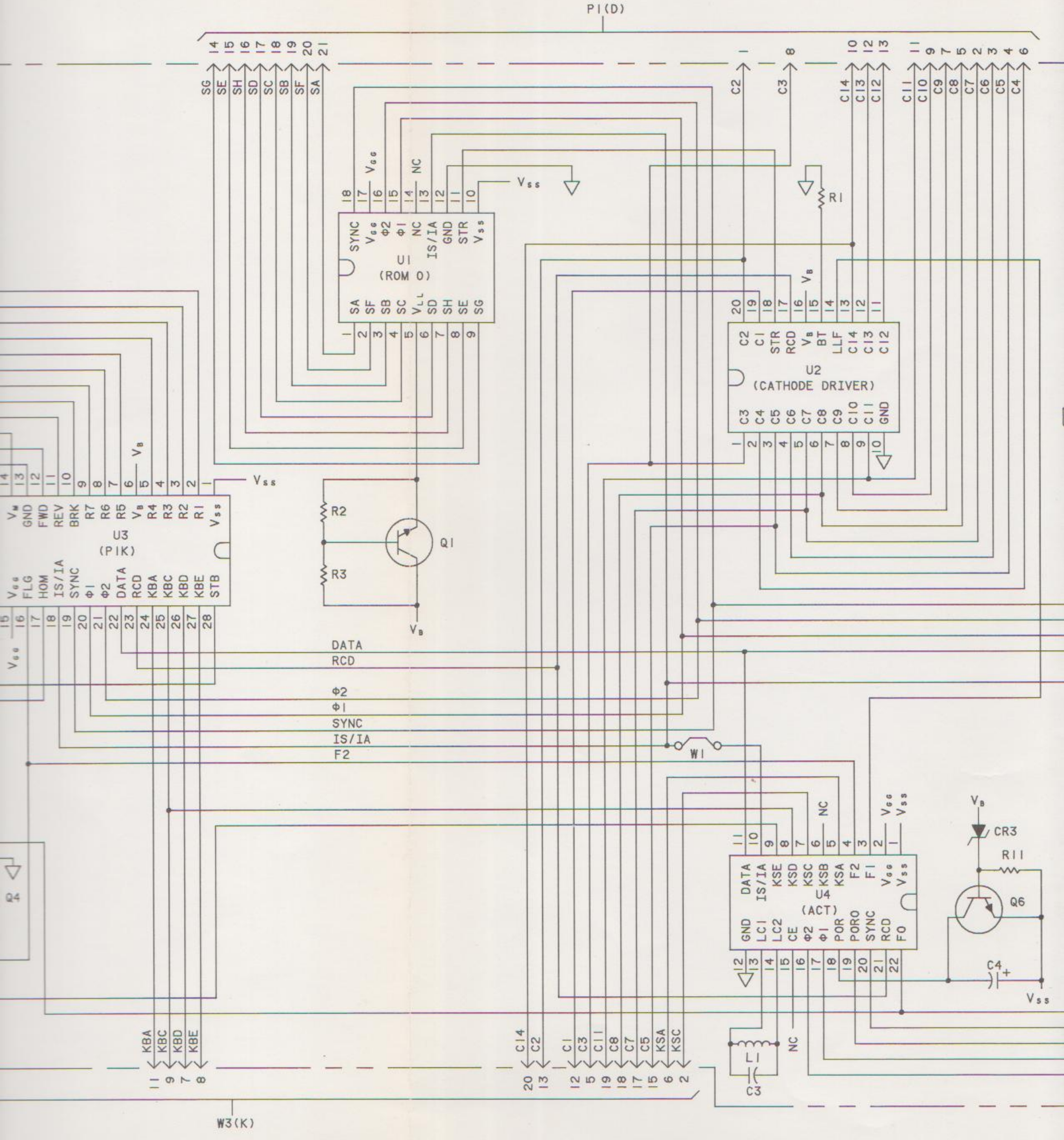
SD
SC
SB
SF
SA



P1(D)
U1
(ROM 0)
SYNC
VGG
Φ2
Φ1
NC
IS/IA
GND
STR
VSS
SA
SF
SB
SC
VLL
SD
SH
SE
SG
R1
R2
R3
Q1
VB
U2
(CATHODE DRIVER)
C2
C1
RCD
BT
LLF
C14
C13
C12
C3
C4
C5
C6
C7
C8
C9
C10
C11
U3
(PIK)
VM
FWD
REV
BRK
R7
R6
R5
R4
FLG
HOM
DATA
KBA
KBC
KBD
KBE
STB
F2
W1
U4
(ACT)
KSE
KSD
KSC
KSB
KSA
F1
LC1
LC2
CE
POR
PORO
FO
CR3
R11
Q6
C4
Q4
KSA
KSC
L1
C3
NC
W3(K)

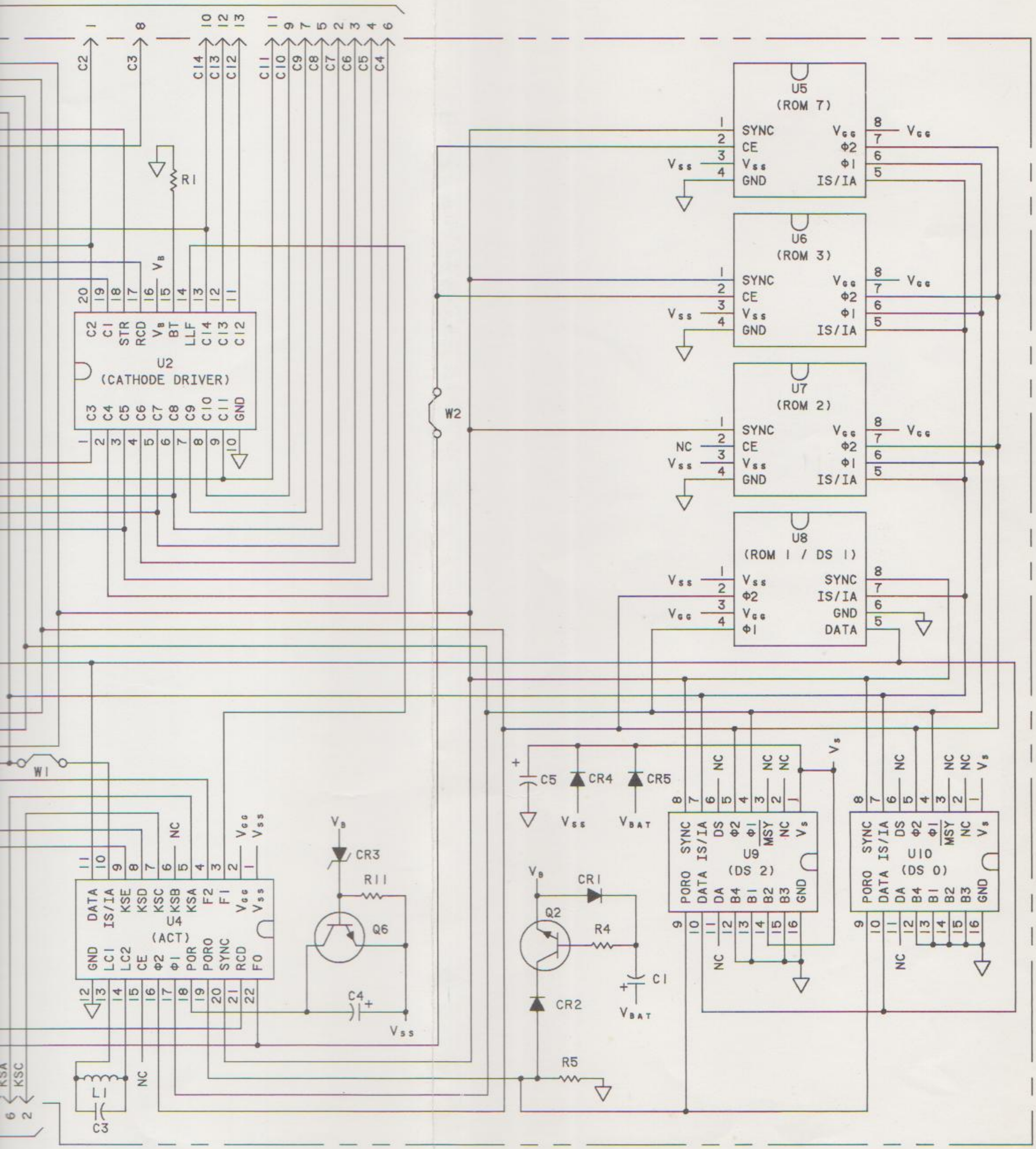


Figure 4-11. Logic PCA Schematic Diagram

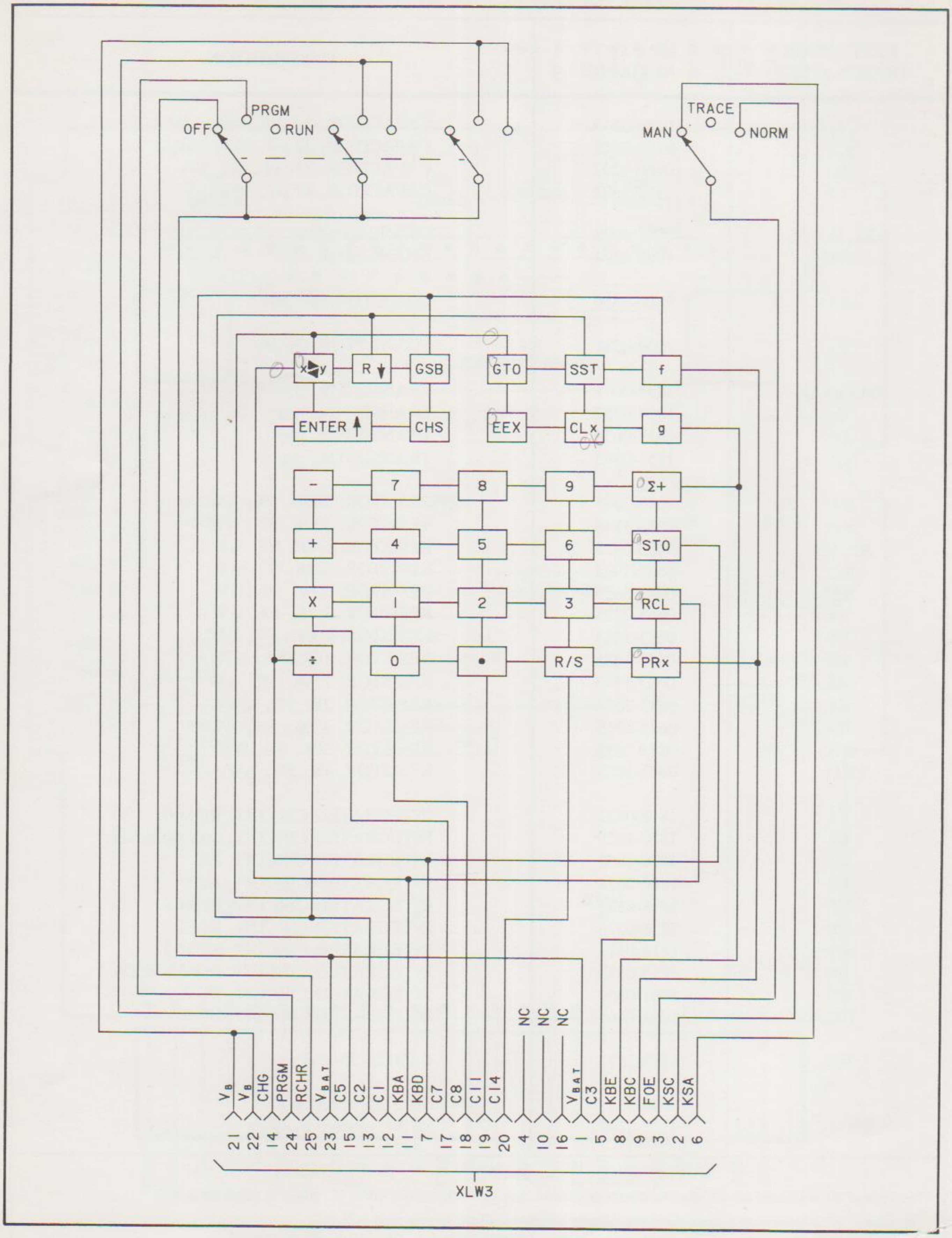


Figure 4-12. Keyboard PCA Schematic Diagram

4-26. PRINTER ASSEMBLY TROUBLESHOOTING

4-27. Table 4-6 lists problems that are sometimes encountered in the operation of the printer, together with possible solutions for each of the problems. Procedures for disassembly and reassembly of the printer are given in paragraph 4-29. See also the Printer Exploded View, figure 7-2.

4-28. If servicing the printer requires disassembly, note the following:

a. Whenever either the flex-cable/print-head assembly or the motor assembly is replaced with a new one, also replace the follower.

b. Whenever the follower is removed from the head carrier for any reason, it should be discarded and a new follower inserted in its place.

c. Whenever the follower is replaced with a new one, lubricate the drive screw with one or two drops of lubricant (part number 6040-0329).

d. Whenever the motor assembly is replaced with a new one, ensure that the length of the printed line has not increased or decreased unacceptably. Refer to the procedures given in table 4-6, and use the line length adjustment tool (part number T-155526).

Table 4-6. Printer Problems and Solutions

PROBLEM	POSSIBLE SOLUTION
Head carrier does not move from home position.	Disconnect the motor wires from printer PCA and connect to a 3.3V dc supply. If the head carrier does not move, remove the motor assembly and manually turn the drive screw. 1. If the head carrier moves, check whether the motor runs when disengaged from the drive screw. a. If so, the shaft of the motor may be slipping in the end of the drive screw when it is engaged there. If this appears to be happening, tighten the screws securing the motor assembly to the printer mainframe; or reassemble the printer with a new drive screw (and follower) and/or motor assembly as necessary. b. If not, the motor assembly is probably faulty. 2. If the head carrier does not move, remove the follower and drive screw. a. If the head carrier moves easily along the guide rod, the cause of the problem is probably the follower and/or the drive screw. Replace the follower with a new one; then, if the problem persists, replace the drive screw also. b. If the head carrier still does not move along the guide rod, reassemble the printer with a new printer service assembly and a new follower.
Head carrier stuck away from home position.	If the calculator is turned off while the head carrier is moving and the resistance of R7 (on the printer PCA) is too large, the calculator will appear to be ''dead'' when turned on again. Therefore, when a calculator is received for repair because the head carrier is stuck away from its home position, replace R7 with a 2.61K resistor. (Refer to table 4-2.)

Table 4-6. Printer Problems and Solutions (Continued)

PROBLEM	POSSIBLE SOLUTION
Head carrier does not stop.	Temporarily replace the printer assembly with one known to be operating correctly, and check whether the head carrier stops at its home position (the right-hand wall of the printer). 1. If so, the cause of the problem is probably the home switch. Slide a head cleaning card from the HP-67/97 Standard Pac or the HP-65 Standard Pac back and forth several times between the home switch contacts, with the red face of the card toward the printer mainframe. Next, clean the contacts with a cotton swab dipped in alcohol. Check the continuity between the swtich leads; the switch should be closed when the head carrier is in its home position. If the head switch is faulty, reassemble the printer with a new printer service assembly, then return the assembled printer into the calculator. 2. If not, the cause of the problem is probably one of the following: a. The resistance of R7 (on the printer PCA) is too small. This resistance determines the voltage across the motor. If the resistance is too small, the voltage will be too high, causing the motor to revolve too quickly for the BRK signal to stop the motor. Therefore, replacing R7 with a 3.83K resistor may decrease the voltage to an adequate level. Unless the problem is caused by one of the components listed below, this reduction in voltage should allow the BRK signal to stop the motor with the head carrier in its home position. b. Failure of U2 on the printer PCA. c. Failure of U3 (PIK) on the logic PCA. d. Failure of U6 (ROM 3) on the logic PCA.
Head carrier moves but head does not print.	1. Push on the platen and ensure that the spring behind the keeper is pushing the platen against the print head. 2. Measure the resistance of each head resistor (pins 8/9 to pins 1 through 7 of PJ1). If the resistance of each head resistor is not between 9.0 and 12.5 ohms, remove the flex-cable/print-head assembly and reassemble the printer with a new one. 3. If the cause of the problem is not found as above, it is probably failure of one of the following components, listed below in order of decreasing probability: a. U3 (PIK) on the logic PCA. b. U1 or U2 on the printer PCA. c. U1 (ROM 0) on the logic PCA. d. U5 (ROM 7) on the logic PCA.

Table 4-6. Printer Problems and Solutions (Continued)

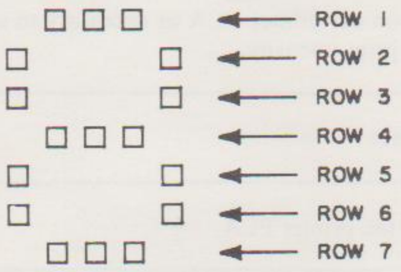
PROBLEM	POSSIBLE SOLUTION
Head prints, but dot row missing. 	1. Measure the resistance of the head resistor corresponding to the missing dot row. (Pin 1 of PJ1 corresponds to the top row of dots; pin 7 corresponds to the bottom row.) If the resistance is not between 9.0 and 12.5 ohms, remove the flex-cable/print-head assembly and reassemble the printer with a new one. 2. If the cause of the missing dot row is not a faulty print head resistor: a. Replace U1 on the printer PCA if dot row 3, 5, 6, or 7 is missing. b. Replace U2 on the printer PCA if dot row 1, 2, or 4 is missing.
Length of printed line too short or too long. 	1. Remove the window from the printer and insert the line length adjustment tool (part number T-155526) in its place. 2. Set switches: RUN MAN 3. Press: f SCI 7. 4. Enter: ***-8.8888888 00***. 5. Press: PRx. 6. Check whether the left half of the minus sign falls under the line scribed on the tool. (See the illustration to the left.) If not, adjust R5 on the printer PCA. 7. Connect a current meter between one of the motor leads and its socket on the printer PCA. 8. Monitoring the current through the motor leads as the head carrier moves from right to left, press PRx. The meter indication should average less than 130 mA. a. If so, proceed to step 9. b. If not, temporarily replace the motor assembly with a new one, then perform step 8 again. (1) If the meter indication now averages less than 130 mA, the old motor assembly was faulty and the new one should be left on the printer assembly. Since the length of the printed line depends in part upon the characteristics of the particular motor, return to step 4. (2) If the meter still indicates more than 130 mA, the problem is not in the motor assembly, so remove the new one and reattach the old one to the printer. Inspect the drive mechanism for drag and repair as necessary, then return to step 4. 9. Remove the line length adjustment tool and return the window into the printer.

Table 4-6. Printer Problems and Solutions (Continued)

PROBLEM	POSSIBLE SOLUTION
Print intensity too light or too dark.	1. Set switches: RUN MAN 2. Press: f SCI 7. 3. Enter: ***-8.8888888-88***. 4. Adjust R4 on the printer PCA as necessary to achieve acceptable print intensity.
Print intensity varies across line but not line to line.	Replace the platen.
Print intensity varies line to line or randomly.	Replace U3 on the printer PCA.
Paper does not advance.	1. Remove paper from printer. (Refer to paragraph 3-6.) Reinsert the paper (refer to paragraph 3-43) and feed by hand until the edge of the paper passes above the window. 2. If no obstruction is found in the step above, disassemble the printer and reassemble with a new printer service assembly.
Motor is noisy. **Note:** The noise characteristics of the motor when used in the HP-19C differ from those when used in the HP-10. Since the head carrier is driven left-to-right on the HP-19C faster than on the HP-10, the motor noise has a higher pitch.	1. Lubricate the drive screw with one or two drops of lubricant (part number 6040-0329). 2. Motor noise *might* be further reduced by replacing the drive screw and follower, or the motor.

4-29. PRINTER DISASSEMBLY AND REASSEMBLY

4-30. The following procedures describe how to disassemble the HP-19C printer so that subassemblies and/or parts can be replaced when necessary, and how to reassemble the printer when the needed replacements have been made. The procedures are given in the following order:

a. Paper Cover Removal and Replacement: paragraph 4-32.

b. Motor Assembly Removal and Replacement: paragraph 4-38.

c. Window Removal and Replacement: paragraph 4-41.

d. Platen Removal and Replacement: paragraph 4-44.

e. Flex-Cable/Print-Head Assembly Removal: paragraph 4-47.

f. Drive Mechanism (head carrier, guide rod, drive screw, follower, follower spring, and head clip) Disassembly: paragraph 4-49.

g. Drive Mechanism Reassembly: paragraph 4-51.

h. Flex-Cable/Print-Head Assembly Replacement: paragraph 4-53.

4-31. For additional aid in disassembly and reassembly, see the Printer Exploded View, figure 7-2.

4-32. Paper Cover Removal and Replacement

4-33. If a roll of paper is still in the printer assembly, remove it using the procedures of paragraph 3-6.

4-34. To remove the paper cover (11, figure 7-2) from the printer assembly, carefully snap the pins on the paper cover, one at a time, out of their sockets in the printer mainframe.

4-35. To attach a new torsion spring (12, figure 7-2) to a new paper cover:

a. Place the spring over the pin with the half-round end, with the long arm of the spring nearest the paper cover.

b. Press the spring down against the half-round shoulder of the pin.

c. Heat-stake the end of the pin until it flattens out, securing the spring on the pin.

4-36. To attach the paper cover with spring to an **old** printer mainframe:

a. Slide the arm of the spring through the hole in the tab on the printer mainframe.

b. Press the pin with the spring into its socket until it snaps in.

c. Press the other pin into its socket until it snaps in.

4-37. To attach the paper cover with spring to a **new** printer mainframe:

a. Press the pins on the paper cover, one at a time, until they snap into their sockets in the printer mainframe.

b. Place the arm of the spring into the groove in the tab on the printer mainframe.

c. Heat-stake the groove closed.

4-38. Motor Assembly Removal and Replacement

4-39. To remove the motor assembly (1, figure 7-2) from the printer assembly, loosen and remove the two screws (22, figure 7-2) holding them together.

4-40. To replace the motor assembly onto the printer assembly:

a. Ensure that a grommet (23, figure 7-2) is located in each of the two holes in the motor adapter plate, and that the grommet flanges are not rolled under.

b. Place the motor assembly in position with the shaft of the motor engaged in the end of the drive screw.

c. Insert shoulder screws through the grommets in the motor adapter plate, then tighten the screws.

d. Ensure that the capacitor on the motor assembly is positioned beneath the motor.

4-41. Window Removal and Replacement

4-42. To remove the window (21, figure 7-2) from the printer assembly, grasp it and pull upward until it snaps free.

4-43. To replace the window onto the printer assembly:

a. Place the pins at the ends of the window into the slots in the top of the printer mainframe.

b Press the top ends of the window down until the ribs snap into the recesses below.

4-44. Platen Removal and Replacement

4-45. To remove the platen (17, figure 7-2) from the printer assembly:

a. Ensure that the window has been removed from the printer assembly. (Refer to paragraph 4-41.)

b. Rotate the drive screw (14, figure 7-2) manually until the head carrier is positioned against the left side of the printer mainframe (5, figure 7-2).

c. Carefully grasp the platen, slide it to the right from behind the print head, and pull it out of the printer assembly.

4-46. To replace the platen into the printer assembly:

a. Rotate the drive screw manually until the head carrier is positioned against the left side of the printer mainframe.

b. Position the platen with its pointed edge down and its slot facing the printer.

c. Press the keeper (7, figure 7-2; the spring-supported subassembly in the upper front of the printer assembly) back against its spring action, and engage the rib on the top of the keeper into the groove in the back of the platen.

4-47. Flex-Cable/Print-Head Assembly Removal

4-48. To remove the flex-cable/print-head assembly (4, figure 7-2) from the head carrier:

a. Ensure that the window has been removed from the printer assembly. (Refer to paragraph 4-41.)

> **CAUTION**
>
> When handling the head clip on the head carrier assembly, take care not to bend it. To do so could impede proper printer operation.

b. Remove the flex-cable clip (20, figure 7-2) from the head clip (19, figure 7-2) as follows:

(1) Lift the center tab of the flex-cable clip out of the hole in the head clip.

(2) Slide the flex-cable clip off of the head clip.

c. Press down on the platen and carefully pull the flex-cable/print-head assembly out of the head carrier.

4-49. Drive Mechanism Disassembly

4-50. To disassemble the drive mechanism (head clip, follower spring, follower, drive screw, guide rod, and head carrier):

> **WARNING**
>
> In the following step, be careful not to allow the follower spring (18, figure 7-2), which is compressed under the head clip, to fly out; if it does, it could injure an eye.

a. Grasp the head clip firmly and carefully rock it upward so that it comes free of the head carrier while keeping the follower spring in the top of the head carrier.

b. Turn the printer assembly upside down and gently shake out the follower spring and follower (15, figure 7-2). Discard the follower.

Note: If the follower does not easily drop out of the head carrier, push it out with a pointed tool inserted between the follower and the groove in the drive screw.

c. Ensure that the motor assembly has been removed. (Refer to paragraph 4-38.)

d. With tweezers or a small, flat-blade screwdriver, pry the retaining ring (16, figure 7-2) located outside the left side of the printer mainframe off of the drive screw.

e. Slide the drive screw (14, figure 7-2) out through the hole in the right side of the printer mainframe.

f. Pry the retaining ring (10, figure 7-2) located inside the left side of the printer mainframe off of the guide rod.

g. Slide the guide rod (9, figure 7-2) out through the hole in the left side of the printer mainframe. The head carrier will slide off the right end of the guide rod.

4-51. Drive Mechanism Reassembly

4-52. To reassemble the printer drive mechanism (guide rod, head carrier, drive screw, follower, follower spring, and head clip):

a. If a new head carrier is to be used, insert the print head and a new head holder (3, figure 7-2) into a new head carriage (2, figure 7-2) as follows:

(1) Insert the print head into the head carriage and place the head holder on top of the two, with the flat face of the head holder up and one tab of the head holder engaged in the slot in the head carriage.

(2) Carefully press down on the head holder until it snaps into the head carriage.

(3) Remove the print head from the head carrier.

b. Slide the oscillator (6, figure 7-2; the moving part in the lower front of the printer assembly) up against the keeper (7, figure 7-2; the spring-supported subassembly in the upper front of the printer assembly).

c. Insert the head carrier behind the oscillator stabilizer (8, figure 7-2; the rod with the gears on its ends), engaging the lower groove in the tab of the head carrier over the horizontal lip on the oscillator.

d. Slide the head carrier and oscillator down, engaging the end of the tab of the head carrier in the channel along the bottom of the printer mainframe.

e. Position the guide rod with its shoulder toward the right, and slide it to the right through the smaller of the two holes in the left side of the mainframe.

f. Continue sliding the guide rod to the right through the smaller of the two holes in the head carrier and then into the hole in the right side of the mainframe.

g. Insert the $^1/_{16}$-inch retaining ring over the guide rod at the inside of the left side of the mainframe.

h. Position the drive screw with its shoulder toward the left, and slide it to the left through the hole in the right side of the mainframe.

i. Continue sliding the drive screw to the left through the hole in the head carrier and then into the hole in the left side of the mainframe.

j. Insert the $^3/_{32}$-inch retaining ring over the drive screw at the outside of the left side of the mainframe.

k. Rotate the drive screw manually until the portion of the helix groove closest to the left side of the printer is perpendicular to the drive screw shaft when viewed from above.

l. Being careful not to rotate the drive screw, slide the head carrier to the left side of the printer.

m. Position a new follower above the hole in the head carrier with its lip perpendicular to the drive screw shaft.

n. Carefully drop the follower into the head carrier so that the lip on the follower engages in the groove in the drive screw.

o. Place the follower spring into the head carrier above the follower.

p. Place the head clip over the head carrier by first compressing the follower spring with the top of the head clip, then pressing the hole in the front of the head clip over the pin on the front of the head carrier.

q. With a small, flat-blade screwdriver, press the head clip over the pin securely against the head carrier.

4-53. Flex-Cable/Print-Head Assembly Replacement

4-54. To replace the flex-cable/print-head assembly into the head carrier:

a. Ensure that the platen is in position. (Refer to paragraph 4-46.)

b. Insert the print head diagonally up into the head carrier beneath the head clip.

c. Press the platen down and continue sliding the print head up until its top edge is flush with the top edge of the platen. It may be necessary to push upward with the top of your thumb on the head clip so that the print head passes through the head carrier.

CAUTION

When handling the head clip in the following step, be careful not to bend it. To do so could impede proper operation of the printer.

d. Slide the cable clip over the head clip and flex-cable until the center finger of the cable clip snaps down into the hole in the head clip.

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 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-19C 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-19C 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: RUN TRACE

b. *Before each operation to be tested*, press: CLx f REG f FIX 2.

c. Press the keys indicated in table 5-1 for the operation of interest. The display and printout shown 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, the keys pressed are not being entered correctly. This indicates a failure of the PIK, ROM 0, or ROM 3 (in that order of failure probability). To further isolate the faulty component, check for other failure symptoms of these IC's. (Refer to table 4-3.) After replacing an IC, return to step *a*.

(2) If the correct keycode is obtained, replace the IC or, successively, the IC's indicated in the table. 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 the program step number in the display does not increment properly, it is likely that the ACT is faulty.

(2) If the keycode shown in the table is not obtained, the keys pressed are not being entered correctly. This indicates a failure of the PIK, ROM 0, or ROM 3 (in that order of probability). To further isolate the faulty component, check for other failure symptoms of these IC's. (Refer to table 4-3.)

(3) If the program control operations do not manipulate the program correctly, replace the IC indicated in the table for the faulty operation.

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	PRINTOUT	KEYCODE	IC FAILURE
Digit Entry	55	55.		05	DS 1; ROM 0; ROM 3
[•]	[•]	0.		63	ROM 0; ROM 3
[CHS]	5 [CHS]	-5.		22	ROM 3
[CL X]	5 [CL X]	0.00		24	ROM 3
[√x]	25 [f] [√x]	5.00	25.00 √X 5.00 ***	16 53	ROM 1
[x²]	5 [g] [x²]	25.00	5.00 X² 25.00 ***	25 53	ROM 1
[1/x]	5 [g] [1/x]	0.20	5.00 1/X 0.20 ***	25 64	ROM 1
[PAUSE]	[f] [PAUSE]	0.00*		16 64	ROM 1
[INT]	5.2 [f] [INT]	5.00	5.20 INT 5.00 ***	16 52	ROM 3
[FRAC]	5.2 [g] [FRAC]	0.20	5.20 FRC 0.20 ***	25 52	ROM 3
[LAST X]	5 [g] [1/x] [f] [LAST X]	5.00	5.00 1/X 0.20 *** LSTX 5.00 ***	16 63	DS 1; ROM 0; ROM 3
[π]	[g] [π]	3.14	Pi 3.14 ***	25 63	ROM 2; ROM 3
[R↓]	5 [R↓] [R↓] [R↓] [R↓]	5.00	5.00 R↓ 0.00 *** R↓ 0.00 *** R↓ 0.00 *** R↓ 5.00 ***	12	ROM 3; DS 2
[ENTER↑]	5 [ENTER↑] [CL X] [R↓]	5.00	5.00 ENT↑ CLX R↓ 5.00 ***	21	ROM 3
[x⇄y]	5 [ENTER↑] 2 [x⇄y]	5.00	5.00 ENT↑ 2.00 X⇄Y 5.00 ***	11	ROM 3
[−]	5 [ENTER↑] 2 [−]	3.00	5.00 ENT↑ 2.00 - 3.00 ***	31	ROM 1

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

OPERATION	KEYSTROKES	DISPLAY	PRINTOUT	KEYCODE	IC FAILURE
+	5 ENTER↑ 2 +	7.00	5.00 ENT↑ 2.00 + 7.00 ***	41	ROM 1
×	5 ENTER↑ 2 ×	10.00	5.00 ENT↑ 2.00 × 10.00 ***	51	ROM 1
÷	5 ENTER↑ 2 ÷	2.50	5.00 ENT↑ 2.00 ÷ 2.50 ***	61	ROM 1
EEX	EEX 9	1. 09		23	ROM 3
ABS	5 CHS g ABS	5.00	-5.00 ABS 5.00 ***	25 54	ROM 3
y^x	2 ENTER↑ 3 f y^x	8.00	2.00 ENT↑ 3.00 y^x 8.00 ***	16 54	ROM 1
%	150 ENTER↑ 6 g %	9.00	150.00 ENT↑ 6.00 % 9.00 ***	25 11	ROM 1
ENG	123 f ENG 3	123.0 00	123.00 ENG3 123.0+00 ***	16 15 03	ROM 1; DS 2
SCI	123 f SCI 4	1.2300 02	123.000 SCI4 1.2300+02 ***	16 14 04	ROM 1; DS 2
FIX	123 f FIX 2	123.00	123.0000 FIX2 123.00 ***	16 13 02	ROM 1; DS 2
ln	11 f ln	2.40	11.00 LN 2.40 ***	16 32	ROM 1; ROM 2
e^x	1 g e^x	2.72	1.00 e^x 2.72 ***	25 32	ROM 1
log	20 f log	1.30	20.00 LOG 1.30 ***	16 33	ROM 1; ROM 2
10^x	3 g 10^x	1000.00	3.00 10^x 1000.00 ***	25 33	ROM 1
sin	30 f sin	0.50	30.00 SIN 0.50 ***	16 42	ROM 2
sin^{-1}	g sin^{-1}	30.00	SIN^{-1} 30.00 ***	25 42	ROM 2

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

OPERATION	KEYSTROKES	DISPLAY	PRINTOUT	KEYCODE	IC FAILURE
COS	60 f COS		60.00 COS	16 43	ROM 2
		0.50	0.50 ***		
COS⁻¹	g COS⁻¹		COS⁻¹	25 43	ROM 2
		60.00	60.00 ***		
tan	45 f tan		45.00 TAN	16 44	ROM 2
		1.00	1.00 ***		
tan⁻¹	g tan⁻¹		TAN⁻¹	25 44	ROM 2
		45.00	45.00 ***		
→P	3 ENTER↑		3.00 ENT↑	25 34	ROM 2
	4 g →P		4.00 →P		
		5.00	5.00 ***		
	x⇄y		X⇄Y		
		36.87	36.87 ***		
→R	5 f →R		5.00 →R	16 34	ROM 2
		4.00	4.00 ***		
	x⇄y		X⇄Y		
		3.00	3.00 ***		
RAD	g π		PI	25 23	ROM 3; DS 2
			3.14 ***		
	g RAD		RAD		
	f COS		COS		
		-1.00	-1.00 ***		
GRD	200 g GRD		200.00 GRAD	25 22	ROM 3; DS 2
	f COS		COS		
		-1.00	-1.00 ***		
DEG	30 g DEG		30.00 DEG	25 24	ROM 3; DS 2
	f sin		SIN		
		0.50	0.50 ***		
→H.MS	6.7 f →H.MS		6.70 →HMS	16 62	ROM 1
		6.42	6.42 ***		
→H	6.42 g →H		6.42 →H	25 62	ROM 1
		6.70	6.70 ***		
STO n†	5 STO 1		5.00 STO1	45 01	DS 0; ROM 3
	CLX		CLX		
RCL n†	RCL 1		RCL1	55 01	DS 0; ROM 3
		5.00	5.00 ***		
STO . n‡	5 STO . 1		5.00 ST.1	45 .1	DS 0; ROM 3
	CLX		CLX		
RCL . n‡	RCL . 1		RC.1	55 .1	DS 0; ROM 3
		5.00	5.00 ***		

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

OPERATION	KEYSTROKES	DISPLAY	PRINTOUT	KEYCODE	IC FAILURE
[STO] [+] n†	5 [STO] 1 2 [STO] [+] 1 [RCL] 1	7.00	5.00 STO1 2.00 ST+1 RCL1 7.00 ***	45 41 01	DS 0; ROM 3; ROM 1
[STO] [−] n†	5 [STO] 1 2 [STO] [−] 1 [RCL] 1	3.00	5.00 STO1 2.00 ST−1 RCL1 3.00 ***	45 31 01	DS 0; ROM 3; ROM 1
[STO] [×] n†	5 [STO] 1 2 [STO] [×] 1 [RCL] 1	10.00	5.00 STO1 2.00 ST×1 RCL1 10.00 ***	45 51 01	DS 0; ROM 3; ROM 1
[STO] [÷] n†	5 [STO] 1 2 [STO] [÷] 1 [RCL] 1	2.50	5.00 STO1 2.00 ST÷1 RCL1 2.50 ***	45 61 01	DS 0; ROM 3; ROM 1
[STO] [+] [•] n‡	5 [STO] [•] 1 2 [STO] [+] [•] 1 [RCL] [•] 1	7.00	5.00 ST.1 2.00 S+.1 RC.1 7.00 ***	45 41 .1	DS 0; ROM 3; ROM 1
[STO] [−] [•] n‡	5 [STO] [•] 1 2 [STO] [−] [•] 1 [RCL] [•] 1	3.00	5.00 ST.1 2.00 S−.1 RC.1 3.00 ***	45 31 .1	DS 0; ROM 3; ROM 1
[STO] [×] [•] n‡	5 [STO] [•] 1 2 [STO] [×] [•] 1 [RCL] [•] 1	10.00	5.00 ST.1 2.00 S×.1 RC.1 10.00 ***	45 51 .1	DS 0; ROM 3; ROM 1
[STO] [÷] [•] n‡	5 [STO] [•] 1 2 [STO] [÷] [•] 1 [RCL] [•] 1	2.50	5.00 ST.1 2.00 S÷.1 RC.1 2.50 ***	45 61 .1	DS 0; ROM 3; ROM 1
[STO] [i] § [RCL] [i] §	16 [STO] 0 5 [STO] [i] [CLx] [RCL] [i]	5.00	16.00 STO0 5.00 STOi CLX RCLi 5.00 ***	45 12 55 12	DS 1; ROM 3 DS 1; ROM 3
[STO] [+] [i] §	16 [STO] 0 5 [STO] [i] 2 [STO] [+] [i] [RCL] [i]	7.00	16.00 STO0 5.00 STOi 2.00 ST+i RCLi 7.00 ***	45 41 12	DS 1; DS 0; ROM 3; ROM 1

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

OPERATION	KEYSTROKES	DISPLAY	PRINTOUT	KEYCODE	IC FAILURE
STO − i §	16 STO 0		16.00 STO0	45 31 12	DS 1; DS 0; ROM 3; ROM 1
	5 STO i		5.00 STOi		
	2 STO − i		2.00 ST-i		
	RCL i		RCLi		
		3.00	3.00 ***		
STO × i §	16 STO 0		16.00 STO0	45 51 12	DS 1; DS 0; ROM 3; ROM 1
	5 STO i		5.00 STOi		
	2 STO × i		2.00 ST×i		
	RCL i		RCLi		
		10.00	10.00 ***		
STO ÷ i §	16 STO 0		16.00 STO0	45 61 12	DS 1; DS 0; ROM 3; ROM 1
	5 STO i		5.00 STOi		
	2 STO ÷ i		2.00 ST÷i		
	RCL i		RCLi		
		2.50	2.50 ***		
ISZ	g ISZ		ISZ	25 55	DS 0; ROM 3
	RCL 0		RCL0		
		1.00	1.00 ***		
DSZ	g DSZ		DSZ	25 45	DS 0; ROM 3
	RCL 0		RCL0		
		−1.00	−1.00 ***		
Σ+	1 ENTER↑		1.00 ENT↑	35	DS 0; ROM 1
	2 Σ+		2.00 Σ+		
		1.00	1.00 ***		
	2 ENTER↑		2.00 ENT↑		
	3 Σ+		3.00 Σ+		
		2.00	2.00 ***		
	3 ENTER↑		3.00 ENT↑		
	6 Σ+		6.00 Σ+		
		3.00	3.00 ***		
	3 ENTER↑		3.00 ENT↑		
Σ-	6 f Σ-		6.00 Σ-		DS 0; ROM 1
		2.00	2.00 ***		
RCL Σ+	RCL Σ+		RCΣ+	55 35	DS 0; ROM 1
		5.00	5.00 ***		
	x⇄y		X⇄Y		
		3.00	3.00 ***		
x̄	f x̄		x̄	16 11	DS 0; ROM 1
		2.50	2.50 ***		
	x⇄y		X⇄Y		
		1.50	1.50 ***		
s	f s		s	16 12	DS 0; ROM 1
		0.71	0.71 ***		
	x⇄y		X⇄Y		
		0.71	0.71 ***		

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

OPERATION	KEYSTROKES	DISPLAY	PRINTOUT	KEYCODE	IC FAILURE
PRTPRGM	g PRTPRGM	0.00	01 R/S		ROM 7; ROM 0; ROM 3
PRTΣ	f PRTΣ	 0.00	PRTΣ 0.00 N 0.00 ΣX 0.00 ΣX² 0.00 ΣY 0.00 ΣY² 0.00 ΣXY	16 45	ROM 7; ROM 0; ROM 3
PRTREG	f PRTREG	 0.00	PREG 0.00 0 0.00 1 0.00 2 0.00 3 0.00 4 0.00 5 0.00 6 0.00 7 0.00 8 0.00 9 0.00 .0 0.00 .1 0.00 .2 0.00 .3 0.00 .4 0.00 .5 0.00 16 0.00 17 0.00 18 0.00 19 0.00 20 0.00 21 0.00 22 0.00 23 0.00 24 0.00 25 0.00 26 0.00 27 0.00 28 0.00 29	16 55	ROM 7; ROM 0; ROM 3
PRTSTK	f PRTSTK	 0.00	PRST 0.00 T 0.00 Z 0.00 Y 0.00 X	16 65	ROM 7; ROM 0; ROM 3
PRx	PRx	0.00	0.00 ***	65	ROM 0

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

OPERATION	KEYSTROKES	DISPLAY	PRINTOUT	KEYCODE	IC FAILURE
[SPC]	[g] [SPC]	0.00	(paper advances)	25 65	ROM 0
CLEAR [REG]	5 [STO] 1 [f] [REG] [RCL] 1	 0.00	5.00 STO1 CLRG RCL1 0.00 ***	16 23	DS 1 or DS 0; ROM 0
CLEAR [Σ]	5 [STO] [·] 0 [f] [Σ] [RCL] [·] 0	 0.00	5.00 ST.0 CLΣ RC.0 0.00 ***	16 24	DS 0; ROM 0
CLEAR [PREFIX]	12 [STO] [f] [PREFIX] 3	 123.			ROM 0; ACT

*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	[switch] PRGM	00	ROM 0
2	CLEAR [PRGM]	[f] CLEAR [PRGM]	00	ROM 0
3	[LBL]	[g] [LBL] 0	01 25 14 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 25 13	ROM 3
9	[R/S]	[R/S]	06 64	ROM 0
10	[GTO] [·]	[GTO] [·] 00	00	ROM 1
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] [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 25 14 01
	0	02 00
	STO 0	03 45 00
	2	04 02
	ENTER↑	05 21
	5	06 05
x≤y	f x≤y	07 16 31
	GTO 2	08 14 02
	g ISZ	09 25 55
x<0	g x<0	10 25 31
	GTO 2	11 14 02
	g ISZ	12 25 55
x=y	f x=y	13 16 61
	GTO 2	14 14 02
	g ISZ	15 25 55
	CHS	16 22
x>y	f x>y	17 16 41
	GTO 2	18 14 02
	g ISZ	19 25 55
x>0	g x>0	20 25 41
	GTO 2	21 14 02
	GTO ISZ	22 25 55
x=0	g x=0	23 25 61
	GTO 2	24 14 02
	g ISZ	25 25 55
	CHS	26 22
	5	27 05
x≠y	f x≠y	28 16 51
	GTO 2	29 14 02
	g ISZ	30 25 55
	CLx	31 24
x≠0	g x≠0	32 25 51
	GTO 2	33 14 02
	g ISZ	34 25 55
	g LBL 2	35 25 14 02
	RCL 0	36 55 00
	g RTN	37 25 13

5-14. ABBREVIATED OPERATIONAL TEST

5-15. The abbreviated operational test is used to quickly check the operating capabilities of the HP-19C 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: PRGM TRACE

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, the keys pressed are not being entered correctly. This indicates a failure of the PIK, ROM 0, or ROM 3 (in that order of failure probability). To further isolate the faulty component, check for other failure symptoms of these IC's. (Refer to table 4-3.) After replacing an IC, return to step *a*.

(3) If following any step the correct program step number and keycode are obtained but the printout is incorrect, it is likely that there is a failure in the PIK, ROM 0, or ROM 7.

(4) If the correct program step number, keycode, and printout 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 display should agree with that shown in the table. If so, part 1 of the abbreviated operational test is passed; proceed with part 2. If not, proceed with step *f*.

f. If the incorrect display occurs after any of the steps 1 through 7, 9 through 12, or 14 through 32, 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.

g. If the incorrect display occurs after execution of the sub-program called at step 8:

(1) If the calculator does not respond to the keystrokes of step 8, replace successively the IC's listed for this step in table 5-5. Return to step *a* after each replacement, until the calculator responds properly.

(2) Ensure that each step of the program in table 5-4 has been stored correctly by comparing the mnemonics in the printout with the program steps listed in table 5-4. (The correct printout is shown in figure 5-1.) If program steps appear in the print-out as ***R/S*** or **ΣXY** in blocks of seven, there is a failure in DS 2.

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

STEP	KEYSTROKES	DISPLAY	PRINTOUT	IC FAILURE
1	g LBL 4	01 25 14 04	01 *LBL4	
2	STO 0	02 45 00	02 STO0	
3	g DSZ	03 25 45	03 DSZ	
4	g LBL 5	04 25 14 05	04 *LBL5	
5	RCL 0	05 55 00	05 RCL0	DS 0; ROM 3
6	×	06 51	06 ×	ROM 1
7	g DSZ	07 25 45	07 DSZ	
8	GTO 5	08 14 05	08 GTO5	
9	R/S	09 64	09 R/S	
10	g LBL 7	10 25 14 07	10 *LBL7	
11	RCL . 1	11 55 .1	11 RC.1	DS 0; ROM 3
12	÷	12 61	12 ÷	ROM 1
13	EEX	13 23	13 EEX	
14	2	14 02	14 2	
15	×	15 51	15 ×	ROM 1

(3) If all program steps have been stored correctly, compare the calculated answers in the calculator printout with those shown in figure 5-1. If the answer following execution of program step 5 or 6 is incorrect, replace the IC indicated in table 5-4 for that step, then return to step *a*.

(4) If the calculated answers in the printout are all correct, check whether step 7 of the program was executed correctly. If not, replace the IC indicated for this step in table 5-4.

h. If the incorrect display occurs after pressing [R/S] in step 13:

(1) If the calculator does not respond to the [R/S], switch to PRGM mode. If the display does not show program step 10, the [GTO] 7 did not operate correctly and the ROM indicated in table 5-5 for step 12 should be replaced. If the display does show program step 10, the [R/S] did not operate correctly and the ROM indicated in table 5-5 for step 13 should be replaced.

(2) Ensure that each step of the program in table 5-4 has been stored correctly by comparing the mnemonics in the printout with the program steps listed in table 5-4. If program steps appear in the printout as ***R/S*** or **ΣXY** in blocks of seven, there is a failure in DS 2.

(3) If all program steps have been stored correctly, compare the calculated answers in the calculator printout with those shown in figure 5-1. If the answer following execution of program step 11, 12, or 15 is incorrect, replace the IC indicated in table 5-4 for that step, then return to step *a*.

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
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

```
        6.00 FIX8            07  DSZ                    -1260.000000 ***
  6.00000000 ***             08  GTO5                   13  EEX
             CLΣ             04 *LBL5                   14  2
  1.00000000 Σ+              05  RCL0                   15  x
  1.00000000 ***               3.00000000 ***           -126000.0000 ***
             RCΣ+            06  x                      16  R/S
  1.00000000 ***              2520.000000 ***                        CHS
             +               07  DSZ                     126000.0000 ***
  7.00000000 ***             08  GTO5                                √X
             GSB4            04 *LBL5                    354.9647870 ***
01 *LBL4                     05  RCL0                                Pi
02  STO0                       2.00000000 ***             3.14159265 ***
03  DSZ                      06  x                                   →R
04 *LBL5                      5040.000000 ***             3.12946908 ***
05  RCL0                     07  DSZ                                 Pi
  6.00000000 ***             08  GTO5                     3.14159265 ***
06  x                        04 *LBL5                                x
 42.00000000 ***             05  RCL0                     9.83151706 ***
07  DSZ                        1.00000000 ***                        INT
08  GTO5                     06  x                        9.00000000 ***
04 *LBL5                      5040.000000 ***                        1/X
05  RCL0                     07  DSZ                      0.11111111 ***
  5.00000000 ***             09  R/S                            1.+29 ENT↑
06  x                          5.00000000 S-.1            3.00000000 Yˣ
 210.0000000 ***                          X⇄Y           1.0000000+87 ***
07  DSZ                       5040.000000 ***                        ÷
08  GTO5                                  GTO7          1.1111111-88 ***
04 *LBL5                                  R/S                        STOi
05  RCL0                     10 *LBL7                     8.00000000 STx0
  4.00000000 ***             11  RC.1                                RCLi
06  x                         -4.00000000 ***           8.8888888-88 ***
 840.0000000 ***             12  ÷                                   CHS
                                                       -8.8888888-88 ***
```

Figure 5-1. Abbreviated Operational Test, Part 1

5-18. Abbreviated Operational Test, Part 2

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

a. Set switches: [OFF/RUN switch] RUN   MAN [switch]

b. Press: [f] [FIX] 2.

c. Switch to: [switch] PRGM

d. Press: [f] CLEAR [PRGM].

e. Press [+] repeatedly until this function (keycode ***41***) has been entered into the first 97 program steps.

f. Press [R/S]. The final display should be ***98*** ***64***.

g. Switch to: [switch] 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. Check that all program steps have been entered correctly by pressing [g] [PRTPRGM]. Program steps 1 through 97 should contain +, with keycode ***41***; program step 98 should contain ***R/S***, with keycode ***64***. If any program step is incorrect, 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: PRGM MAN

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". 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.

Table 5-6. Full Operational Test

TEST STEP	FUNCTION	ACTUAL KEYS	DISPLAY	MOST PROBABLE IC FAILURE
1	LBL 0	g GTO 0	01 25 14 00	ROM 3; ROM 0
2	5	5	02 05	DS 1; ROM 3
3	STO − (i)	STO − R↓	03 45 31 12	ROM; ROM 1; DS 0
4	1	1	04 01	DS 1; ROM 3
5	GTO 1	GTO 1	05 14 01	ROM 3
6	ISZ	g RCL	06 25 55	ROM 1; DS 0
7	STO + 0	STO + 0	07 45 41 00	ROM 3; ROM 1; DS 0
8	ISZ	g RCL	08 25 55	ROM 1; DS 0
9	GSB (i)	GSB R↓	09 13 12	ROM 3; ACT
10	RTN	g GSB	10 25 13	ROM 3; ACT
11	LBL 1	g GTO 1	11 25 14 01	ROM 3; ROM 0
12	GSB (i)	GSB g R↓	12 13 12	ROM 3; ACT
13	RTN	g GSB	13 25 13	ROM 3; ACT
14	CLEAR REG	f EEX	14 16 23	ROM 0; DS 0; DS 1
15	FIX 2	f GSB 2	15 16 13 02	ROM 3; DS 2
16	GSB (i)	GSB R↓	16 13 12	ROM 3; ACT
17	RCL 0	RCL 0	17 55 00	ROM 3; DS 0
18	x≠0	g ×	18 25 51	ROM 3
19	GTO 2	GTO 2	19 14 02	ROM 3
20	2	2	20 02	DS 1; ROM 3
21	9	9	21 09	DS 1; ROM 3
22	STO (i)	STO g R↓	22 45 12	ROM 3; DS 0
23	LBL 9	g GTO 9	23 25 14 09	ROM 3; ROM 0
24	RCL 0	RCL 0	24 55 00	ROM 3; DS 0
25	10^x	g 8	25 25 33	ROM 1; ROM 2
26	STO + (i)	STO + g R↓	26 45 41 12	ROM 3; ROM 1; DS 0 or DS 1
27	RCL (i)	g R↓	27 55 12	ROM 3; ROM 1; DS 0 or DS 1
28	x≠y	f ×	28 16 51	ROM 3
29	GTO 2	GTO 2	29 14 02	ROM 3
30	DSZ	g STO	30 25 45	ROM 1; DS 0
31	GTO 9	GTO 9	31 14 09	ROM 3
32	R↓	R↓	32 12	ROM 3
33	log	f 8	33 16 33	ROM 1; ROM 2
34	GRD	g CHS	34 25 22	ROM 2; DS 2
35	→R	f 9	35 16 34	ROM 2; DS 2

Table 5-6. Full Operational Test (Continued)

TEST STEP	FUNCTION	ACTUAL KEYS	DISPLAY	MOST PROBABLE IC FAILURE
36	[e^x]	[g] 7	36 25 32	ROM 1; ROM 2
37	[RAD]	[g] [EEX]	37 25 23	ROM 2; DS 2
38	[→P]	[g] 9	38 25 34	ROM 2; DS 2
39	[x^2]	[g] 2	39 25 53	ROM 1
40	[ln]	[f] 7	40 16 32	ROM 2; ROM 1
41	[x<0]	[g] [−]	41 25 31	ROM 3
42	[GTO] 2	[GTO] 2	42 14 02	ROM 3
43	[→H.MS]	[f] 0	43 16 62	ROM 1
44	[COS^{-1}]	[g] 5	44 25 43	ROM 2; DS 2
45	[→H]	[g] 0	45 25 62	ROM 1
46	[INT]	[f] 1	46 16 52	ROM 3
47	[x≤y]	[f] [−]	47 16 31	ROM 3
48	[GTO] 2	[GTO] 2	48 14 02	ROM 3
49	[$\sqrt{x}$]	[f] 2	49 16 53	ROM 1
50	[DEG]	[g] [CLx]	50 25 24	ROM 2; DS 2
51	[sin^{-1}]	[g] 4	51 25 42	ROM 2; DS 2
52	8	8	52 08	*
53	[COS]	[f] 5	53 16 43	*
54	[BST]	[g] [SST]	52 08	*
55	[DEL]	[g] [Σ+]	51 25 42	*
56	[SST]	[SST]	52 16 43	ROM 2; DS 2
57	[x>0]	[g] [+]	53 25 41	ROM 3
58	[GTO] 2	[GTO] 2	54 14 02	ROM 3
59	[LAST X]	[f] [·]	55 16 63	DS 1; ROM 3
60	[ENG] 4	[f] [SST] 4	56 16 15 04	ROM 3; DS 2
61	CLEAR [Σ]	[f] [CLx]	57 16 24	ROM 0
62	9	9	58 09	DS 1; ROM 3
63	[Σ+]	[Σ+]	59 35	ROM 1; DS 0
64	[RCL] [Σ+]	[RCL] [Σ+]	60 55 35	ROM 1; DS 0
65	[Σ+]	[Σ+]	61 35	ROM 1; DS 0
66	7	7	62 07	DS 1; ROM 3
67	[ENTER↑]	[ENTER↑]	63 21	ROM 3
68	3	3	64 03	DS 1; ROM 3
69	[Σ+]	[Σ+]	65 35	ROM 1; DS 0
70	7	7	66 07	DS 1; ROM 3
71	[LAST X]	[f] [·]	67 16 63	DS 1; ROM 3
72	[Σ-]	[f] [Σ+]	68 16 35	ROM 1; DS 0
73	[$\bar{x}$]	[f] [x⇄y]	69 16 11	ROM 1; DS 0
74	[x>y]	[f] [+]	70 16 41	ROM 3
75	[GTO] 2	[GTO] 2	71 14 02	ROM 3
76	CLEAR [PREFIX]	[f] [ENTER↑]	71 14 02	
77	[x⇄y]	[x⇄y]	72 11	ROM 3
78	[STO] [÷] 1	[STO] [÷] 1	73 45 61 01	ROM 3; ROM 1; DS 0
79	[sin]	[f] 4	74 16 42	ROM 2; DS 2
80	[π]	[g] [·]	75 25 63	ROM 2
81	[%]	[g] [x⇄y]	76 25 11	ROM 1
82	[R↓]	[R↓]	77 12	ROM 3
83	[−]	[−]	78 31	ROM 1
84	[STO] [×] 1	[STO] [×] 1	79 45 51 01	ROM 3; ROM 1; DS 0

Table 5-6. Full Operational Test (Continued)

TEST STEP	FUNCTION	ACTUAL KEYS	DISPLAY	MOST PROBABLE IC FAILURE
85	x=0	g ÷	80 25 61	ROM 3
86	GTO 2	GTO 2	81 14 02	ROM 3
87	3	3	82 03	DS 1; ROM 3
88	1/x	g R/S	83 25 64	ROM 1
89	y^x	f 3	84 16 54	ROM 1; ROM 2
90	x=y	f ÷	85 16 61	ROM 3
91	GTO 2	GTO 2	86 14 02	ROM 3
92	RCL 1	RCL 1	87 55 01	ROM 3; DS 0
93	CHS	CHS	88 22	ROM 3
94	SCI 9	f GTO 9	89 16 14 09	ROM 3; DS 2
95	EEX	EEX	90 23	DS 1; ROM 3
96	8	8	91 08	DS 1; ROM 3
97	7	7	92 07	DS 1; ROM 3
98	CHS	CHS	93 22	ROM 3
99	×	×	94 51	ROM 1
100	SPC	g PRx	95 25 65	ROM 0
101	PRx	PRx	96 65	ROM 0
102	PAUSE	f R/S	97 16 64	ROM 2; ROM 1
103	R/S	R/S	98 64	ROM 0; ROM 3

*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.

d. Switch to RUN.

e. Press:
CLx f FIX 3
GTO · 14 R/S

f. When execution of the test program is completed, the calculator should display and print **-8.8888888-88**. If not, *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 and stored correctly:

(1) Switch to PRGM.

(2) Press: GTO · 00.

(3) Press: g PRTPRGM.

(4) Compare the resulting program listing, line-by-line, to that shown in figure 5-2. If an incorrect program step is found, proceed with step (5).

(5) Go to the incorrect step using GTO · nn.

(6) Press: g DEL.

(7) Press the correct keys indicated for the program step until the calculator display shows the correct keycode.

(8) If pressing the correct keys does not result in the correct keycode, the logic PCA should be replaced. If the correct keycode is obtained, check that the keycode has been stored correctly by pressing g BST SST. If the correct keycode is still displayed, return to step *d;* if not, the logic PCA should be replaced.

5-23. To perform the full operational test during component-level service:

a. Perform steps *a* through *e* of paragraph 5-22. When execution of the test program is completed, the calculator display and printout should show **-8.8888888-88**. If so, the calculator has passed the full operational test; if not, proceed with step *b*.

b. Check that all program steps have been entered and stored correctly as follows:

(1) Switch to PRGM.

(2) Press: GTO · 00.

(3) Press: g PRTPRGM.

(4) Compare the resulting program listing, line-by-line, to that shown in figure 5-2. If an incorrect program step is found, proceed with step (5); if not, proceed with step *c*.

(5) Go to the incorrect step using GTO · nn.

(6) Press: g DEL.

```
01 *LBL0 25 14 00
02    5       05
03  ST-i 45 31 12
04    1       01
05  GTO1   14 01
06   ISZ   25 55
07  ST+0 45 41 00
08   ISZ   25 55
09  GSBi   13 12
10   RTN   25 13
11 *LBL1 25 14 01
12  GSBi   13 12
13   RTN   25 13
14  CLRG   16 23
15  FIX2 16 13 02
16  GSBi   13 12
17  RCL0   55 00
18  X≠0?   25 51
19  GTO2   14 02
20    2       02
21    9       09
22  STOi   45 12
23 *LBL9 25 14 09
24  RCL0   55 00
25   10ˣ   25 33
26  ST+i 45 41 12
27  RCLi   55 12
28  X≠Y?   16 51
29  GTO2   14 02
30   DSZ   25 45
31  GTO9   14 09
32    R↓      12
33   LOG   16 33
34  GRAD   25 22
35    →R   16 34
36    eˣ   25 32
37   RAD   25 23
38    →P   25 34
39    X²   25 53
40    LN   16 32
41  X<0?   25 31
42  GTO2   14 02
43  →HMS   16 62
44  COS⁻¹  25 43
45    →H   25 62
46   INT   16 52
47  X≤Y?   16 31
48  GTO2   14 02
49    √X   16 53
50   DEG   25 24
51  SIN⁻¹  25 42
52   COS   16 43
53  X>0?   25 41
54  GTO2   14 02
55  LSTX   16 63
56  ENG4 16 15 04
57   CLΣ   16 24
58    9       09
59    Σ+      35
60  RCΣ+   55 35
61    Σ+      35
62    7       07
63  ENT↑      21
64    3       03
65    Σ+      35
66    7       07
67  LSTX   16 63
68    Σ-   16 35
69    x̄    16 11
70  X>Y?   16 41
71  GTO2   14 02
72   X⇄Y      11
73  ST÷1 45 61 01
74   SIN   16 42
75    Pi   25 63
76    %    25 11
77    R↓      12
78    -       31
79  ST×1 45 51 01
80  X=0?   25 61
81  GTO2   14 02
82    3       03
83   1/X   25 64
84    Yˣ   16 54
85  X=Y?   16 61
86  GTO2   14 02
87  RCL1   55 01
88   CHS      22
89  SCI9 16 14 09
90   EEX      23
91    8       08
92    7       07
93   CHS      22
94    x       51
95   SPC   25 65
96  PRTX      65
97   PSE   16 64
98   R/S      64
```

Figure 5-2. Full Operational Test, Program Listing

(7) Press the correct keys indicated for the program step until the calculator display shows the correct keycode.

(8) If pressing the correct keys does not result in the correct keycode, the keys pressed are not being entered correctly. This indicates a failure of the PIK, ROM 0, or ROM 3 (in that order of failure probability). If the correct keycode is obtained, check that the keycode has been stored correctly by pressing [g] [BST] [SST]. If the correct keycode is still displayed, return to step *d* of paragraph 4-22 and run the test again. If the keycode displayed is incorrect, replace DS 2 and return to step *a*.

c. If the program listing obtained in step *b* agrees exactly with that shown in figure 5-2, one of the ROM's accessed during program execution is faulty. To determine which one, proceed with step *d*.

d. Switch to RUN.

e. Press:
[CLX] [f] [FIX] 3
[GTO] [•] 14

f. Switch to TRACE.

g. Press: [R/S] .

h. Compare the resulting printout to that shown in figure 5-3. The lines in the printout with *** at the right contain the results of calculations performed during program execution. Look for the first printed answer that does not agree with its counterpart in figure 5-3. This indicates the approximate point at which a faulty IC was accessed. To isolate the faulty IC, note the following:

(1) Check whether each of the program steps listed between the last correct printed answer and the first incorrect printed answer agree with those shown in figure 5-3. If they are not all identical, the last step shown correctly was probably executed incorrectly. If all intervening steps are shown correctly, the last step shown before the printed answer was probably executed incorrectly. For either case, the IC or IC's that probably failed are shown alongside the program step in table 5-6. After replacing an IC, return to step *a*.

(2) During a successful test, none of the program steps 19, 29, 42, 48, 54, 71, 81, or 86—each of which contains [GTO] 2—is executed. If an IC accessed by the functions preceding one of these steps is faulty, the [GTO] 2 may be executed. Since there is no [LBL] 2 in the program, when this occurs the calcu-

lator will print ***GTO2*** (preceded by its program step number), display and print ***Error***, then stop. To determine 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.

(3) If program step 29 is executed, a failure has occurred in a storage register. The indirect address of this register (see figure 1-1) is indicated by the last answer printed following program step 24. 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, the number 16 through 29 signifies a failure in DS 1; any other number signifies a failure in DS 0.

```
           R/S
14  CLRG
15  FIX2
          0.00  ***
16  GSBi
01 *LBL0
02    5
03  ST-i
04    1
05  GTO1
11 *LBL1
12  GSBi
07  ST+0
08   ISZ
09  GSBi
06   ISZ
07  ST+0
08   ISZ
10   RTN
10   RTN
13   RTN
17  RCL0
          0.00  ***
18  X≠0?
20    2
21    9
22  STOi
23 *LBL9
24  RCL0
         29.00  ***
25   10x
       1.00+29  ***
26  ST+i
27  RCLi
       1.00+29  ***
28  X≠Y?
30   DSZ
31  GTO9
23 *LBL9
24  RCL0
         28.00  ***
25   10x
       1.00+28  ***
26  ST+i
27  RCLi
       1.00+28  ***
28  X≠Y?
30   DSZ
31  GTO9
23 *LBL9
24  RCL0
         27.00  ***
25   10x
       1.00+27  ***
26  ST+i
27  RCLi
       1.00+27  ***
28  X≠Y?
30   DSZ
31  GTO9
23 *LBL9
24  RCL0
         26.00  ***
25   10x
       1.00+26  ***
26  ST+i
27  RCLi
       1.00+26  ***
28  X≠Y?
30   DSZ
31  GTO9
23 *LBL9
24  RCL0
         25.00  ***
25   10x
       1.00+25  ***
26  ST+i
27  RCLi
       1.00+25  ***
28  X≠Y?
30   DSZ
31  GTO9
23 *LBL9
24  RCL0
         24.00  ***
25   10x
       1.00+24  ***
26  ST+i
27  RCLi
       1.00+24  ***
28  X≠Y?
30   DSZ
31  GTO9
23 *LBL9
24  RCL0
         23.00  ***
25   10x
       1.00+23  ***
26  ST+i
27  RCLi
       1.00+23  ***
28  X≠Y?
30   DSZ
31  GTO9
23 *LBL9
24  RCL0
         22.00  ***
25   10x
       1.00+22  ***
26  ST+i
27  RCLi
       1.00+22  ***
28  X≠Y?
30   DSZ
31  GTO9
23 *LBL9
24  RCL0
         21.00  ***
25   10x
       1.00+21  ***
26  ST+i
27  RCLi
       1.00+21  ***
28  X≠Y?
30   DSZ
31  GTO9
23 *LBL9
24  RCL0
         20.00  ***
25   10x
       1.00+20  ***
26  ST+i
27  RCLi
       1.00+20  ***
28  X≠Y?
30   DSZ
31  GTO9
23 *LBL9
24  RCL0
         19.00  ***
25   10x
       1.00+19  ***
26  ST+i
27  RCLi
       1.00+19  ***
28  X≠Y?
30   DSZ
31  GTO9
23 *LBL9
24  RCL0
         18.00  ***
25   10x
       1.00+18  ***
26  ST+i
27  RCLi
       1.00+18  ***
28  X≠Y?
30   DSZ
31  GTO9
23 *LBL9
```

Figure 5-3. Full Operational Test, Program Execution

```
24  RCL0
        17.00  ***
25   10^x
      1.00+17  ***
26  ST+i
27  RCLi
      1.00+17  ***
28  X≠Y?
30   DSZ
31  GTO9
23 *LBL9
24  RCL0
        16.00  ***
25   10^x
      1.00+16  ***
26  ST+i
27  RCLi
      1.00+16  ***
28  X≠Y?
30   DSZ
31  GTO9
23 *LBL9
24  RCL0
        15.00  ***
25   10^x
      1.00+15  ***
26  ST+i
27  RCLi
      1.00+15  ***
28  X≠Y?
30   DSZ
31  GTO9
23 *LBL9
24  RCL0
        14.00  ***
25   10^x
      1.00+14  ***
26  ST+i
27  RCLi
      1.00+14  ***
28  X≠Y?
30   DSZ
31  GTO9
23 *LBL9
24  RCL0
        13.00  ***
25   10^x
      1.00+13  ***
```

```
26  ST+i
27  RCLi
      1.00+13  ***
28  X≠Y?
30   DSZ
31  GTO9
23 *LBL9
24  RCL0
        12.00  ***
25   10^x
      1.00+12  ***
26  ST+i
27  RCLi
      1.00+12  ***
28  X≠Y?
30   DSZ
31  GTO9
23 *LBL9
24  RCL0
        11.00  ***
25   10^x
      1.00+11  ***
26  ST+i
27  RCLi
      1.00+11  ***
28  X≠Y?
30   DSZ
31  GTO9
23 *LBL9
24  RCL0
        10.00  ***
25   10^x
      1.00+10  ***
26  ST+i
27  RCLi
      1.00+10  ***
28  X≠Y?
30   DSZ
31  GTO9
23 *LBL9
24  RCL0
         9.00  ***
25   10^x
  1000000000.  ***
26  ST+i
27  RCLi
  1000000000.  ***
28  X≠Y?
```

```
30   DSZ
31  GTO9
23 *LBL9
24  RCL0
         8.00  ***
25   10^x
  100000000.0  ***
26  ST+i
27  RCLi
  100000000.0  ***
28  X≠Y?
30   DSZ
31  GTO9
23 *LBL9
24  RCL0
         7.00  ***
25   10^x
  10000000.00  ***
26  ST+i
27  RCLi
  10000000.00  ***
28  X≠Y?
30   DSZ
31  GTO9
23 *LBL9
24  RCL0
         6.00  ***
25   10^x
   1000000.00  ***
26  ST+i
27  RCLi
   1000000.00  ***
28  X≠Y?
30   DSZ
31  GTO9
23 *LBL9
24  RCL0
         5.00  ***
25   10^x
    100000.00  ***
26  ST+i
27  RCLi
    100000.00  ***
28  X≠Y?
30   DSZ
31  GTO9
23 *LBL9
24  RCL0
```

```
         4.00  ***
25   10^x
     10000.00  ***
26  ST+i
27  RCLi
     10000.00  ***
28  X≠Y?
30   DSZ
31  GTO9
23 *LBL9
24  RCL0
         3.00  ***
25   10^x
      1000.00  ***
26  ST+i
27  RCLi
      1000.00  ***
28  X≠Y?
30   DSZ
31  GTO9
23 *LBL9
24  RCL0
         2.00  ***
25   10^x
       100.00  ***
26  ST+i
27  RCLi
       100.00  ***
28  X≠Y?
30   DSZ
31  GTO9
23 *LBL9
24  RCL0
         1.00  ***
25   10^x
        10.00  ***
26  ST+i
27  RCLi
        10.00  ***
28  X≠Y?
30   DSZ
32    R↓
        10.00  ***
33   LOG
         1.00  ***
34  GRAD
35    →R
         0.00  ***
```

Figure 5-3. Full Operational Test, Program Execution (Continued)

```
36   e^x
       1.00  ***
37   RAD
38   →P
       1.41  ***
39   X²
       2.00  ***
40   LN
       0.69  ***
41   X<0?
43   →HMS
       0.41  ***
44   COS⁻¹
       1.14  ***
45   →H
       1.25  ***
46   INT
       1.00  ***
47   X≤Y?
49   √X
       1.00  ***
50   DEG
51   SIN⁻¹

       90.00  ***
52   COS
       0.00  ***
53   X>0?
55   LSTX
       90.00  ***
56   ENG4
     90.000+00  ***
57   CLΣ
58     9
59     Σ+
     1.0000+00  ***
60   RCΣ+
     9.0000+00  ***
61     Σ+
     2.0000+00  ***
62     7
63   ENT↑
64     3
65     Σ+
     3.0000+00  ***
66     7
67   LSTX

     3.0000+00  ***
68     Σ-
     2.0000+00  ***
69     x̄
     9.0000+00  ***
70   X>Y?
72   X⇄Y
     90.000+00  ***
73   ST÷1
74   SIN
     1.0000+00  ***
75   Pi
     3.1416+00  ***
76     %
     31.416-03  ***
77     R↓
     1.0000+00  ***
78     -
     8.0000+00  ***
79   ST×1
80   X=0?
82     3
83   1/X

     333.33-03  ***
84     Y^x
     2.0000+00  ***
85   X=Y?
87   RCL1
     888.89-03  ***
88   CHS
    -888.89-03  ***
89   SCI9
-8.8888888-01  ***
90   EEX
91     8
92     7
93   CHS
94     x
-8.8888888-88  ***
95   SPC

96   PRTX
-8.8888888-88  ***
97   PSE
98   R/S
```

Figure 5-3. Full Operational Test, Program Execution (Continued)

Accessories

6-1. INTRODUCTION

6-2. This section identifies the accessories available for use with the HP-19C. 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. BATTERY PACK

6-4. Figure 6-1 shows the HP 82052A 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 a calculator (HP-19C or HP-10) 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 4.4 Vdc, discard the battery pack. If the voltage is at least 4.4 Vdc, the battery pack is good; in this case, charge it again for at least 5 hours, then store the pack for later use.

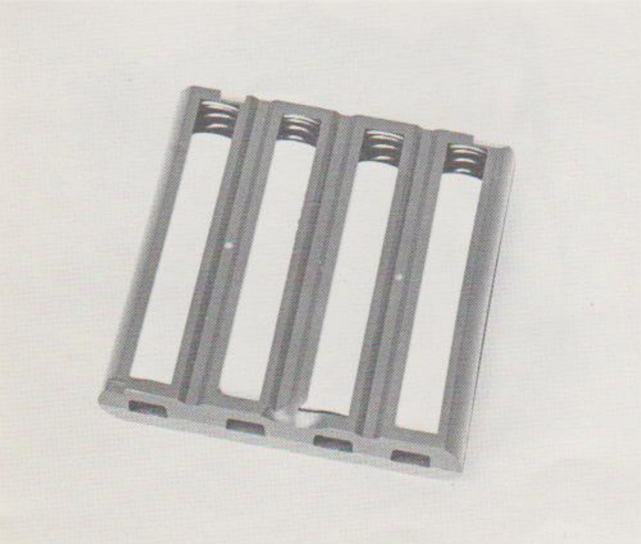


Figure 6-1. HP 82052A Battery Pack

6-5. AC ADAPTER/RECHARGERS

6-6. Table 6-1 lists the various ac adapter/rechargers available for use with the HP-19C. 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
82059A	115	US
82066A	230	European
82067A	230	UK desktop
82067A Opt 001	230	UK with RSA plug
82068A	230	Australian
82069A	115	European

*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, 5%, 10W 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 2.5 and 3.3 Vdc, the recharger is functioning properly. If not, proceed with step *e*.

e. Unplug the recharger from the calculator.

f. With an ac (rms) 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, $V_{MIN} = V_{IN}/21.10$ and $V_{MAX} = V_{IN}/15.65$.

(2) If V_{IN} is approximately 115 Vac, $V_{MIN} = V_{IN}/10.55$ and $V_{MAX} = V_{IN}/7.82$.

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, 5%, 5W resistor across the output of the recharger, and measure V_{OUT} across the load with an ac voltmeter. If V_{OUT} is between 5.3 and 7.3 Vac, the problem is in the charging circuitry on the printer PCA; otherwise, the recharger is defective and should be replaced.

Figure 6-2. HP 82059A AC Adapter/Recharger

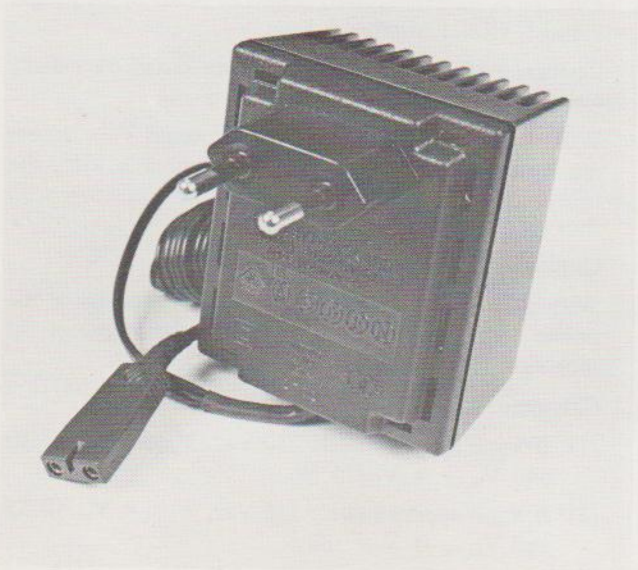


Figure 6-3. HP 82066A AC Adapter/Recharger

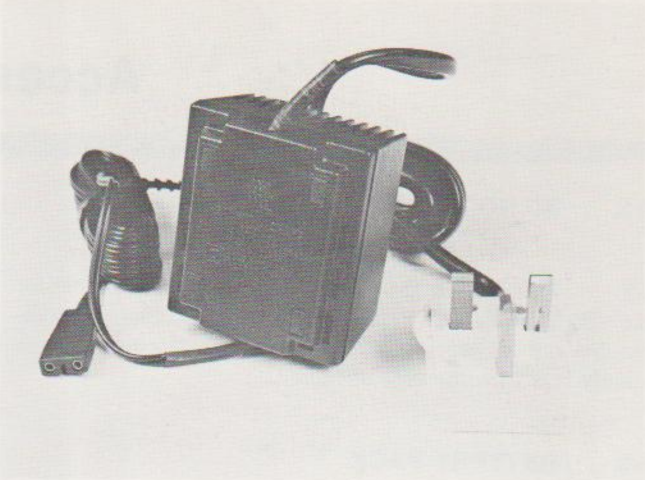


Figure 6-4. HP 82067A AC Adapter/Recharger

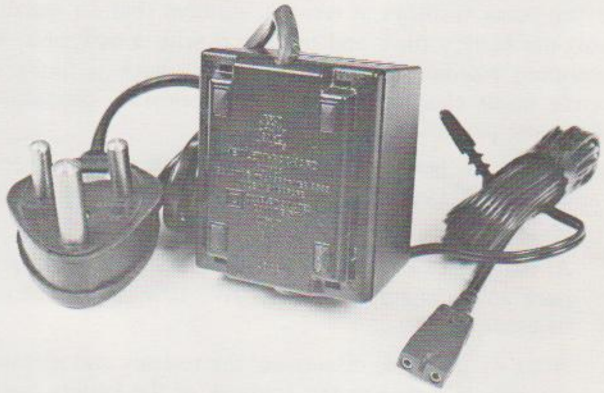


Figure 6-5. HP 82067A Opt 001 AC Adapter/Recharger

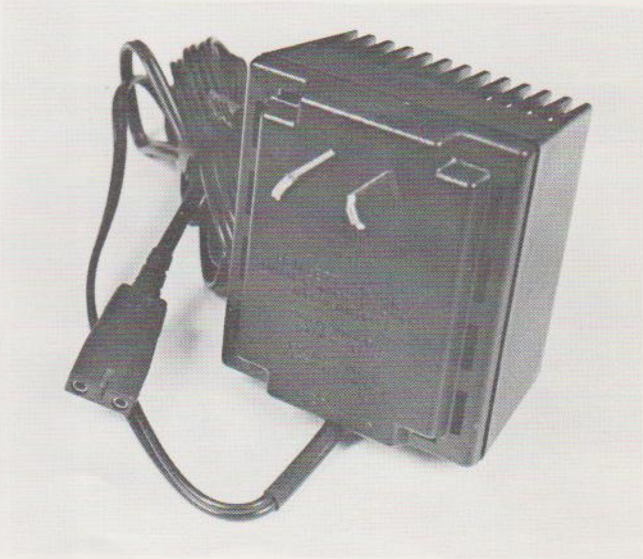


Figure 6-6. HP 82068A AC Adapter/Recharger

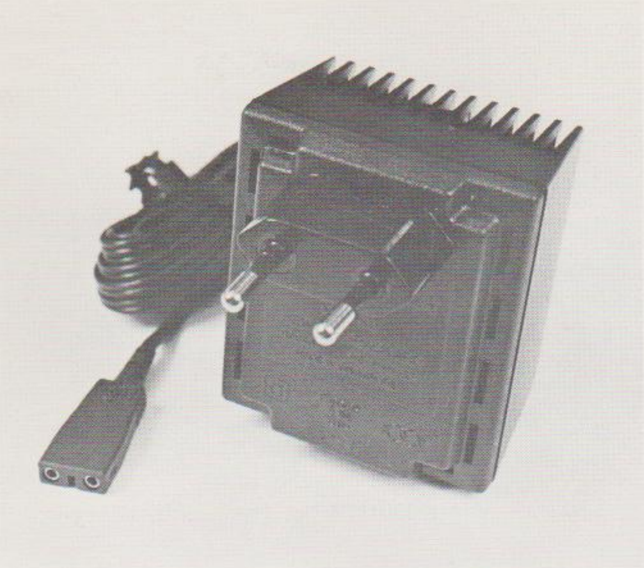


Figure 6-7. HP 82069A AC Adapter/Recharger

Replaceable Parts

7-1. INTRODUCTION

7-2. This section contains information pertaining to the parts used in the HP-19C. Table 7-1 lists these parts, giving the HP part number, description, and quantity; see also the HP-19C Exploded View, figure 7-1. Table 7-2 lists the parts and subassemblies of the HP-19C printer assembly; see also the Printer Assembly Exploded View, figure 7-2.

7-3. Replaceable parts for the logic PCA and printer PCA are listed for convenience opposite the corresponding component location and schematic diagrams in section IV.

7-4. Assemblies or parts listed without an HP part number are identified for reference only and cannot be ordered as named. Such items either are supplied as part of the assemblies under which they are listed, or can be obtained by ordering their indicated constituent parts.

7-5. ORDERING INFORMATION

7-6. To order replacement assemblies or parts, 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-19C Replaceable Parts

FIGURE & INDEX NUMBER	HP PART NUMBER	DESCRIPTION	QTY
7-1-			
1	00019-60001	PCA (L), logic (refer to table 4-5)	1
2	00019-60002	PCA (P), printer (refer to table 4-2)	1
3		ASSEMBLY (P), printer (refer to table 7-2)	1
4	00019-60007	ASSEMBLY (K), keyboard/topcase	1
5	00010-60014	ASSEMBLY (B), battery pack	1
6	00010-60012	ASSEMBLY, bottom case	1
7	00035-40008	• FOOT	4
8	1990-0633	DISPLAY	1
9	5040-9493	CONNECTOR, top/bottom case	1
10	5040-9491	DOOR, battery	1
11	5040-9495	WINDOW, display	1
12	5040-9499	LATCH, slide	1
13	0624-0303	SCREW, 2-28 x 0.312 inch	6
14	3030-0667	SCREW, shoulder, 2-56	3
15	0400-0126	GROMMET	3
16	9270-0535	PAPER, thermal	1/6
17	7120-6343	LABEL, top case, nameplate	1
18	7120-6345	LABEL, bottom case, mfg location (USA)	1
	7120-6346	LABEL, bottom case, mfg location (SGP)	
19	7120-6472	LABEL, bottom case, information	1

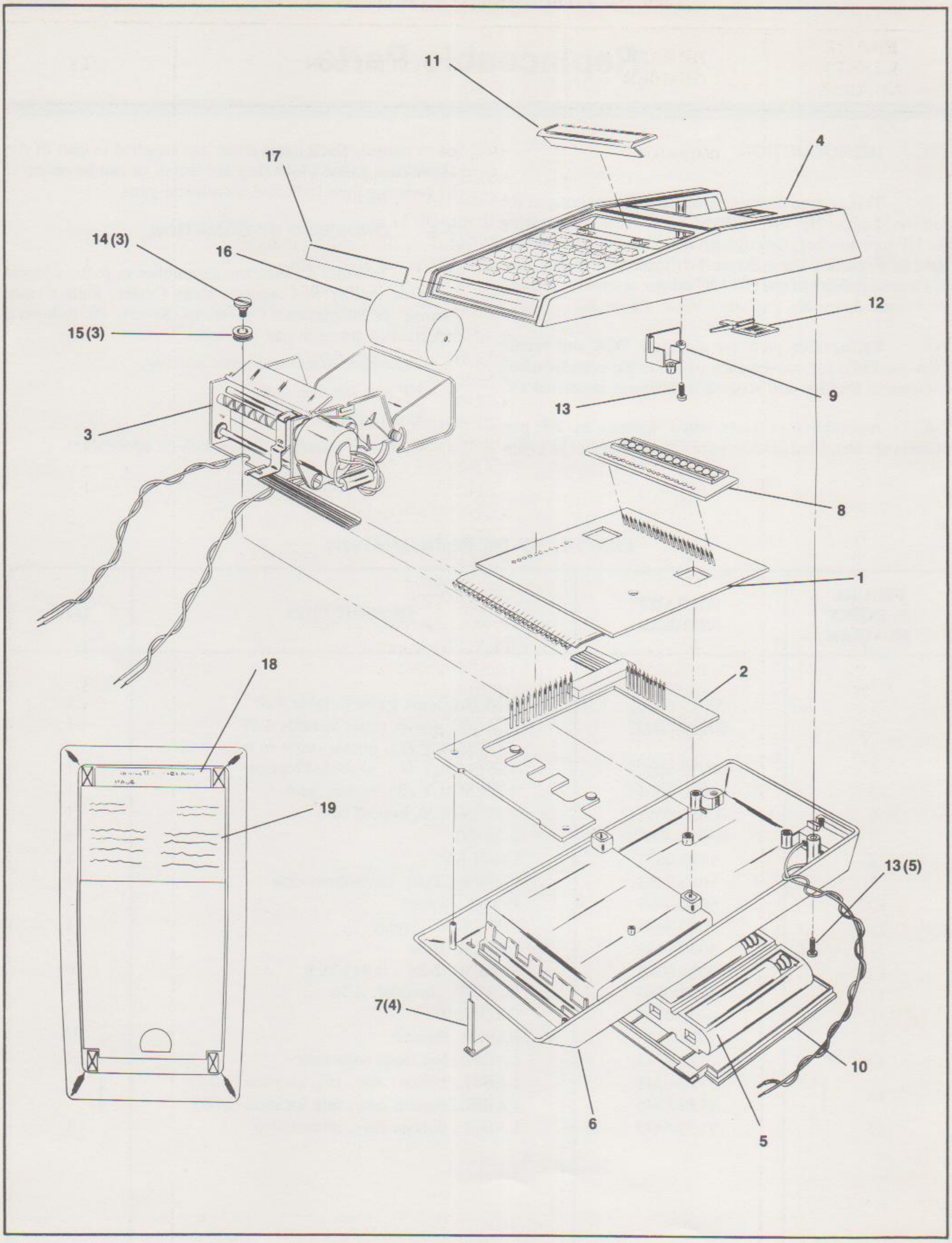


Figure 7-1. HP-19C Exploded View

Table 7-2. Printer Assembly (P) Replaceable Parts

FIGURE & INDEX NUMBER	HP PART NUMBER	DESCRIPTION	QTY
7-2-			
1	00010-60008	ASSEMBLY, motor (production)	1
		ASSEMBLY, head carrier	1
2	5040-9441	• CARRIAGE, head	1
3	5040-9448	• HOLDER, head	1
4	00010-60009	ASSEMBLY, flex-cable/print-head	1
	00010-60902	ASSEMBLY, printer (service)	1
5		• ASSEMBLY, mainframe	1
6		• ASSEMBLY, oscillator	1
7		• ASSEMBLY, keeper	1
8		• STABILIZER, oscillator	1
		• SHIELD	1
		• GUIDE, paper	2
	1410-0616	• BEARING, needle roller	4
9	1530-1956	• ROD, guide	1
10	0510-0810	• RING, retaining, 1/16 inch	1
	1460-1530	• SPRING, platen	1
11	5040-9445	• COVER, paper roll	1
12	1460-1523	• SPRING, torsion	1
13	5081-5544	• WIRE, twisted pair, home switch	1
14	5020-9235	SCREW, drive	1
15	1530-1958	FOLLOWER	1
16	0510-0261	RING, retaining, 3/32 inch	1
17	5041-1101	PLATEN, lapped	1
18	1460-1529	SPRING, follower	1
19	1600-0596	CLIP, head	1
20	5040-9766	CLIP, flex-cable	1
21	5040-9444	WINDOW	1
22	3030-0667	SCREW, shoulder, 2-56	2
23	0400-0126	GROMMET	2

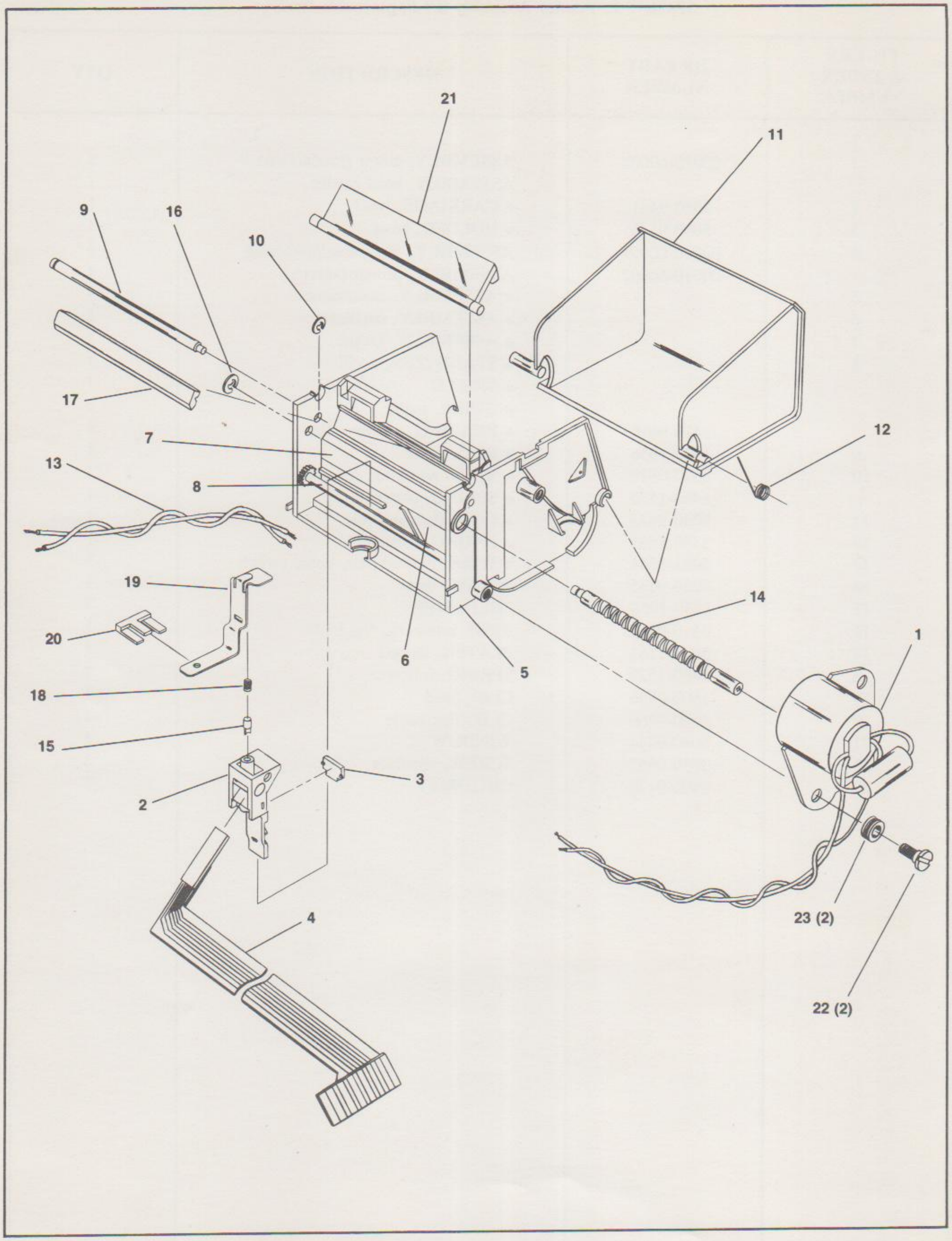


Figure 7-2. Printer Assembly Exploded View

Error Conditions

A-1. If an improper operation (that is, an operation that is meaningless under certain conditions) is attempted, the calculator will display ***Error***. Conditions resulting in an error display are listed in table A-1. The calculator will display ***Error*** also when the calculator is turned on, if the contents of the CMOS data/program storage have been lost or altered as a result of a discharged battery or discharged capacitor LC5. Whenever the word ***Error*** is displayed, it will also be printed if the print mode switch is set to TRACE or NORM. An ***Error*** display can also result from a failure in ROM 3 (refer to table 4-3) or a jam in the printer assembly.

Table A-1. Error Conditions

OPERATION	CONDITION
÷	$x = 0$
y^x	1. $y = 0$ and $x \leq 0$ 2. $y < 0$ and x non-integer
$\sqrt{x}$	$x < 0$
$1/x$	$x = 0$
log ln	$x \leq 0$
$\sin^{-1}$ $\cos^{-1}$	$\lvert x \rvert > 1$
STO ÷	$x = 0$
$\bar{x}$	$n = 0$
s	$n \leq 1$
STO i RCL i	ABS $[\text{INT}(R_0)] > 29$
GTO i GSB i	1. $\text{INT}(R_0) > -99$ 2. $\text{INT}(R_0) > 9$ 3. $0 \leq \text{INT}(R_0) \leq 9$ and there is no such label.
STO + n STO − n STO × n STO ÷ n	Magnitude of number in storage register R_n would then be larger than $9.999999999 \times 10^{99}$.
STO + . n STO − . n STO × . n STO ÷ . n	Magnitude of number in storage register $R_{.n}$ would then be larger than $9.999999999 \times 10^{99}$.
STO + i STO − i STO × i STO ÷ i	1. ABS $[\text{INT}(R_0)] > 29$ 2. Magnitude of number in storage register addressed by R_0 would then be larger than $9.999999999 \times 10^{99}$.