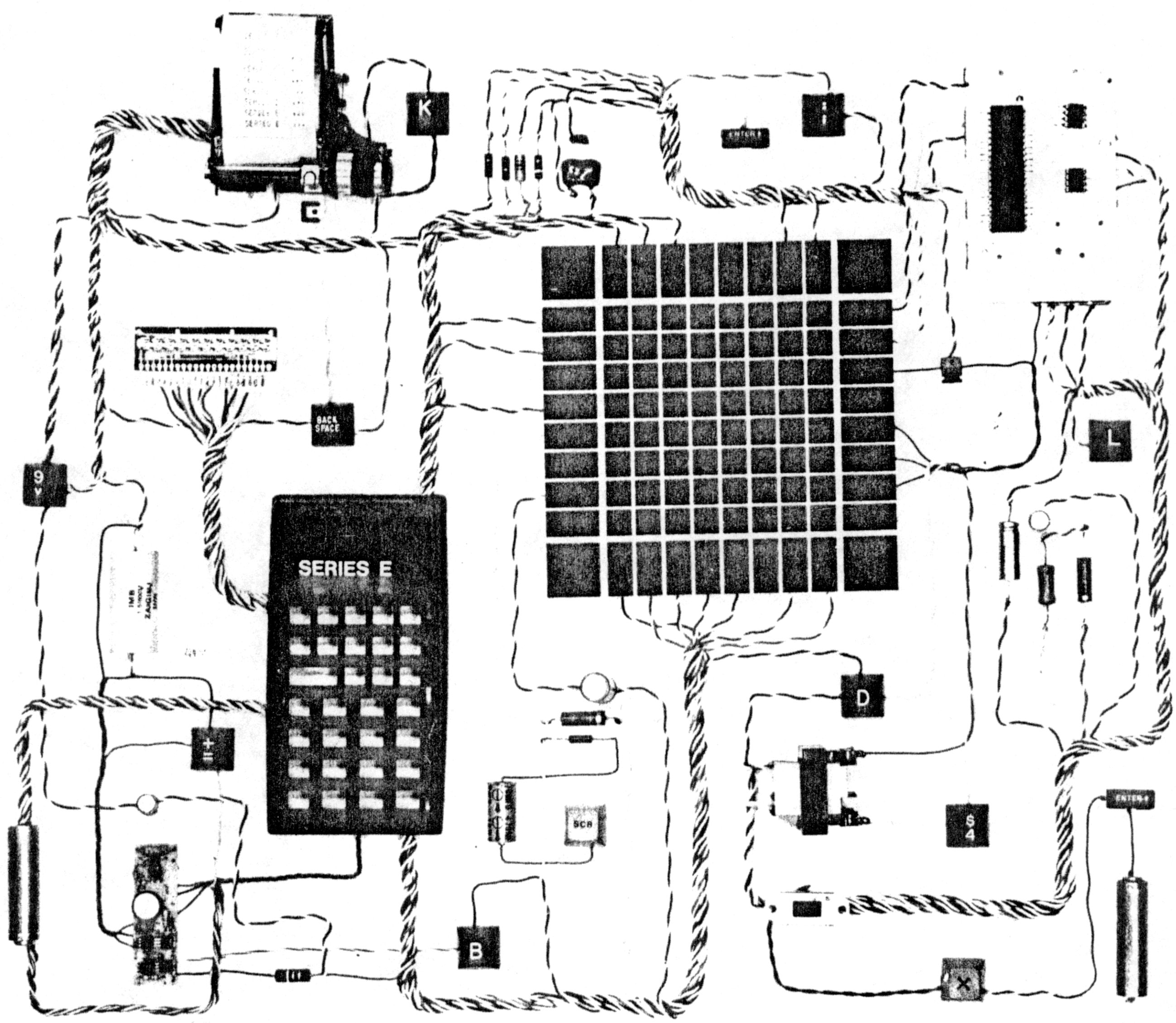
HEWLETT-PACKARD

Series E Calculators Service Manual



HEWLETT hp PACKARD

Series E Calculators

SERVICE MANUAL

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General Information

1-1. INTRODUCTION

1-2. This service manual presents information to help you repair Hewlett-Packard Series E calculators. All models in Series E are covered by this one manual. For each model there are two pages that contain all the information applicable only to that particular model (including the list of replaceable parts); these pages are located at the end of section III. The rest of the manual is applicable to all Series E models.

1-3. This section gives you a general description of Series E calculators and an introduction to the organization and use of the *Series E Calculators Service Manual*. The sections following will help you:

a. **Learn how the calculator works: section II.**

b. **Learn how to troubleshoot and test the calculator: section III.**

c. **Learn how to take apart the calculator and put it together again: section IV.**

d. **Identify the electrical accessories available for use with Series E calculators: section V.**

1-4. DESCRIPTION

1-5. Series E calculators are designed to be inexpensive to manufacture and quick to service. The low cost and ease of service are made possible primarily by the following features:

a. All IC's are pressure-connected in a "sandwich" that can be quickly opened and closed. Thus, no desoldering or soldering of IC leads is ever necessary, and replacement of faulty IC's takes only seconds.

b. All discrete components of each calculator, which make up the power supply and recharger interface circuitry, are mounted on an inexpensive assembly that is also pressure-connected rather than soldered in place. Whenever components on this assembly fail, the assembly is replaced as a whole. Thus, no soldering or desoldering of discrete components is ever necessary.

c. Each calculator is capable of testing its IC's for failures. When a faulty IC is detected by this self-check, which is initiated by pressing two keys, an error indication is displayed. Pressing another key then results in the display of a number that signifies which IC has failed. Thus, the time required for troubleshooting is virtually eliminated.

1-6. Functionally, Series E calculators offer capabilities found in the HP-21 series. However, a programmable financial calculator is included, and all Series E calculators have additional features not found on previous HP calculators. In addition to the self-check capability mentioned above, these features include:

a. Temporarily displaying all 10 digits of the mantissa of the number in the X-register, regardless of the display format in effect.

b. Automatic punctuation in the display, separating each group of three digits to the left of the decimal point. This feature is implemented in two ways, depending on the country in which the calculator is sold: the display shows either a period for decimal point and a comma for the three-digit separator, or a comma for the decimal point and a period for the three-digit separator. For a complete description of how the punctuation version is determined, refer to paragraph 3-44. Procedures for changing the puncutation version are given in paragraph 3-47.

1-7. The features of each Series E calculator are described in its owner's handbook plus, depending on whether the calculator is designed for scientific or financial applications, either *Solving Problems With Your Hewlett-Packard Calculator* or *Your HP Financial Calculator: An Introduction to Financial Concepts and Problem Solving*. Specifications for Series E calculators are given in table 1-1.

1-8. IDENTIFICATION

1-9. The serial number of the calculator, which is located on the bottom case, is used for identification, indication of punctuation version, and determination of warranty status. Its format is described opposite.

1-10. The format for the serial number of the ac adapter/recharger is given in section V, Accessories.

*YYMM {A, B, Q, S} XXXXX

- XXXXX — Sequence number.
- A/B/Q/S — Location manufactured:
  - A = U.S.A.
  - B = Brazil
  - Q = United Kingdom
  - S = Singapore
- MM — Month manufactured.
- YY — Year manufactured (YY = years since 1960).
- * — Punctuation version indicator. (Refer to table 3-2.)

Table 1-1. Series E Calculator Specifications

Dimensions

- Length: 14.20 centimeters (5.59 inches).
- Width: 7.57 centimeters (2.98 inches).
- Height: 3.17 centimeters (1.25 inches).

Weight

- Calculator with battery pack: 200.48 grams (7.07 ounces).

Power

- Battery

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

  Operating time: 2 to 6 hours.

  Recharging time: 5 to 9 hours, calculator off; 17 hours, calculator on.

- AC Adapter/Rechargers

US	HP 82087A	90 to 120 Vac
Australia	HP 82088A	210 to 250 Vac
UK	HP 82089A	210 to 250 Vac
UK with RSA plug	HP 82089A Opt 001	210 to 250 Vac
Europe	HP 82090A	210 to 250 Vac

Output

- Display module consisting of 10 character positions plus an additional position for the mantissa sign and low battery indication.
- Each character position consists of nine light-emitting diode segments for displaying ***0*** through ***9***, ***0.*** through ***9.***, and ***0,*** through ***9,***.
- Mantissa of displayed numbers are separated into 3-digit groups with punctuation.
- Numbers are shown with a maximum of 10 digits, or a 7-digit mantissa and 2-digit exponent.
- Displayed numbers are rounded to the last displayed digit; calculations are performed internally with at least 10 digits.
- Minimum/maximum displayed number: ±***1.000000-99*** to ±***9.999999 99***.
- Special Indications

Error:	***Error n*** displayed when improper operation is attempted.
Overflow:	Overflow of the X-register results in a display of the number ±***9.999999 99***. Overflow of a storage register results in a display of ***Error 1***.
Underflow:	Zero in scientific notation display format. If in fixed point display format, automatically reverts to scientific notation display format for small numbers that would otherwise appear as zero.
Low Battery:	Dot in mantissa sign position lights for 1 to 25 minutes before display disappears.

Environmental Specifications

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

Principles of Operation

2-1. SERIES E ARCHITECTURE

2-2. The architecture of Series E calculators (see figure 2-1) is based on a CPU (Central Processing Unit) plus, depending on the particular model, one to three additional integrated circuits (IC's). The additional IC's are referred to as "data/ROM's" since they contain both data storage registers and read-only-memory (ROM). The CPU and data/ROM's utilize NMOS (N-channel Metal-Oxide-Semiconductor) technology.

2-3. Input to Series E calculators is through a keyboard with 30 keys. Output is through an LED (light-emitting diode) display module capable of displaying up to 10 characters.

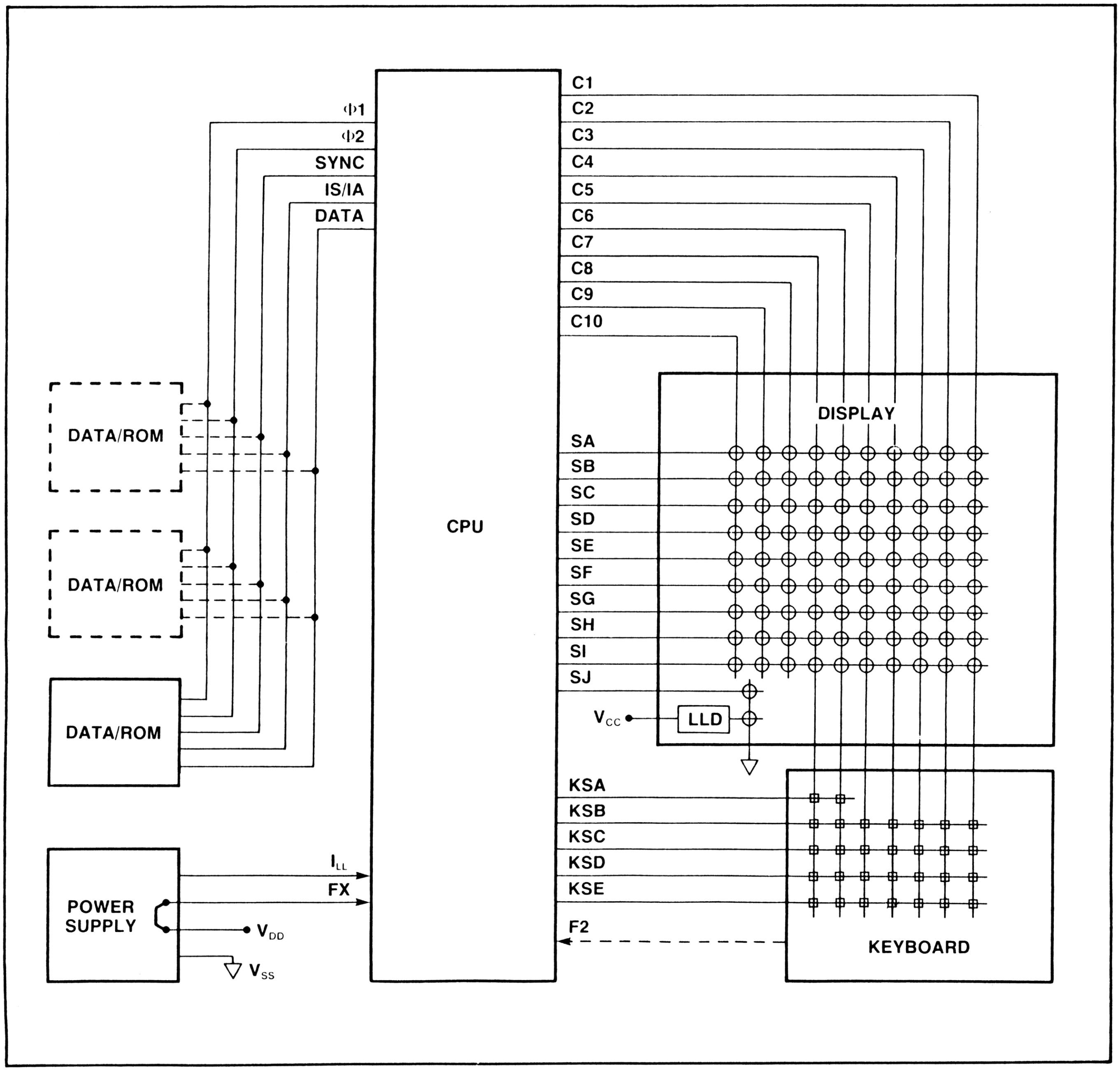


Figure 2-1. Series E Calculator Block Diagram

2-4. All IC's are pressure-connected in the logic-keyboard assembly. All discrete components of the calculator, which make up the power supply and recharger interface circuitry, are mounted on a single printed-circuit assembly (referred to for convenience as the power supply assembly).

2-5. CPU

2-6. The CPU is the "brain" of the calculator. Three versions of the CPU are used in Series E calculators: two for scientific models and one for financial models. These versions are identical except for the contents of their ROM portions.

2-7. The CPU includes system functions (arithmetic, control, and timing; cathode drivers; anode drivers; and ROM) that in previous HP personal calculators were divided among three or four separate IC's. In all, the CPU consists of 11 basic sections:

a. Timing and control.

b. Address, status, and format register.

c. Pointer and status counters.

d. Instruction buffer and decoding.

e. Data registers.

f. Arithmetic and logic unit.

g. Self-check logic.

h. Cathode driver logic.

i. Anode driver logic.

j. Keyboard interface.

k. ROM and associated logic.

2-8. Timing and Control

2-9. This section of the CPU includes logic for generating three timing signals used by the various IC's in the calculator: Φ1, Φ2, and SYNC. The frequency of the Φ1 and Φ2 pulses ranges from 110 to 240 kHz, depending on the characteristics of the particular CPU. The Φ1 pulses lead the Φ2 pulses by approximately two pulse widths. Bits of information on the IS/IA and DATA bus lines (see below) extend between successive trailing edges of Φ2 pulses.

2-10. 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 first SYNC pulse generated by the CPU following power-on is used by the data/ROM's to synchronize their internal timing circuits. Subsequently, the presence or absence of the SYNC pulse signifies to the data/ROM's whether information on the IS/IA line is an instruction or an address.

2-11. Additional logic in this section defines the 56-bit word time and generates signals which are used to regulate the scanning of the cathode and anode driver lines. Included here as well is the power-on reset logic, which ensures that certain arithmetic and status registers in the CPU are initialized correctly when the calculator is turned on. Unlike the corresponding system functions in the ACT of previous calculators, both the timing and power-on reset logic are entirely self-contained within the CPU.

2-12. Address, Status, and Format Register

2-13. This 56-bit register includes:

a. Twelve bits for the current instruction address.

b. Twenty-four bits for return instruction addresses necessary for branch instructions.

c. Four bits for display format information.

d. Sixteen bits for status information, including the result of the self-check (see below) and status of the F2 flag. On Series E models having a PRGM/RUN or BEGIN/END switch, this flag indicates to the CPU the status of the switch.

2-14. Data Registers

2-15. This section consists of eight 56-bit registers:

a. Three registers (A, B, and C) used for arithmetic operations by the arithmetic and logic unit and for formatting numbers to be displayed. The C-register is connected to the DATA line and therefore is used for data transfer operations with data storage registers in the data/ROM's.

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

c. Two registers (M and N) used for temporary internal storage and/or user storage of data.

2-16. Arithmetic and Logic Unit

2-17. The major portions of this section are:

a. Register input/output control logic for controlling data transfers among all CPU registers.

b. A 56-bit, serial, binary adder/subtracter for performing arithmetic operations on all or part of the data in the A-, B-, and C-registers.

2-18. Self-Check Logic

2-19. The self-check logic is used to check whether the logic, data registers, and read-only-memory in the IC's are correct. This check is done when the keys [STO] [ENTER↑] are pressed. The use of the self-check to identify a bad IC is discussed in paragraph 3-17.

2-20. Cathode Driver Logic

2-21. The cathode driver logic sequentially pulls the 10 cathode lines low for one 56-bit word time, beginning with cathode line 1. These lines are used both to drive the display and also to decode the keyboard.

2-22. Anode Driver Logic

2-23. The anode driver logic consists of the following:

a. Anode counter. This counter sequentially enables all 10 anode lines each word time. However, only those anode lines selected by the character and punctuation decoder/drivers are actually driven high during the scan.

b. Two 4-bit registers. As the scan of the anode lines advances from one line to another, these registers receive successive 4-bit codes from the A- and B-registers. The codes from the A-register represent, in BCD, the character (*0* through *9*, *E*, *r*, or *o*) to be displayed in each character position of the display. The codes from the B-register represent the punctuation (minus sign, period, or comma) to be displayed in each character position.

c. Character decoder/driver. This consists of logic that determines, from the BCD codes in the appropriate 4-bit register, the proper combination of anodes to be driven for representing a character. The combination of anodes for each character is stored in a small section of ROM associated with this logic.

d. Punctuation decoder/driver. This consists of logic and ROM for generating the proper punctuation from the BCD codes in the other 4-bit register. One of the four bits in the register signifies which punctuation system is in effect. This bit is connected externally to the FX pin of the power supply assembly. The punctuation system in effect is determined by whether a jumper wire connects the FX and V_{DD} pins of the power supply assembly.

2-24. Keyboard Interface

2-25. This section consists of logic plus two 4-bit key buffers. One buffer contains the code for a cathode line, the other the code for a key line. Five key lines (KSA through KSE) and seven cathode lines (C1 through C7) interface between here and the keyboard. When a key is pressed, it connects one of the cathode lines with one of the key lines. Since each cathode line is brought low by the CPU once every 12 word times, the key line under the pressed key is brought low by the cathode line there at the same rate. The logic waits 40 word times after the low key line is first detected to negate the effects of key bounce, which causes multiple entries. It then loads into the two buffers the codes for the cathode line and key line connected together. The resultant 8-bit keycode is used by the instructions in ROM to determine what operation is to be performed.

2-26. ROM and Associated Logic

2-27. Unlike the ACT of previous calculators, the CPU contains 1024 words of ROM. This ROM is the only section of the CPU that differs between the three CPU versions. ROM is further described in paragraph 2-32.

2-28. DATA/ROM's

2-29. The data/ROM's, which correspond to the memory of a digital computer, contain both data storage registers and read-only-memory. There are two types of data/ROM's in Series E calculators: one has 1024 words of ROM and four data storage registers; the other has 1536 words of ROM and 16 data storage registers. Different models in Series E have only one of the two or combinations of both. The quantity and types of data/ROM's in each model depend upon the amount of ROM and the number of data storage registers necessary for implementing its particular capabilities.

2-30. Data Storage Registers

2-31. The data storage registers in the data/ROM's are each 56 bits long. Each calculator has several of these registers available to the user for storing and recalling numbers. Some of these registers are also used internally only, for machine status and for scratch use during trigonometric, statistical, and financial calculations. In addition, programmable calculators use some of the registers for storage of program steps rather than data. Program storage registers contain seven program steps, since each program step is represented in the register by an 8-bit code.

2-32. ROM

2-33. The read-only-memory in the data/ROM's and in the CPU contains 10-bit instructions that are used by the CPU for executing all operations. Most operations require instructions stored in more than on ROM. However, only one ROM is accessed at any time. A ROM address register in each ROM receives a 12-bit address from the CPU on the IS/IA line, least significant bits first. A decoder associated with the ROM compares the two or three (depending on the size of the data/ROM) most significant bits of the address to the ROM's preassigned enable code. If a match is found, the enabled ROM outputs the instruction addressed 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 in the CPU.

2-34. KEYBOARD

2-35. Data is input to the calculator through a keyboard with 30 keys. Beneath the keys are the five key lines on an actuator, and beneath the actuator are the seven cathode lines on the logic-keyboard assembly. The key lines and cathode lines are located such that when a key is pressed, one key line makes electrical contact with one cathode line. (See figure 2-2.)

2-36. DISPLAY

2-37. Data is output from the CPU through a display module consisting of 10 character positions plus an additional position for the mantissa sign and low battery indication. Each character position is capable of displaying a character represented by a pattern of seven segments plus a period or comma represented by one or two additional segments. (See figure 2-3.)

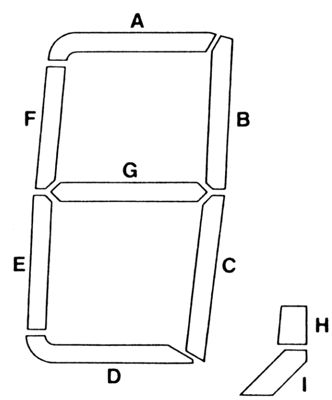


Figure 2-3. Displayed Digit Structure

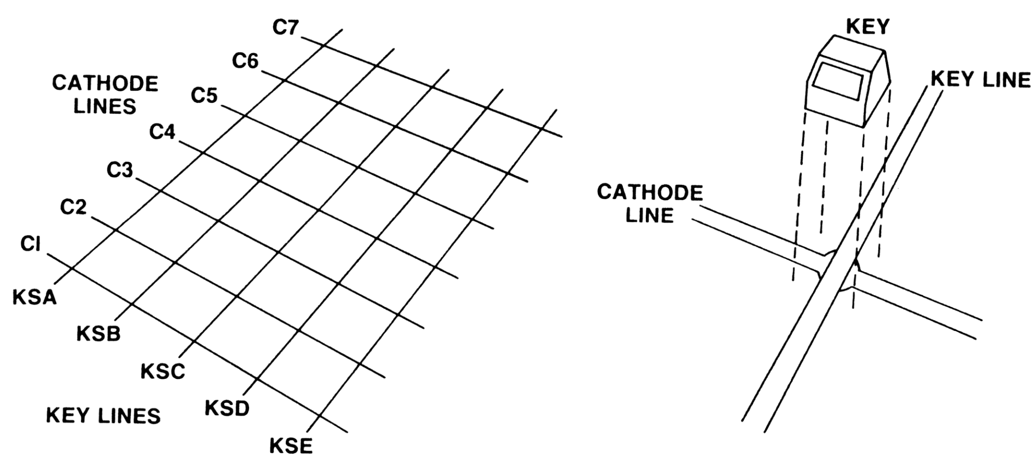


Figure 2-2. Keyboard Operation

2-38. Each segment is a cluster 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. At each character position, all nine LED segments share a common cathode, which is connected to one of the 10 cathode lines. (See figure 2-4.) The anodes of the corresponding segments of all 10 character positions are bonded together and connected to one of the anode lines SA through SI. Anode line SJ is connected only to a single LED segment, used for displaying the mantissa sign, located to the left of character position 1.

2-39. To display a number, the CPU sequentially grounds the cathode lines while selectively driving current through the anode lines. Each cathode line is grounded for one 56-bit word time every 10 word times. (See figure 2-5.) Thus, all nine LED segments at each character position have their cathode grounded for one word time. During each word time, the CPU sequentially scans its anode driver logic to determine which of the nine anodes are to be driven during that word time. The anodes are scanned in the order shown in figure 2-6.

2-40. The scan time for anodes *A* through *G* and *J* is 6 bit times, that for anode *H* is 4 bit times, and that for anode *I* is 3 bit times. (Note that this amounts to only 55 bits each word time. During the first bit time of each word time, none of the anodes is driven. This is done to ensure that the *I* segment is not lit when the next cathode line is pulled low.) 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.

2-41. Segments *H* and *I* are used for displaying the punctuation. The anodes of both segments are driven to display a comma, while only the anode of segment *H* is driven to display a period. The cathode of the LED segment used for displaying the mantissa sign is connected directly to ground at all times. However, the CPU drives current through its anode only while cathode line C1 is low.

2-42. The low battery indication is an LED dot located above the mantissa minus sign at the left of the display. The cathode of this LED dot is connected to ground, and its anode is driven by the output of the LLD

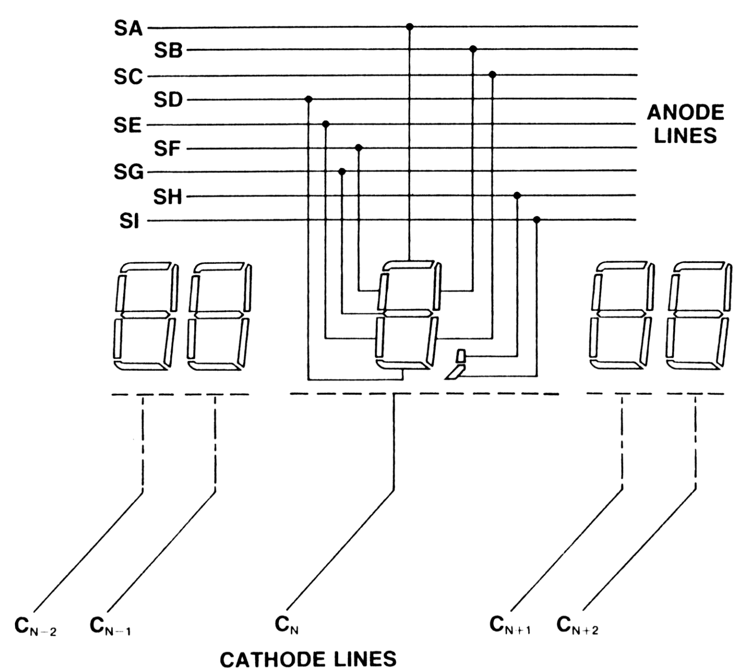


Figure 2-4. Anode and Cathode Lines

(Low Level Detector) IC. Bonded to the display module, this bipolar IC consists of a very precise differential amplifier and voltage divider. Its circuit is designed to output 0.8 to 1.8 mA of current when the instantaneous value of the supply voltage V_{CC} drops below (depending on the particular IC) 2.165V to 2.225V.

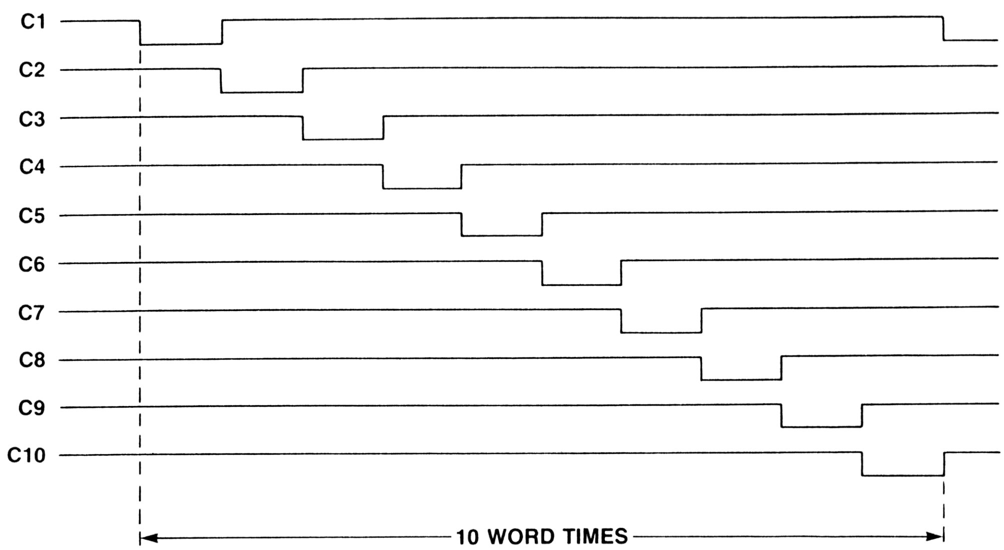


Figure 2-5. Scan of Cathode Lines

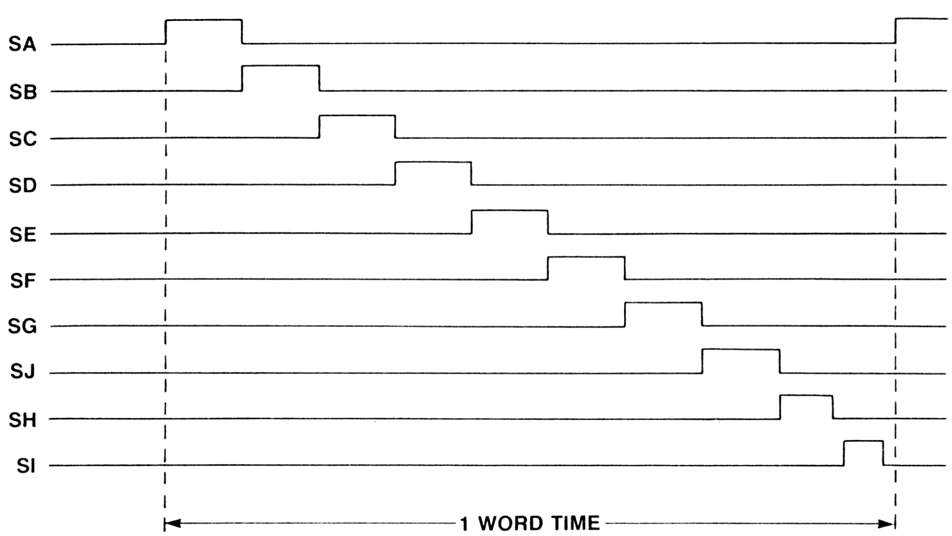


Figure 2-6. Scan of Anode Lines

2-43. POWER SUPPLY

2-44. The primary power source for Series E calculators is a battery pack consisting of two quick-charge nickel-cadmium batteries. The calculator can also be powered from ac line voltage (approximately 115 or 240 Vac), and the batteries charged, through the use of an ac adapter/recharger.

2-45. The power supply consists of circuitry for converting the battery or ac power to the levels necessary for operating the calculator, plus circuitry for charging the batteries. These circuits are implemented with discrete components that are mounted on a single printed-circuit assembly.

2-46. The power supply is basically a dc-to-dc converter, plus a half-wave rectifier for converting the 10 Vac from the ac adapter/recharger to dc. The operation of the circuitry is similar to that used in the HP-21 series of calculators. There are two significant differences, however. First, V_{GG} has been eliminated since it is not required by the design of the IC's used in Series E calculators. Second, V_{LL} has been replaced by a constant current source (I_{LL}). (V_{LL} was an unregulated voltage applied to the anode drivers in the ROM 0 IC, and the current through the display LED's was regulated by a constant current source located in the cathode driver IC.) The operation of the power supply and battery charging circuitry will not be explained in detail here, since the power supply assembly is replaced as a whole when it is not operating properly.

2-47. SYSTEM OPERATION

2-48. While the calculator is on but idle, the CPU continually drives the display and simultaneously calls and executes instructions from a microprogram loop in ROM. These instructions tell the CPU to interrogate its keyboard control and status control portions to determine whether a key has been pressed or the position of a switch (if present on the calculator) has been changed.

2-49. If a key has been pressed, the ACT loads into its key buffer an 8-bit keycode corresponding to the key pressed. If the key pressed is a prefix key, the CPU continues driving the display and monitoring the keyboard and status until the next key is pressed. The CPU then merges the keycodes for the prefix and subsequent key (or keys, in some cases) into a single, 8-bit keycode.

2-50. To fetch an instruction from ROM, the CPU places the 12-bit address of the instruction on the IS/IA line during bit times 16 through 27. (See figure 2-7.) In response, the ROM containing the location addressed places the 10-bit contents of that location onto the IS/IA line during bit times 46 through 55. Usually, these contents represent an instruction to be executed by the CPU (they can also represent an address), and the CPU generates a SYNC pulse during the same interval to tell the data/ROM's that an instruction is present on the IS/IA line. Each data/ROM monitors

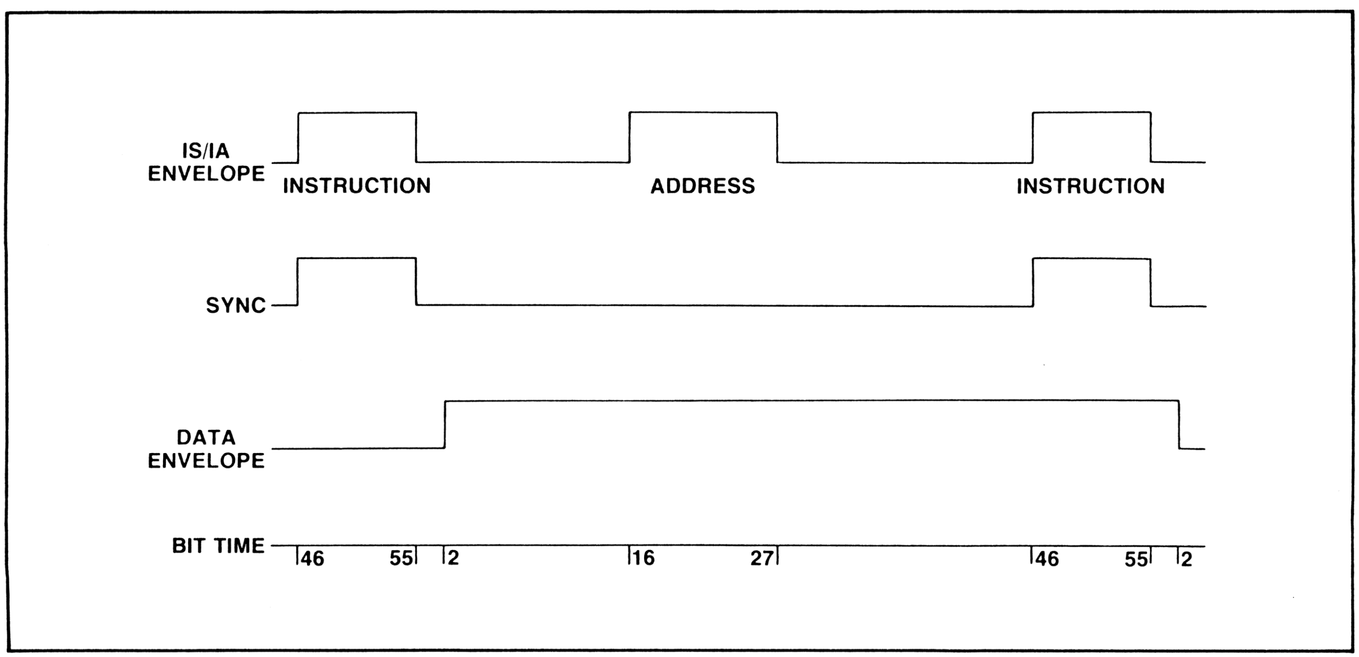


Figure 2-7. IS/IA, SYNC, and DATA Timing

the instruction to check whether action (such as outputting data) is required of it. The CPU executes the instruction during the following word time, and increments the contents of its instruction address register by 1 to specify the new address.

2-51. If the instruction executed 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 56-bit data transfer. Thus, the data specified appears on the DATA line beginning at bit time 2 of the following word time.

SECTION III

Troubleshooting and Testing

3-1. INTRODUCTION

3-2. This section describes how to fix the various problems you may find on Series E calculators. Most of the information applies to all Series E models. However, for each model there are two pages that contain all the information (self-check codes, replaceable parts, and key entry test) that applies to only that particular model. These pages are located at the end of the section.

3-3. The troubleshooting procedures described below were developed partly from our experience with calculators returned to the factory for repair. Since the Corvallis Repair Center receives calculators from the entire USA, we have worked on many calculators with all possible problems. Therefore, these procedures will help you fix our calculators as quickly and completely as possible.

3-4. Frequently a calculator is received for repair with a message from the customer telling you what the problem is. The problems you may find on Series E calculators are listed in table 3-1, together with the parts that could cause the problem. The table also tells you where to find procedures for fixing each problem. If the problem mentioned by the customer does not require you to do the self-check (paragraph 3-17) or key entry test (paragraph 3-35), be sure that you do them, as well as replacing any damaged mechanical parts, before returning the calculator to the customer.

3-5. If the calculator is received for repair with no message from the customer telling you what the problem is, proceed as follows:

a. **Test for a discharged or bad battery pack, a bad CPU, bad power supply assembly, or bad display module by switching the calculator on.** If you get no display, you can determine which of these parts is bad using the procedures of paragraph 3-11, No Display.

b. **Test for bad IC's or a bad display module by doing the self-check.** This test is described in paragraph 3-17.

c. **Test for keys not working properly** using the Key Entry Test, described in paragraph 3-35.

d. **Look for a damaged display window, top case, bottom case, foot, or key.** If you find damage and have not already replaced the part, do it now.

3-6. POOR CHARGE RETENTION

3-7. If the battery pack cannot be charged or does not hold its charge very long, this can be caused by any of the following:

a. The ac adapter/recharger is bad.

b. The battery pack is bad.

c. The charging circuitry on the power supply assembly is bad.

d. There is a short between traces on the power supply assembly, which results in too much current being drained from the battery pack.

Note: When the power supply assembly must be replaced because of either condition *c* or condition *d*, you may have to remove a jumper wire from this assembly, depending on the display punctuation version used. For more information, refer to paragraph 3-42, Power Supply Replacement.

3-8. The procedures below will help you determine which of the conditions listed above is causing the problem.

a. Ensure that the calculator is switched off, and remove the battery pack from the calculator.

b. Plug the recharger into the calculator.

c. Plug the recharger into a power outlet of the correct voltage. (If you are not certain of the correct voltage, refer to table 5-1.)

d. Connect a 10Ω, 5W to 10W, 5% resistor across the battery contacts in the calculator.

e. With a dc voltmeter, measure the voltage V_R across the resistor. If V_R is between 2.0 and 4.0 Vdc, then either the battery pack is bad or there is a shorted trace on the power supply assembly; proceed with step *f* to determine which of these is causing the problem. If V_R is not between 2.0 and 4.0 Vdc, then either the recharger is bad or the charging circuitry on the power supply assembly is bad; proceed with step *k* to determine which of these is causing the problem.

f. Unplug the recharger from the calculator.

g. Connect a dc power supply to the battery contacts of the calculator.

CAUTION

Ensure that the power supply is connected to the contacts with correct polarity. The negative (−) battery contact is the one closest to the top of the calculator.

h. Connect a current meter, with correct polarity, between one lead of the power supply and the correct battery contact.

i. Switch the power supply on and set it to 2.5 Vdc.

j. Switch the calculator on and check whether the current going into the calculator is more or less than 185 mA (scientific models) or 170 mA (financial models). If the meter indicates more current than that specified, then probably a short on the power supply assembly is causing excessive current drain from the battery pack. (If you replace the power supply assembly, check whether the old assembly

Table 3-1. Calculator Problems, Causes, and Troubleshooting

PROBLEM	CAUSE	TROUBLESHOOTING PROCEDURES
The battery pack cannot be charged or does not hold its charge very long.	1. Bad battery pack. 2. Bad ac adapter/recharger. 3. Bad power supply assembly.	Refer to Poor Charge Retention (paragraph 3-6).
The calculator does not indicate a low battery condition before going completely dead.	1. Bad display module. 2. Bad power supply assembly. 3. Bad logic-keyboard assembly.	Refer to No Low Battery Indication (paragraph 3-9).
The calculator indicates a low battery condition when the battery pack is sufficiently charged.	Poor contact between batteries and battery contacts.	Clean battery contacts.
There is no display when the calculator is switched on.	1. Discharged or bad battery pack. 2. Bad power supply assembly. 3. Bad CPU. 4. Bad display module.	Refer to No Display (paragraph 3-11).
The display is dim.	Bad power supply assembly.	Replace power supply assembly. (Refer to Power Supply Replacement, paragraph 3-42.)
LED segments missing or added in display.	1. Bad display module. 2. Bad CPU. 3. Bad logic-keyboard assembly.	Refer to Bad Display (paragraph 3-14).
Certain functions or operations do not work correctly.	1. Bad data/ROM. 2. Bad CPU. 3. Bad logic-keyboard assembly.	Do the Self-Check (paragraph 3-17).
Certain keys have no effect.	1. Bad actuator. 2. Bad keys. 3. Bad logic-keyboard assembly. 4. Bad CPU.	Do the Self-Check (paragraph 3-17) and then the Key Entry Test (paragraph 3-35).

has a jumper wire on it; refer to paragraph 3-42.) If the meter indicates less current than that specified, then probably the battery pack is bad.

k. Unplug the recharger from the calculator.

l. With an ac voltmeter, measure the voltage at the power outlet (V_{IN}) and the voltage at the output of the recharger (V_{OUT}). V_{OUT} should be approximately 10.00 Vac. More exactly, V_{OUT} should equal $V_{IN}/230 \times 10.0$ Vac ± 5% or $V_{IN}/115 \times 10.00$ Vac ± 1.5%.

m. If V_{OUT} is not within the correct range, the recharger is bad. If V_{OUT} is within the correct range, connect a 12Ω, 5W, 5% resistor across the output of the recharger, and measure the voltage V_R arcoss the resistor with an ac voltmeter. If V_R is between 4.71 and 5.06 Vac (line voltage approximately 230 Vac) or 4.86 and 5.23 Vac (line voltage approximately 115 Vac), the recharger is good and the charging circuitry on the power supply assembly is bad. (If you replace the power supply assembly, check whether the old assembly has a jumper wire on it; refer to paragraph 3-42.) If V_R is not within the correct range, the recharger is bad.

3-9. NO LOW BATTERY INDICATION

3-10. If the low battery indication is working correctly, the LLD IC senses the low battery state and lights a special dot on the display module. Therefore, if the low battery indication is *not* working correctly, it is likely that either the LLD IC is bad or the display module is bad. However, since the LLD IC is mounted on the display module, replacing the display module should fix the problem in either case.

3-11. NO DISPLAY

3-12. If there is no display when the calculator is switched on, this can be caused by any of the following:

a. The battery pack is discharged or bad.

b. The power supply assembly is bad.

c. The CPU is bad.

d. The display module is bad.

3-13. To determine which of these is causing the problem, follow the procedures below:

a. Replace the battery pack with a new one.

(1) If this results in a display when the calculator is switched on, the old battery pack could be bad or it could merely need charging. To determine which of these is the case, store the pack and test it later when you have time. The procedures for testing the battery pack are described in paragraph 5-5.

(2) If replacing the battery pack does not result in a display when the calculator is switched on, the old pack was probably good. To save time, leave the new pack in the calculator and store the old pack for later use. Proceed with step *b* to determine why the calculator shows no display.

b. Replace the power supply assembly with a new one.

Note: If you get a display after replacing the power supply assembly, you may have to remove a jumper wire from this assembly, depending on the display punctuation version used. For more information, refer to paragraph 3-42, Power Supply Replacement.

(1) If replacing the power supply assembly results in a display when the calculator is switched on, then the original power supply assembly was bad.

(2) If replacing the power supply assembly does not result in a display when the calculator is switched on, then the original power supply assembly was good. Reinstall it in the calculator and proceed with step *c*.

c. At this point you have determined that both the battery pack and the power supply assembly are good, so the cause of the problem must be either a bad CPU or a bad display module. Try replacing the CPU first, since it is much more likely to go bad than the display module. If you still get no display when the calculator is switched on, return the original CPU to the calculator and replace the display module.

3-14. BAD DISPLAY

3-15. If LED segments are missing or added in the display, this can be caused by any of the following:

a. The display module is bad.

b. The CPU, which contains the cathode and anode drivers, is bad.

c. The logic-keyboard assembly, which contains the cathode and anode lines leading to the display module, is bad.

3-16. To determine which of these is causing the problem, replace them, one at a time in the order listed above, until the LED segments of the display are lit properly.

3-17. SELF-CHECK

3-18. The self-check feature of Series E calculators tests whether the logic, data registers, and read-only-memory in the IC's are correct. If the self-check does not find a bad IC, the calculator displays ***-8,8,8,8,8,8,8,8,8,8,***. If the self-check finds a bad IC, the calculator displays ***Error 9***. When this error indication is displayed, pressing any key will result in a display of a digit signifying which IC is bad.

Note: The self-check tests almost 100 percent of the data/ROM's but not all of the CPU, since the CPU contains more than only data registers and read-only-memory. Therefore, the CPU *could* be bad even if the self-check doesn't say so; however, it is quite likely that if the calculator turns on correctly (which obviously must happen before you can do the self-check), the rest of the CPU is good. The rest of the CPU is checked more completely by the key entry test (refer to paragraph 3-35), which you should do after the self-check is successful and the calculator is reassembled.

3-19. The self-check can be done:

a. When the calculator is fully assembled, as it is when received from the customer. The procedures for doing the self-check at this time are given in paragraph 3-20. To interpret the results of the self-check, refer to paragraphs 3-22 and 3-23.

b. When the calculator is disassembled, as it is when you are replacing a bad IC. The procedures for doing the self-check at this time are given in paragraph 3-21. To interpret the results of the self-check, refer to paragraphs 3-22 and 3-23.

3-20. To do the self-check when the calculator is fully assembled:

a. Switch the calculator on.

b. If the calculator has a PRGM/RUN switch, set it to RUN.

c. Press [STO] [ENTER↑].

3-21. To do the self-check when the calculator is disassembled:

a. Insert the power supply assembly and IC's into the support plate. (Detailed instructions for inserting these parts are given under Assembling the Electronic Package, section IV.)

b. Hold the support plate by its top edge and slide its lower edge onto an EPA holding fixture (part number T-155803) such that the two locating pins near the tool number of the fixture pass into the U-shaped channels in the lower edge of the support plate.

c. Lower the top edge of the support plate until the support plate rests on the supporting pins of the fixture.

d. Place the logic-keyboard assembly onto the support plate. (Detailed instructions for this step are given under Assembling the Electronic Package, section IV.) The retaining clips should *not* be inserted around the edges of the logic-keyboard assembly and support plate.

e. Pull the handles of both toggle clamps simultaneously upward and then inward until they lock in a vertical position, securing the logic-keyboard assembly on the support plate.

f. Position the power contact board, with the battery contacts facing up, over the locating pin at the upper right of the fixture. Lower the power contact board so that the locating pin passes through the hole between the battery contacts.

g. Carefully insert the display module between the upper edges of the logic-keyboard assembly and the support plate.

h. Connect a dc power supply to the battery contacts on the power contact board.

> **CAUTION**
>
> Be sure that the power supply is connected to the battery contacts with correct polarity. The negative (–) battery contact is the one at the *top* when the power contact board is secured on the holding fixture and the tool number of the fixture is facing you.

i. Switch the power supply on and set it to 2.5 Vdc. The display should turn on, since the switch contact traces on the logic-keyboard assembly are shorted by the pads on the toggle clamps.

j. If the calculator were fully assembled, you would do the self-check by pressing STO ENTER↑. Since the top case with the keyboard is not covering the logic-keyboard assembly now, you cannot do the self-check by pressing these keys. However, you can simulate these keystrokes by successively connecting together the key line and cathode line that would normally be connected together when each key is pressed. The contact points for the STO and ENTER↑ keys are shown in figure 3-1. (Note that there are two different contact points shown for the STO key, one for scientific models and one for financial models. This is so because the location of the STO key is different on scientific models than on financial models.) To connect the points together, merely touch the ends of a pair of clip leads to the points indicated. The display blinks when proper contact is made. Thus, to simulate pressing the STO ENTER↑ keys:

(1) Connect the points shown for the STO key. Be sure that you connect the proper points, which depend on whether the calculator is a scientific or financial model.

(2) Connect the points shown for the ENTER↑ key.

3-22. Within a few seconds after you do the self-check, the calculator should display one of the following:

a. ***-8,8,8,8,8,8,8,8,8,8,***. This display indicates that all read-only-memory and data registers are good. Proceed with paragraph 3-24 to check the display.

b. ***Error 9.*** This display indicates that an IC is bad. To determine which IC should be replaced, proceed with paragraph 3-27.

3-23. If within a few seconds after you do the self-check you do not get one of the displays shown above, the self-check feature itself is not operating properly. When this happens, proceed with paragraph 3-31.

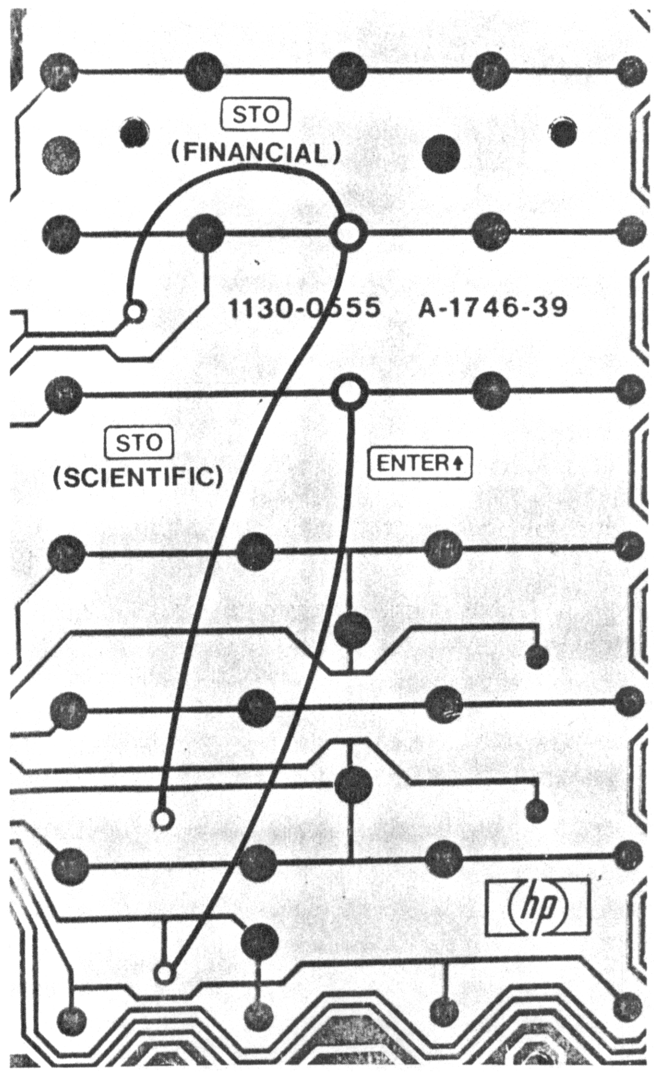


Figure 3-1. Self-Check Contact Points

3-24. Self-Check Shows All 8's

3-25. A display of ***-8,8,8,8,8,8,8,8,8,8,*** indicates that all read-only-memory and data registers are good. Every LED segment in the display (except the one used for the low battery indication) should now be lit. Check whether all segments of all digits are displayed and that the brightness of all segments is the same. In particular, be sure that both segments that make up the commas separating the 8's are displayed. Problems with the display can be caused by any of the following:

a. The display module is bad.

b. The CPU is bad.

c. The logic-keyboard assembly is bad.

3-26. If necessary, replace these parts, one at a time in the order listed above, until all segments are displayed correctly after you do the self-check.

3-27. Self-Check Shows *Error 9*

3-28. A display of ***Error 9*** indicates that an IC is bad. To determine which IC should be replaced:

a. If the calculator is fully assembled, press any key on the keyboard.

b. If the calculator is disassembled and the electronic package is mounted in the EPA holding fixture, connect together again any two contact points shown in figure 3-2 for the [STO] or [ENTER↑] key.

> **Note:** If you want to do the self-check again after step *a* or *b* of the preceding paragraph, you should first remove the power from the calculator, then apply power again. Otherwise, the IC code displayed the second time will not be the same as the code displayed the first time. To remove and reapply the power, or switch the power supply off and on if the calculator is disassembled and the electronic package is mounted in an EPA holding fixture.

3-29. After you do step *a* or *b* of the preceding paragraph, the calculator should display a digit to indicate the bad IC. If it does not, refer to paragraph 3-31. If it does, refer to the table at the end of this section listing the self-check IC codes for the calculator being repaired. This table tells you the reference designation of the bad IC. (Note that the digit displayed is *not* the reference designation number of the IC.) The table also tells you the part number stamped on the IC. This part number is different than the part number listed for the IC in the list of replaceable parts, which is the part number you should use when ordering more IC's. (Note that some IC's may be stamped with either of two part numbers.) You can locate any IC by looking at the exploded view of figure 3-4. This illustration shows each IC labeled with its reference designation as well as with its index number for the list of replaceable parts. The parts list for each Series E model appears in a table below the table containing the self-check IC codes.

> **Note:** The IC indicated by a particular digit is *not* the same for all Series E models. When you refer to the table containing the self-check IC codes, be sure that the model number of the calculator being repaired appears in the title above the table.

3-30. After you replace the IC indicated in the table for the calculator being repaired, do the self-check again to make sure that replacing this IC has actually fixed the calculator. If this still results in a display of ***Error 9*** and then the same digit, disassemble the calculator again and reassemble it with a new logic-keyboard assembly and the original IC's. The reason for this is that the self-check operation cannot tell the difference between a bad IC and an open IS/IA or DATA line. Therefore, when replacing the IC listed does not result in a successful self-check, it is likely that there is a break in one of these lines somewhere on the logic-keyboard assembly.

3-31. Self-Check Does Not Work

3-32. In certain, relatively infrequent cases, the self-check feature itself may not be operating properly, and one of the following results:

a. The calculator does not display either ***Error 9*** or ***-8,8,8,8,8,8,8,8,8,8,*** within a few seconds after you do the self-check.

b. After you press any key (or connect a key line to a cathode line) following a display of ***Error 9,*** the calculator does not display a digit in the range indicated by the appropriate self-check IC table.

3-33. If the self-check feature is not operating properly, this can be caused by any of the following:

a. A data/ROM is bad. One or more of the data/ROM's in each calculator contains a small set of instructions used for executing the self-check operation, as well as the instructions for decoding the [STO] [ENTER↑] key sequence. In addition, each data/ROM contains a few 10-bit words which must be good in order for the self-check to work properly.

b. The CPU is bad. The CPU contains the logic necessary for executing all operations on the calculator, including the self-check operation.

c. The logic-keyboard assembly is bad. If there is a break in the IS/IA line leading to the data/ROM containing the instructions used for executing the self-check operation, the self-check will not work.

3-34. When the self-check feature does not operate properly, replace the following parts, one at a time in the order shown, until the self-check operates properly:

a. The CPU (U1).

b. Data/ROM U2.

c. The remaining data/ROM's, if any, one at a time.

d. The logic-keyboard assembly.

3-35. KEY ENTRY TEST

3-36. The key entry test checks whether every key on the keyboard is being entered. In addition, it checks portions of the CPU not checked by the self-check.

3-37. **The key entry test should always be done before returning the calculator to the customer. It is important that the self-check always be done before the key entry test.** When a certain key has no effect, doing the self-check first eliminates the data/ROM's as a possible cause of the problem.

3-38. As with the self-check codes and replaceable parts lists, there is a different key entry test for each calculator model in Series E. The key entry test for each model is shown in a table located on the back of the page containing the self-check IC codes and replaceable parts list.

3-39. To do the key entry test, refer to the table for the calculator under repair. Press the keys shown there under "PRESS" or (when the RUN/PRGM switch or BEGIN/END switch must be set and later changed) under "PRESS/SWITCH." Note that these keys show the functions appearing on the faces of the keys to be pressed, even when the actual function entered is a prefixed function printed above or on the lower face of the key. The table for a key entry test having several prefixed functions shows the actual functions entered under "FUNCTION."

3-40. At the end of the key entry test, the calculator should display the number shown in the last line of the table under "DISPLAY." If it does not, this can be caused by any of the following:

a. The key actuator is bad.

b. A key is bad.

c. The logic-keyboard assembly is bad.

d. The CPU is bad.

> **Note:** The tables show displays using a period for the decimal point and a comma for the three-digit separator. These will of course be interchanged on calculators using the other display punctuation version.

3-41. If you do not get the correct display at the end of the test, do the test again from the beginning, this time checking the display after each step. The step at which you do not get the correct display can help you determine which key might be bad. Then replace the parts listed above, one at a time in the order shown, until you get the correct display at the end of the test.

3-42. POWER SUPPLY REPLACEMENT

3-43. There are three calculator problems that may require you to replace the power supply assembly:

a. The battery pack cannot be charged or does not hold its charge very long.

b. There is no display when the calculator is switched on.

c. The display is dim. (I_{LL} is low.)

3-44. If replacing the power supply assembly fixes any of these problems, you can leave the new assembly in the calculator *if it is the correct version*. There are two versions of the power supply assembly: one has a jumper wire connecting two traces on it, while the other does not have this jumper wire. The presence or absence of this jumper wire determines which of the two puncutuation versions is used in the calculator's display.

3-45. The location of the jumper wire is shown in figure 3-2. If the jumper wire has been removed, you will see an asterisk (*) before the serial number on the bottom case. Table 3-2 summarizes how to identify the punctuation version from the power supply assembly, serial number, or display.

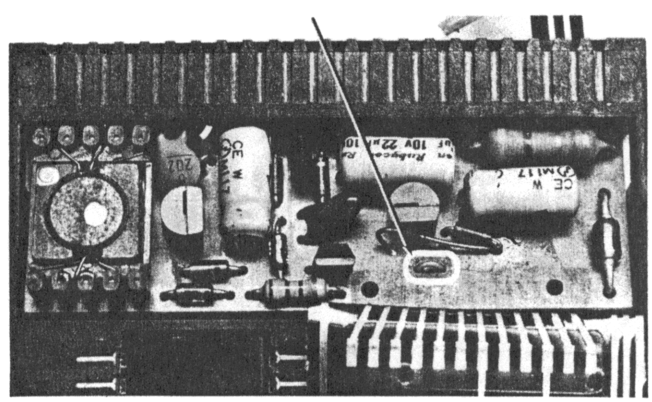


Figure 3-2. Location of Jumper Wire

3-46. **If there is no jumper wire on the bad power supply assembly that you removed from the calculator, remove the jumper wire from the new power supply assembly that you replaced it with.**

Table 3-2. Identification of Display Punctuation Versions

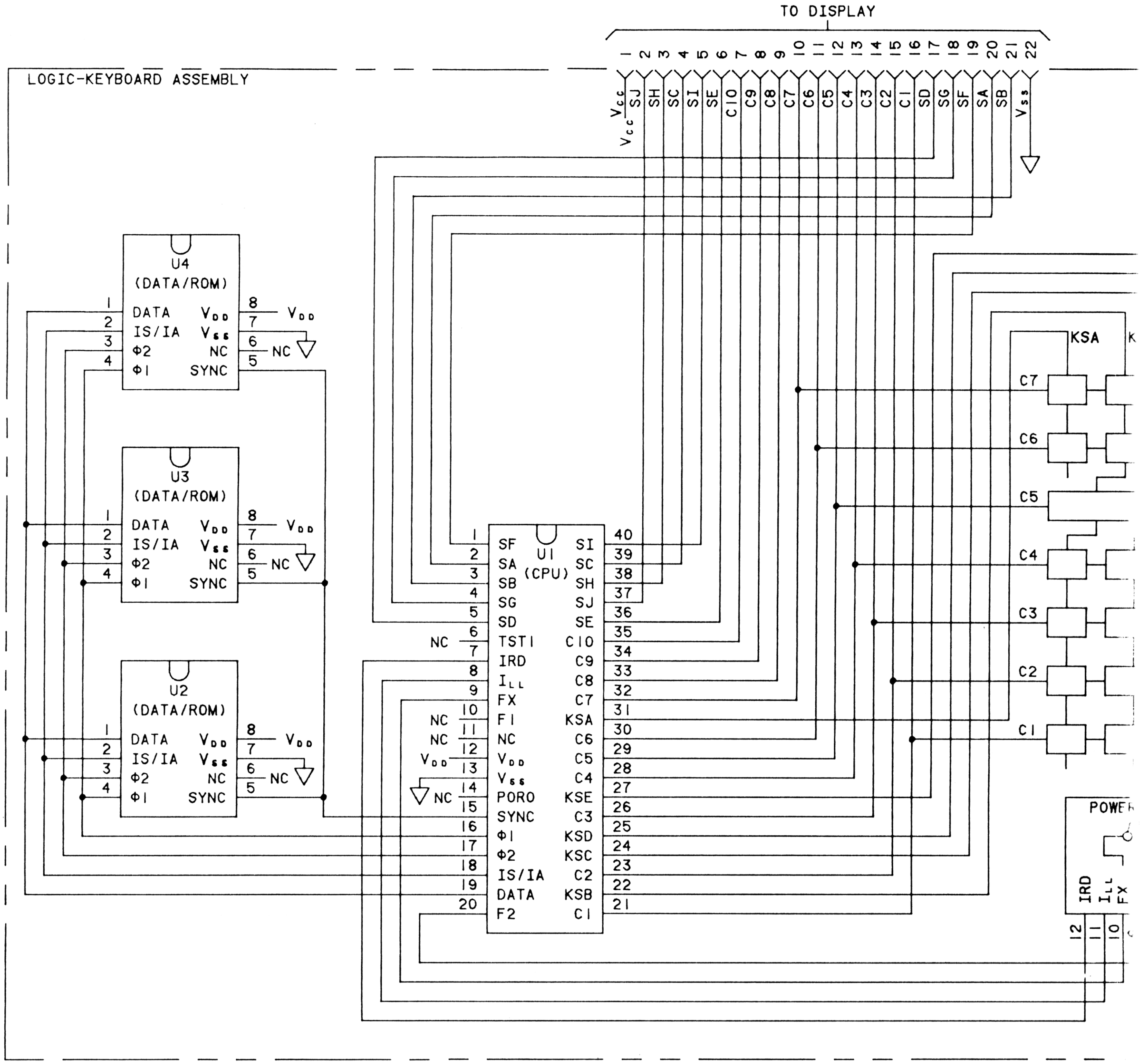
JUMPER WIRE ON POWER SUPPLY?	ASTERISK BEFORE SERIAL NUMBER?	DECIMAL POINT	THREE-DIGIT SEPARATOR	EXAMPLE
Yes	No	Period	Comma	**12,345,678.90**
No	Yes	Comma	Period	**12.345.678,90**

3-47. CHANGING DISPLAY PUNCTUATION VERSION

3-48. **If a customer returns a calculator with a request to change its punctuation version,** this can easily be done. Switch the calculator on and check whether the display shows a period or a comma for the decimal point.

a. If it shows a period, disassemble the calculator, remove the jumper wire from the power supply assembly, then reassemble the calculator.

b. If it shows a comma, disassemble the calculator, insert a jumper wire into the power supply assembly (see figure 3-2), then reassemble the calculator.



NOTE: THIS SCHEMATIC DIAGRAM IS APPLICABLE TO EVERY CALCULATOR MODEL IN THE E SERIES. HOWEVER:

1. NOT EVERY MODEL HAS IC'S U3 AND U4. THE IC'S INCLUDED IN EACH PARTICULAR MODEL ARE LISTED IN ITS TABLE OF REPLACEABLE PARTS.

2. NOT EVERY MODEL HAS SWITCH S2. WHEN INCLUDED, IT IS CLOSED WHEN THE SWITCH IS SET TOWARD THE RIGHT.

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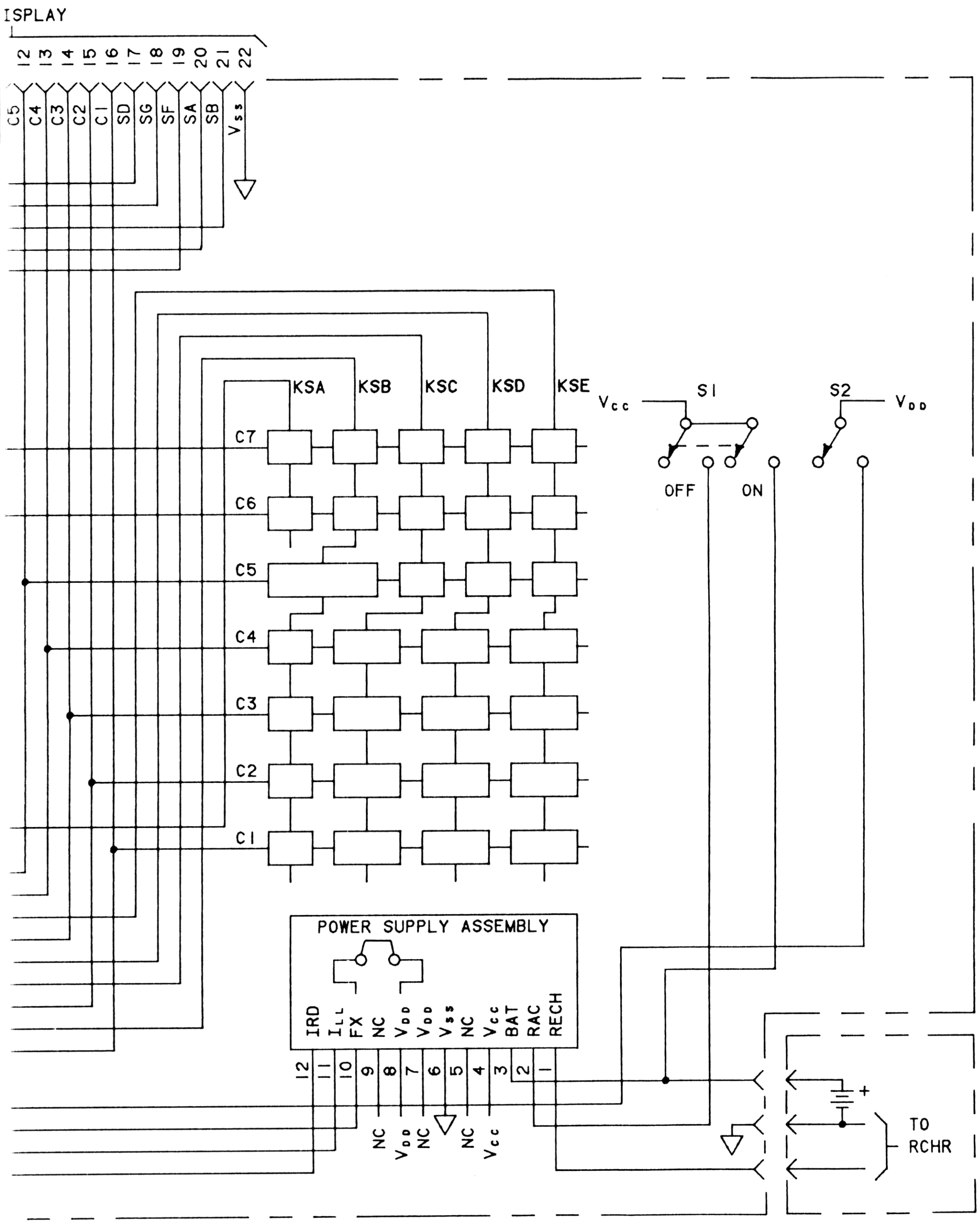
Figure 3-3. Series E Calculator Schematic Diagram



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ımatic Diagram

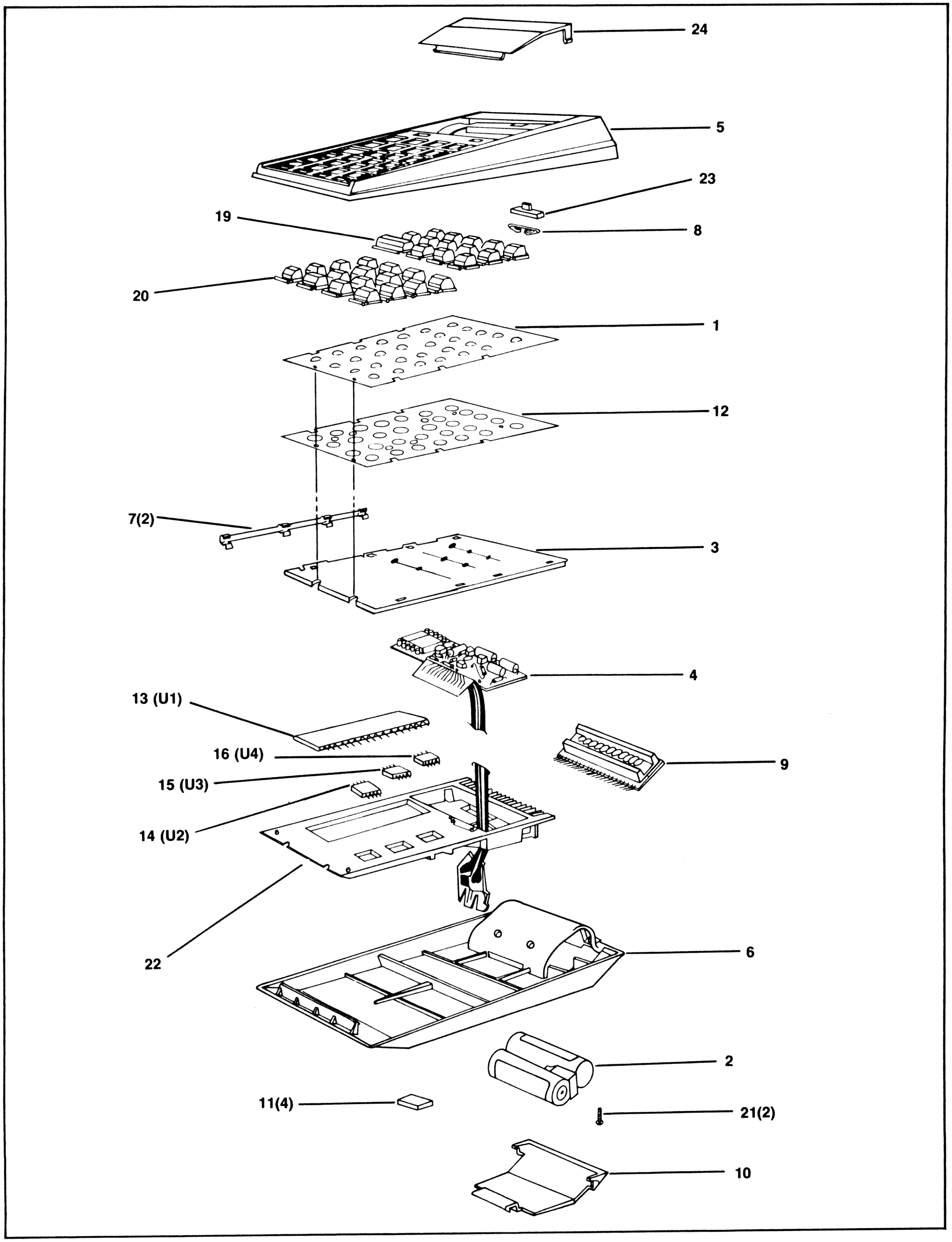


Figure 3-4. Series E Calculator Exploded View

Table 3-3. HP-31E Self-Check IC Codes

SELF-CHECK CODE	REFERENCE DESIGNATION	STAMPED HP PART NUMBER
0	U1	1820-2105, 1MA4-0001
1	U2	1MA1-0002, 1MA3-0001
2	U1	1820-2105, 1MA4-0001
3	U2	1MA1-0002, 1MA3-0001

Table 3-4. HP-31E Replaceable Parts

INDEX NUMBER, FIGURE 3-4	HP PART NUMBER	DESCRIPTION	QTY
1	1130-0554	ACTUATOR, key	1
2	00031-60004	ASSEMBLY, battery pack	1
3	1130-0555	ASSEMBLY, logic-keyboard	1
4	00031-60002	ASSEMBLY, power circuit	1
5	00031-60001	ASSEMBLY, top case	1
6	00031-40002	BOTTOM CASE	1
7	1600-0714	CLIP, retaining	2
8	1460-1691	CONTACT, switch	1
9	1990-0657	DISPLAY MODULE	1
10	00031-40004	DOOR, battery	1
11	0403-0267	FOOT	4
12	0340-0666	INSULATOR	1
13	00031-80003	INTEGRATED CIRCUIT, U1 (CPU)	1
14	00031-80004	INTEGRATED CIRCUIT, U2 (data/ROM)	1
17	00031-40014	KEY, $\boxed{f}$	1
19	00031-40008	KEY CLUSTER, top three rows	1
20	00031-40009	KEY CLUSTER, bottom four rows	1
21	0624-0303	SCREW, 2-28 × 0.312 inch	2
22	00031-40005	SUPPORT PLATE	1
23	00031-40012	SWITCH, slide	1
24	00031-40003	WINDOW, display	1

Table 3-5. HP-31E Key Entry Test

TEST STEP	PRESS	DISPLAY
1	[f] [√x] 8	0.00000000
2	[•]	0.
3	5	0.5
4	[1/x]	2.00000000
5	3	3.
6	[y^x]	8.00000000
7	[e^x]	2,980.957987
8	[x⇄y]	0.00000000
9	[R↓]	2,980.957987
10	[STO] 2	2,980.957987
11	7	7.
12	[ENTER↑]	7.00000000
13	6	6.
14	[−]	1.00000000
15	90	90.
16	[÷]	0.01111111
17	1	1.
18	[CLx]	0.00000000
19	[+]	0.01111111
20	[RCL] 2	2,980.957987
21	[LN]	8.00000000
22	[×]	0.08888889
23	[CHS]	−0.08888889
24	[EEX]	1. 00
25	4	1. 04
26	[%]	−8.88888889
27	[EEX]	1. 00
28	8	1. 08
29	[CHS]	1. −08
30	[+]	−8.88888888

Table 3-6. HP-32E Self-Check IC Codes

SELF-CHECK CODE	REFERENCE DESIGNATION	STAMPED HP PART NUMBER
0	U1	1820-2162, 1MA4-0003
1	U3	1MA1-0009
2	U2	1MA3-0004, 1MA1-0010
3	U1	1820-2162, 1MA4-0003
4	U2	1MA3-0004, 1MA1-0010
5	U3	1MA1-0009

Table 3-7. HP-32E Replaceable Parts

INDEX NUMBER, FIGURE 3-4	HP PART NUMBER	DESCRIPTION	QTY
1	1130-0554	ACTUATOR, key	1
2	00031-60004	ASSEMBLY, battery pack	1
3	1130-0555	ASSEMBLY, logic-keyboard	1
4	00031-60002	ASSEMBLY, power circuit	1
5	00032-60001	ASSEMBLY, top case	1
6	00031-40002	BOTTOM CASE	1
7	1600-0714	CLIP, retaining	2
8	1460-1691	CONTACT, switch	1
9	1990-0657	DISPLAY MODULE	1
10	00031-40004	DOOR, battery	1
11	0403-0267	FOOT	4
12	0340-0666	INSULATOR	1
13	00032-80001	INTEGRATED CIRCUIT, U1 (CPU)	1
14	00032-80002	INTEGRATED CIRCUIT, U2 (data/ROM)	1
15	00032-80003	INTEGRATED CIRCUIT, U3 (data/ROM)	1
17	00031-40014	KEY, f	1
18	00032-40004	KEY, g	1
19	00032-40002	KEY CLUSTER, top three rows	1
20	00032-40003	KEY CLUSTER, bottom four rows	1
21	0624-0303	SCREW, 2–28 × 0.312 inch	2
22	00031-40005	SUPPORT PLATE	1
23	00031-40012	SWITCH, slide	1
24	00031-40003	WINDOW, display	1

Table 3-8. HP-32E Key Entry Test

TEST STEP	PRESS	DISPLAY	FUNCTION
1	[f] [√x] 9	0.000000000	[FIX] 9
2	[g] [CHS]	0.000000000	[RAD]
3	2	2.	2
4	[1/x]	0.500000000	[1/x]
5	[√x]	0.707106781	[√x]
6	[g] 7	0.785398163	[SIN⁻¹]
7	[g] 5	45.00000000	[→DEG]
8	[Σ+]	1.000000000	[Σ+]
9	[RCL] [Σ+]	45.00000000	[RCL] [Σ+]
10	[STO] [+] . 1	45.00000000	[STO] [+] . 1
11	4	4.	4
12	[ENTER↑]	4.000000000	[ENTER↑]
13	3	3.	3
14	[y^x]	64.00000000	[y^x]
15	5	5.	5
16	[CLX]	0.000000000	[CLX]
17	[R↓]	64.00000000	[R↓]
18	8	8.	8
19	[x⇄y]	64.00000000	[x⇄y]
20	[f] [%]	71.11111111	[%Σ]
21	6	6.	6
22	0	60.	0
23	[−]	11.11111111	[−]
24	[EEX]	1. 00	[EEX]
25	1	1. 01	1
26	[÷]	1.111111111	[÷]
27	[×]	8.888888888	[×]
28	[CHS]	−8.888888888	[CHS]

Table 3-9. HP-33E Self-Check IC Codes

SELF-CHECK CODE	REFERENCE DESIGNATION	STAMPED HP PART NUMBER
0	U1	1820-2105, 1MA4-0001
1	U3	1MA1-0004
2	U2	1MA1-0003, 1MA3-0002
3	U1	1820-2105, 1MA4-0001
4	U2	1MA1-0003, 1MA3-0002
5	U3	1MA1-0004

Table 3-10. HP-33E Replaceable Parts

INDEX NUMBER, FIGURE 3-4	HP PART NUMBER	DESCRIPTION	QTY
1	1130-0554	ACTUATOR, key	1
2	00031-60004	ASSEMBLY, battery pack	1
3	1130-0555	ASSEMBLY, logic-keyboard	1
4	00031-60002	ASSEMBLY, power circuit	1
5	00033-60001	ASSEMBLY, top case	1
6	00031-40002	BOTTOM CASE	1
7	1600-0714	CLIP, retaining	2
8	1460-1691	CONTACT, switch	2
9	1990-0657	DISPLAY MODULE	1
10	00031-40004	DOOR, battery	1
11	0403-0267	FOOT	4
12	0340-0666	INSULATOR	1
13	00031-80003	INTEGRATED CIRCUIT, U1 (CPU)	1
14	00033-80001	INTEGRATED CIRCUIT, U2 data/ROM)	1
15	00033-80002	INTEGRATED CIRCUIT, U3 (data/ROM)	1
17	00031-40014	KEY, f	1
18	00032-40004	KEY, g	1
19	00033-40002	KEY CLUSTER, top three rows	1
20	00033-40004	KEY CLUSTER, bottom four rows	1
21	0624-0303	SCREW, 2–28 × 0.312 inch	2
22	00031-40005	SUPPORT PLATE	1
23	00031-40012	SWITCH, slide	2
24	00031-40003	WINDOW, display	1

Table 3-11. HP-33E Key Entry Test

TEST STEP	PRESS/SWITCH	DISPLAY	FUNCTION
1	PRGM		
2	f CHS	00	CLEAR PRGM
3	f EEX	01– 14 33	CLEAR REG
4	f CLx	02– 14 34	CLEAR STK
5	f SST 9	03–14 11 9	FIX 9
6	4	04– 4	4
7	ENTER↑	05– 31	ENTER↑
8	6	06– 6	6
9	Σ+	07– 25	Σ+
10	R↓	08– 22	R↓
11	Σ+	09– 25	Σ+
12	7	10– 7	7
13	STO + 2	11–23 51 2	STO + 2
14	3	12– 3	3
15	+	13– 51	+
16	2	14– 2	2
17	−	15– 41	−
18	8	16– 8	8
19	f ×	17– 14 61	x≠y
20	R/S	18– 74	R/S
21	GTO 25	19– 13 25	GTO 25
22	GTO .24	24– 13 00	GTO .24
23	g RCL	25– 15 24	x̄
24	x⇄y	26– 21	x⇄y
25	R↓	27– 22	R↓
26	×	28– 61	×
27	1	29– 1	1
28	CHS	30– 32	CHS
29	÷	31– 71	÷
30	RUN		
31	GSB 01	−8.888888888	GSB 01

Table 3-12. HP-37E Self-Check IC Codes

SELF-CHECK CODE	REFERENCE DESIGNATION	STAMPED HP PART NUMBER
0	U1	1820-2122, 1MA4-0002
1	U2	1MA1-0008
2	U1	1820-2122, 1MA4-0002
3	U2	1MA1-0008
4	U2	1MA1-0008

Table 3-13. HP-37E Replaceable Parts

INDEX NUMBER, FIGURE 3-4	HP PART NUMBER	DESCRIPTION	QTY
1	1130-0554	ACTUATOR, key	1
2	00031-60004	ASSEMBLY, battery pack	1
3	1130-0555	ASSEMBLY, logic-keyboard	1
4	00031-60002	ASSEMBLY, power circuit	1
5	00037-60001	ASSEMBLY, top case	1
6	00031-40002	BOTTOM CASE	1
7	1600-0714	CLIP, retaining	2
8	1460-1691	CONTACT, switch	2
9	1990-0657	DISPLAY MODULE	1
10	00031-40004	DOOR, battery	1
11	0403-0267	FOOT	4
12	0340-0666	INSULATOR	1
13	00037-80001	INTEGRATED CIRCUIT, U1 (CPU)	1
14	00037-80002	INTEGRATED CIRCUIT, U2 (data/ROM)	1
17	00031-40014	KEY, f	1
19	00037-40001	KEY CLUSTER, top three rows	1
20	00037-40002	KEY CLUSTER, bottom four rows	1
21	0624-0303	SCREW, 2-28 × 0.312 inch	2
22	00031-40005	SUPPORT PLATE	1
23	00031-40012	SWITCH, slide	2
24	00031-40003	WINDOW, display	1

Table 3-14. HP-37E Key Entry Test

TEST STEP	PRESS/SWITCH	DISPLAY
1	[f] 9	0.000000000
2	8	8.
3	[STO] 1	8.000000000
4	[•]	0.
5	5	0.5
6	[÷]	16.00000000
7	3	3.
8	[×]	48.00000000
9	6	6.
10	0	60.
11	[+]	108.0000000
12	7	7.
13	[−]	101.0000000
14	1	1.
15	[n]	1.000000000
16	[CHS]	−1.000000000
17	[+]	100.0000000
18	[i]	100.0000000
19	[ENTER↑]	100.0000000
20	4	4.
21	[%]	4.000000000
22	[Σ+]	9.000000000
23	[x⇄y]	100.0000000
24	[CLX]	0.000000000
25	[RCL] 2	4.000000000
26	[%T]	44.44444444
27	[PMT]	44.44444444
28	BEGIN [switch]	44.44444444
29	[PV]	−44.44444444
30	[switch] END	−44.44444444
31	[FV]	44.44444444
32	[−]	−88.88888888

Note: Certain self-check codes for the HP-38E, as shown in table 3-15, indicate that one of two IC's is bad. For these self-check codes, the IC listed first is more likely than the other to be bad. If the calculator still displays ***Error* 9** and then the same digit after you replace the first IC and do the self-check, return the original first IC to the calculator and replace the second IC listed for that self-check code.

Table 3-15. HP-38E Self-Check IC Codes

SELF-CHECK CODE	REFERENCE DESIGNATION	STAMPED HP PART NUMBER
0	U1	1820-2122, 1MA4-0002
1	U2	1MA1-0005
2	U3	1MA1-0006
3	U4	1MA1-0007, 1MA3-0003
4	U1	1820-2122, 1MA4-0002
5	U2 or U4	1MA1-0005; or 1MA1-0007, 1MA3-0003
6	U3 or U2	1MA1-0006; or 1MA1-0005
7	U3	1MA1-0006
8	U4 or U2	1MA1-0007, 1MA3-0003; or 1MA1-0005

Table 3-16. HP-38E Replaceable Parts

INDEX NUMBER, FIGURE 3-4	HP PART NUMBER	DESCRIPTION	QTY
1	1130-0554	ACTUATOR, key	1
2	00031-60004	ASSEMBLY, battery pack	1
3	1130-0555	ASSEMBLY, logic-keyboard	1
4	00031-60002	ASSEMBLY, power circuit	1
5	00038-60001	ASSEMBLY, top case	1
6	00031-40002	BOTTOM CASE	1
7	1600-0714	CLIP, retaining	2
8	1460-1691	CONTACT, switch	2
9	1990-0657	DISPLAY MODULE	1
10	00031-40004	DOOR, battery	1
11	0403-0267	FOOT	4
12	0340-0666	INSULATOR	1
13	00037-80001	INTEGRATED CIRCUIT, U1 (CPU)	1
14	00038-80001	INTEGRATED CIRCUIT, U2 (data/ROM)	1
15	00038-80002	INTEGRATED CIRCUIT, U3 (data/ROM)	1
16	00038-80003	INTEGRATED CIRCUIT, U4 (data/ROM)	1
17	00031-40014	KEY, $\boxed{f}$	1
18	00032-40004	KEY, $\boxed{g}$	1
19	00038-40004	KEY CLUSTER, top three rows	1
20	00038-40005	KEY CLUSTER, bottom four rows	1
21	0624-0303	SCREW, 2-28 × 0.312 inch	2
22	00031-40005	SUPPORT PLATE	1
23	00031-40012	SWITCH, slide	2
24	00031-40003	WINDOW, display	1

Table 3-17. HP-38E Key Entry Test

TEST STEP	PRESS/SWITCH	DISPLAY
1	1	*1.*
2	[STO] 1	*1.00*
3	5	*5.*
4	7	*57.*
5	[ENTER↑]	*57.00*
6	4	*4.*
7	3	*3.*
8	[+]	*100.00*
9	[i]	*100.00*
10	[%]	*1.00*
11	[n]	*1.00*
12	[•]	*0.*
13	0	*0.0*
14	9	*0.09*
15	[f] [R/S]	*2.00*
16	[x⇄y]	*1.00*
17	[CLx]	*0.00*
18	[RCL] 6	*0.09*
19	[÷]	*22.22*
20	2	*2.*
21	[g] [CHS]	*2. 00*
22	8	*2. 08*
23	[×]	*4,444,444,444.*
24	[PMT]	*4,444,444,444.*
25	BEGIN switch	*4,444,444,444.*
26	[PV]	*−4,444,444,444.*
27	switch END	*−4,444,444,444.*
28	[FV]	*4,444,444,444.*
29	[−]	*−8,888,888,888.*

SECTION IV

Disassembly and Reassembly

This section describes—both in words and in pictures—how to take apart a Series E calculator and put it together again. Throughout the procedures, a number in parentheses following a reference to a part identifies it in the exploded view of figure 3-4. This illustration is located on a page that folds out to the left so that you can see it while you are following the procedures and photographs.

CAUTION

Parts in the calculator can easily be contaminated with grease or dirt while you are handling them. To prevent this from happening, wear finger cots (part number 9300-0398) or white gloves (small, part number 8650-0029; large, part number 8650-0030). Failure to do so can result in improper operation of the calculator.

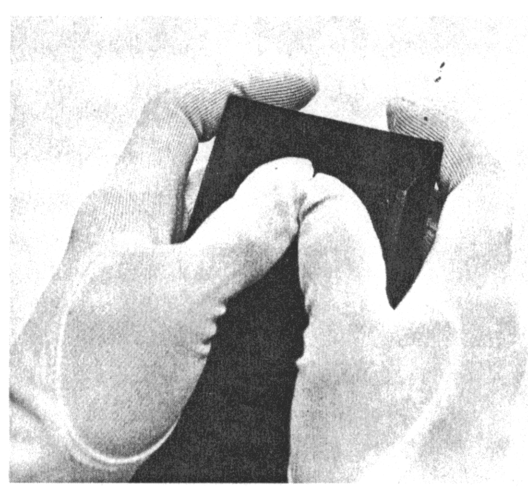
The disassembly and reassembly procedures are grouped into the following steps:

1. Removing the battery pack and door from the calculator.
2. Separating the bottom case from the top case.
3. Removing the electronic package from the top case.
4. Disassembling the electronic package.
5. Removing parts from the top case.
6. Inserting parts into the top case.
7. Assembling the electronic package.
8. Inserting the electronic package into the top case.
9. Attaching the bottom case to the top case.
10. Inserting the battery pack and door into the calculator.
11. Replacing a foot on the bottom case.

1 REMOVING THE BATTERY PACK AND DOOR FROM THE CALCULATOR

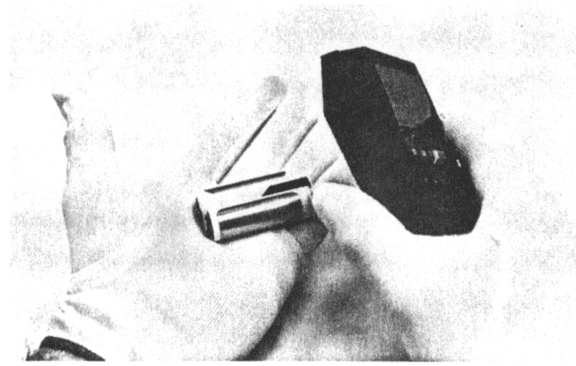
a. Hold the calculator as shown with your thumbs on on the battery door (10).

b. Press down while pushing away from you, until the battery door snaps free. Remove the battery door from the bottom case.



1

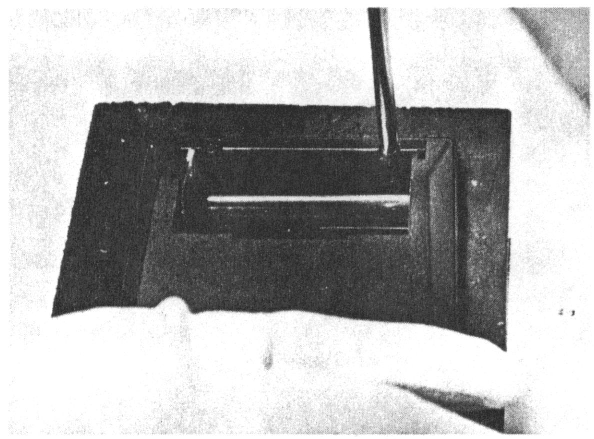
c. Turn the calculator over and gently shake it until the battery pack (2) falls into your hand.



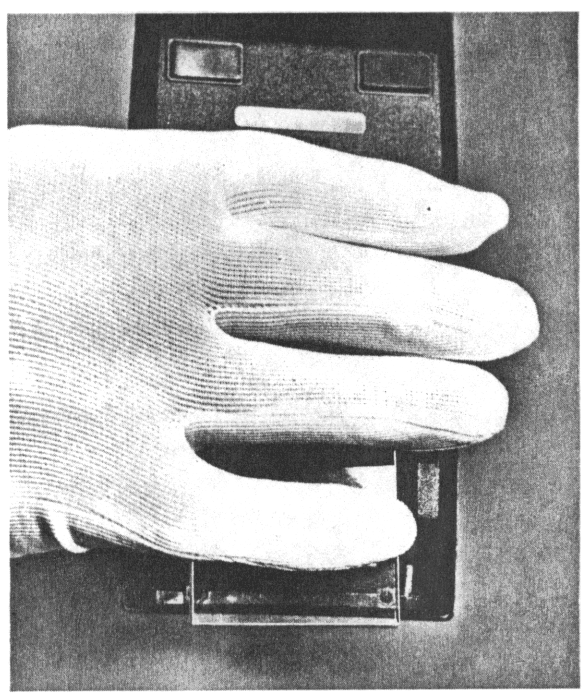
2

SEPARATING THE BOTTOM CASE FROM THE TOP CASE

a. Place the calculator face down in a molded support fixture (part number T-93328). With a small Phillips screwdriver, unscrew the two screws (21) at the top of the exposed battery pack compartment.



b. Place the tongue of a case separation tool (part number T-190583) into the slot in the bottom case above the battery pack compartment. Holding the tool and calculator firmly as shown, rap the end of the tool on your repair bench. The cases should snap apart.



CAUTION

In the next step, be careful not to bend the battery contacts. If they get bent, they may eventually break apart.

c. Lift the cases together off the tool. Hold them with the bottom case facing up, and lift the bottom case off of the top case. You may have to turn the bottom case or press on the battery contacts so that the case does not get caught on the contacts.

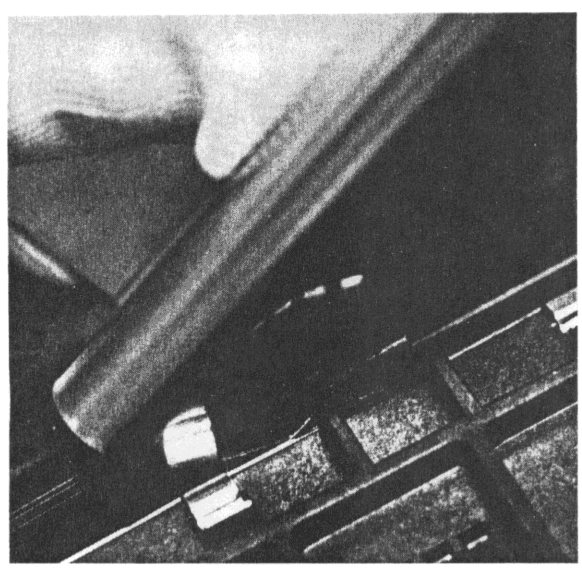
3 REMOVING THE ELECTRONIC PACKAGE FROM THE TOP CASE

Note: The "electronic package" consists of:

1. The logic-keyboard assembly (3).
2. The support plate (22).
3. The retaining clips (7), which hold the logic-keyboard assembly and the support plate together.
4. The IC's (13 thru 16) and power supply assembly (4), which are held between the logic-keyboard assembly and the support plate.
5. The display module (9), whose pins are held between the logic-keyboard assembly and the support plate.

a. Place the calculator facedown in a molded support fixture (part number T-93328). Remove the power contact board from the top case.

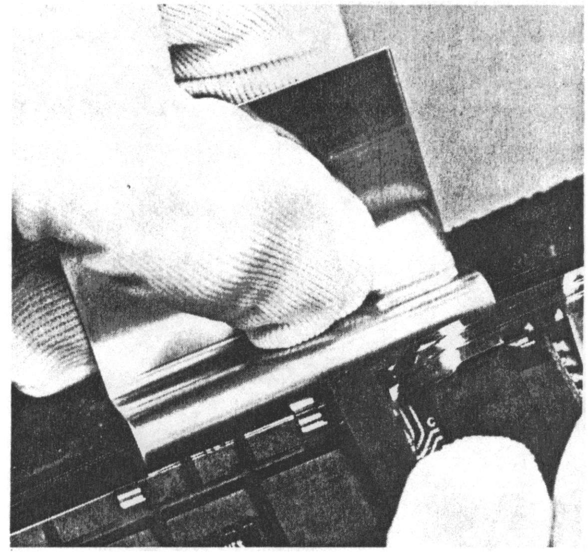
b. Brace the lower corner of an EPA assembly tool (part number T-155802) against the retaining clip, next to the middle of the three plastic retaining tabs as shown. Slide or turn the tool until it passes between the retaining clip and the retaining tab.



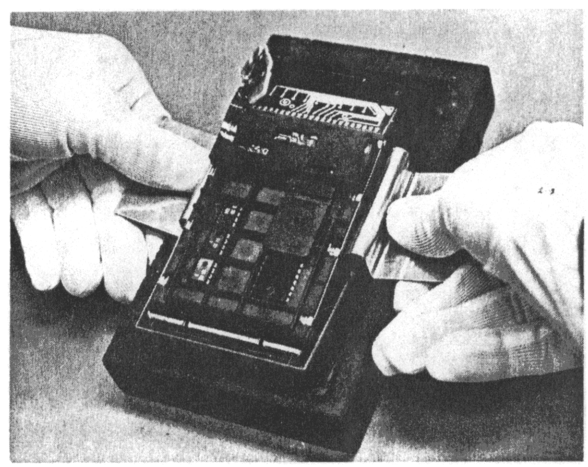
3

c. Turn the tool so that its upper corner passes between the retaining clip and the retaining tab next to the battery well.

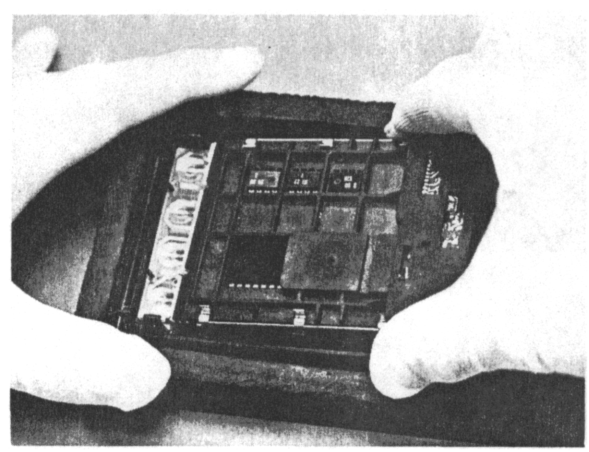
d. With another EPA assembly tool, repeat steps *b* and *c* for the retaining tabs on the other side of the electronic package.



e. Press the flat portions of both tools downward. The electronic package should pop up from the top case.



f. Remove the tools and slide the electronic package out from beneath the two lower retaining tabs.



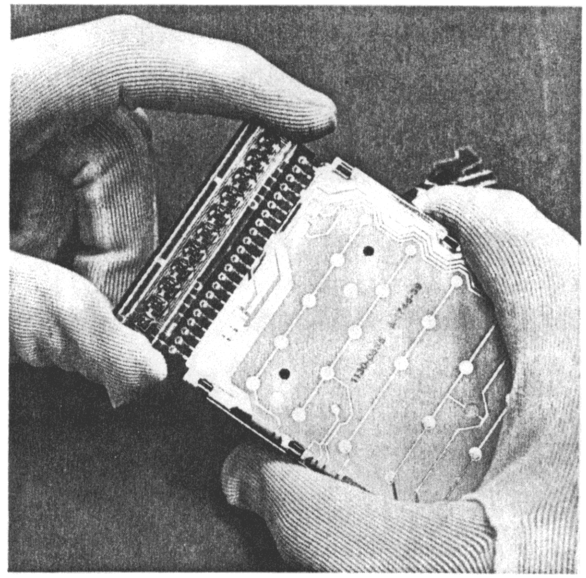
CAUTION

Ensure that the exposed logic-keyboard assembly is not touched or placed on an unclean surface. To do so could contaminate it with grease or dirt, which might result in improper operation of the calculator.

g. With the logic-keyboard assembly facing up, lay the electronic package down on a clean surface.

4 DISASSEMBLING THE ELECTRONIC PACKAGE

a. Hold the electronic package by its edges and gently pull off the display module as shown.

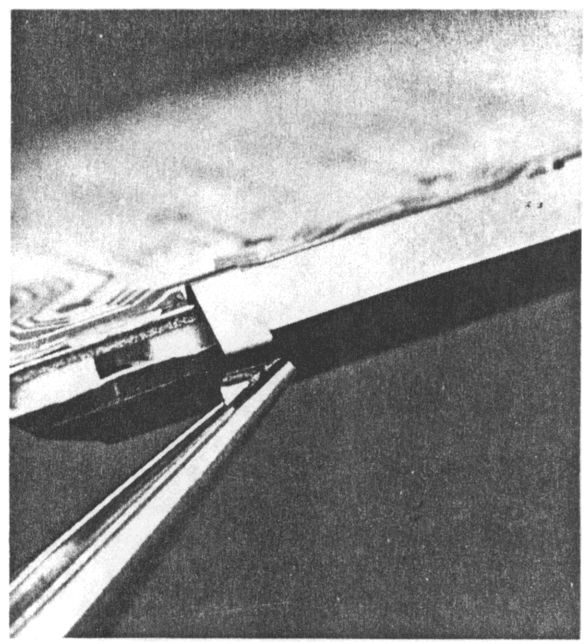


b. Hold the electronic package with the support plate facing down and the logic-keyboard assembly facing up.

c. With needle-nose pliers, carefully pry the lower, larger arms of one of the retaining clips outward. When the clip is disengaged from the electronic package, discard it.

d. Turn the electronic package around and remove the retaining clip from the other side as above. Discard it also.

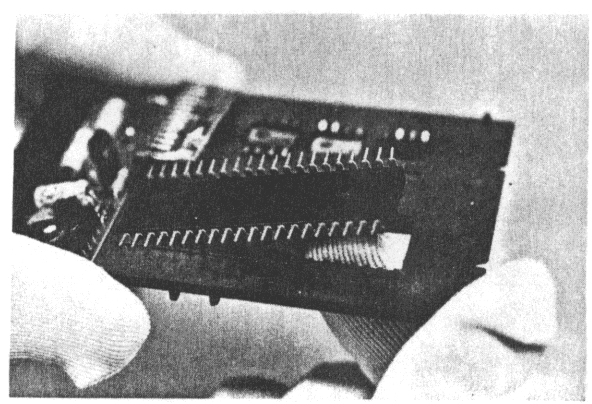
e. Carefully lift the logic-keyboard assembly off of the support plate and place it on a clean surface.



CAUTION

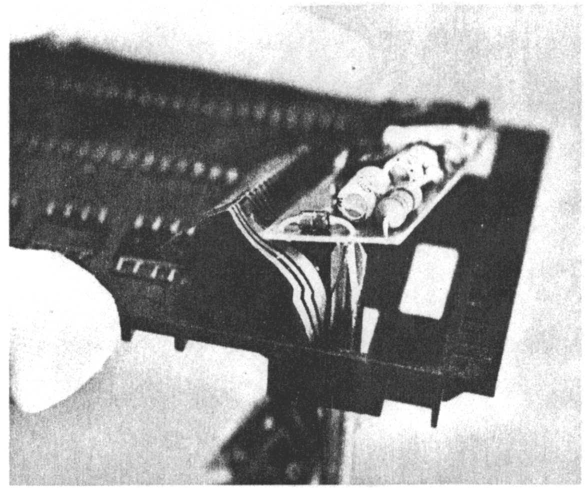
In the following step, be careful not to touch any IC leads with your fingers. To do so could contaminate them with grease or dirt, which might result in improper operation of the calculator.

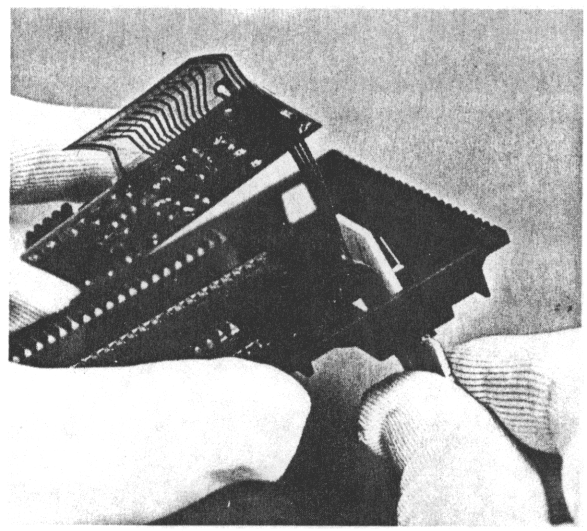
f. To remove an IC, push it up from below with your fingers.



4

h. To remove the power supply assembly from the support plate, push it up from below by inserting a screwdriver through the slot in the power supply well. Then thread the power contact board through the slot.



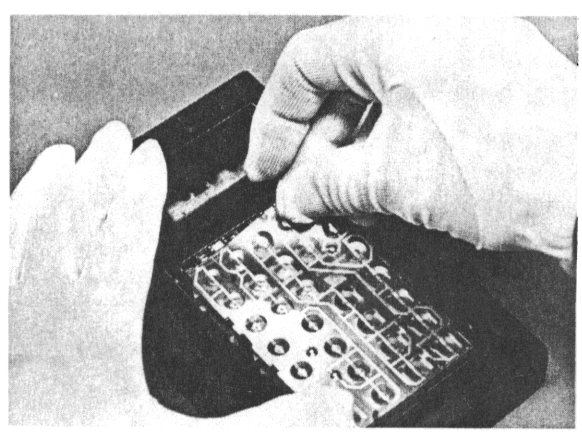


5 **REMOVING PARTS FROM THE TOP CASE**

CAUTION

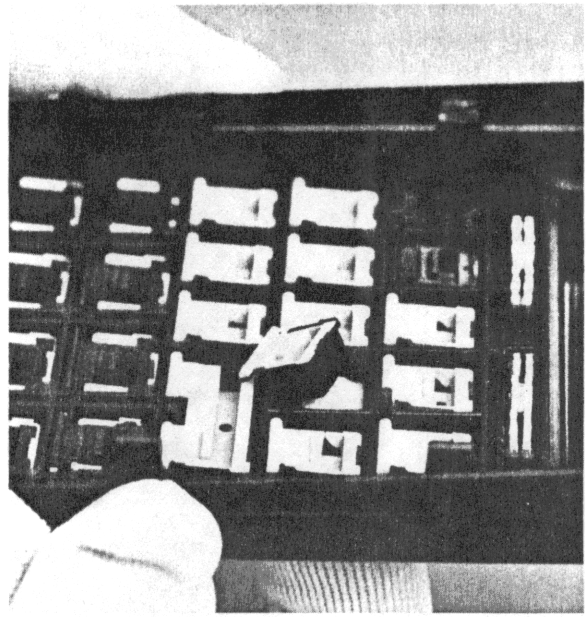
After removing the insulator and key actuator from the top case do not turn the top case over. If you do so, all the keys will fall out.

a. **To remove the insulator** (12) **and key actuator** (1), lift them out by grasping their corners as shown.

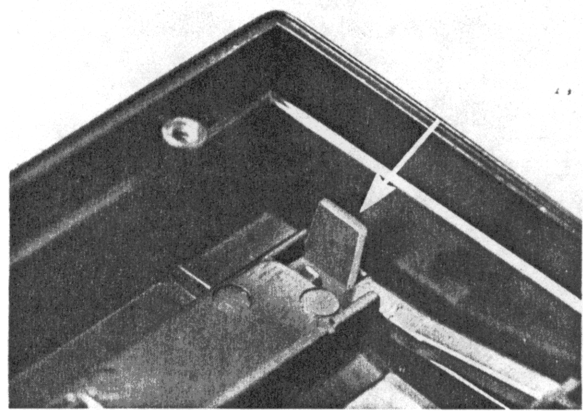


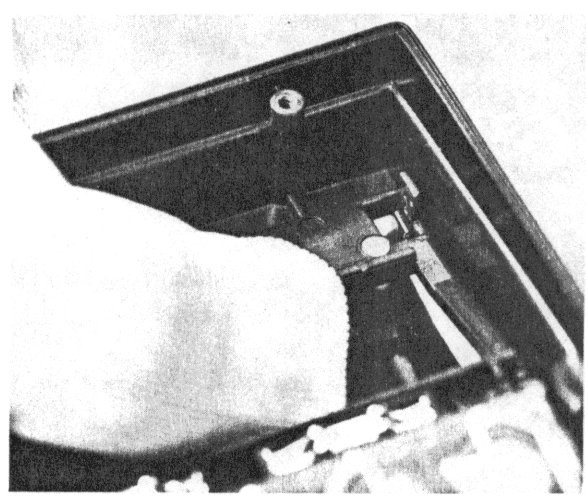
5

b. **To remove a key** (17 thru 20), push it up from below with your finger, then lift it out from above.



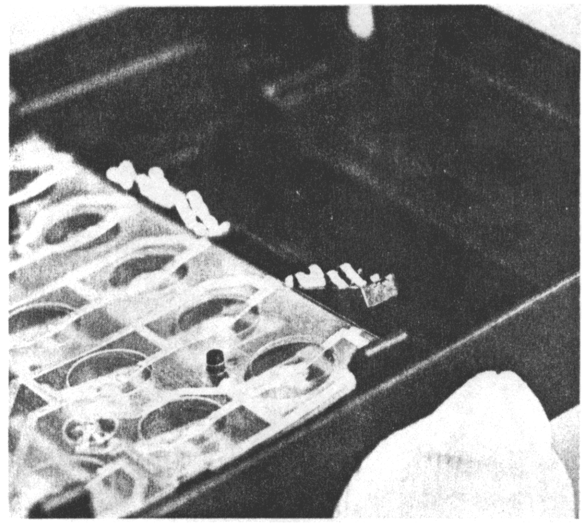
c. **To remove the window** (24), gently pry the exposed retaining tab from the window inward with your thumb. Then press the window downward until it drops out of the top case.





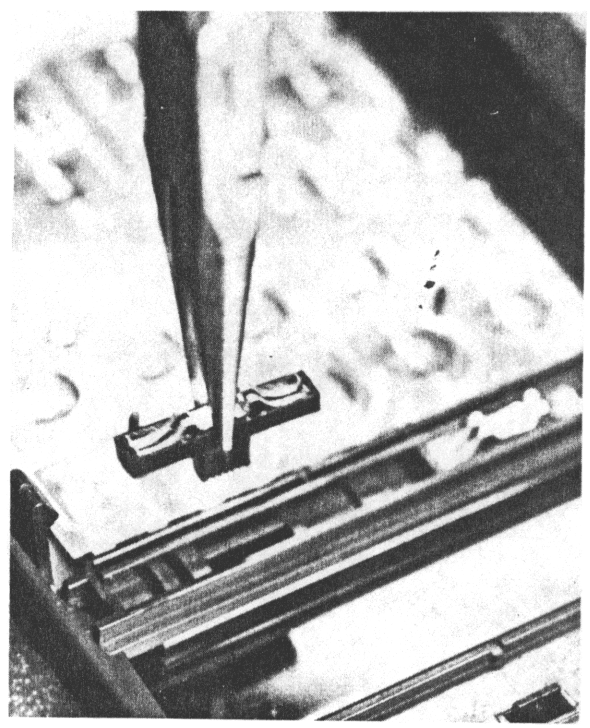
5

d. **To remove a slide switch** (23) **and switch contact** (8), push the switch up from below with your finger. To remove the switch contact from the slide switch, turn the switch over and allow the switch contact to drop out.



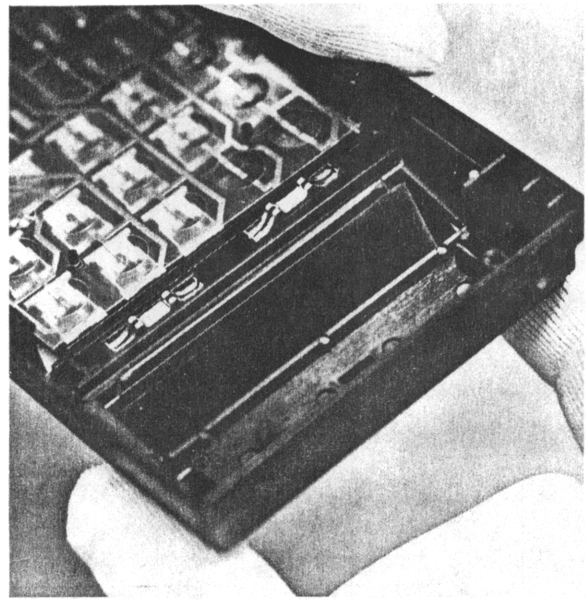
6 INSERTING PARTS INTO THE TOP CASE

a. **To insert a slide switch and slide switch contact,** drop them together into the top case from the inside.

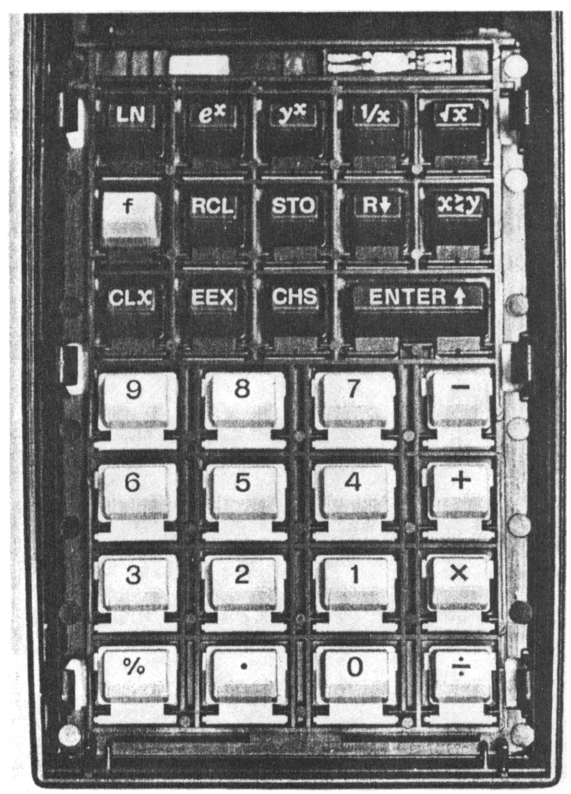


6

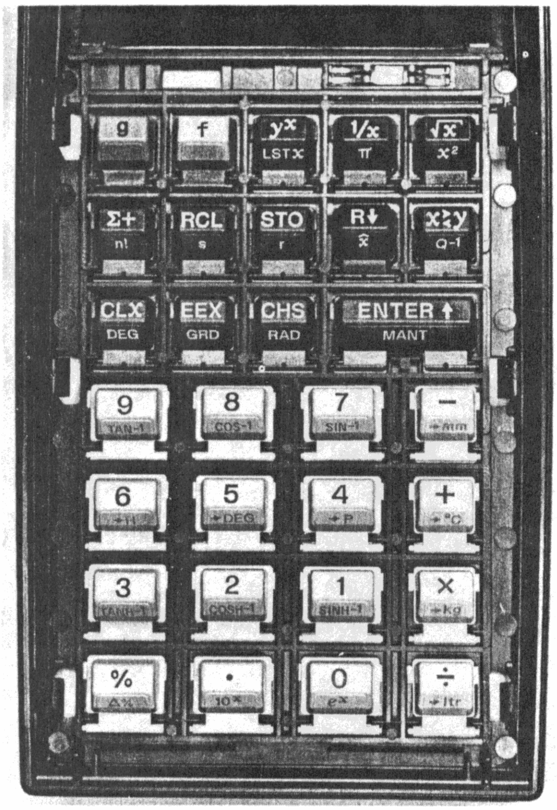
b. **To insert a window,** hold it under the top case and engage its lip on the lower edge of the cutout in the top case as shown. Press the top edge of the window up toward the top case until the two retaining tabs from the window lock into the top case.



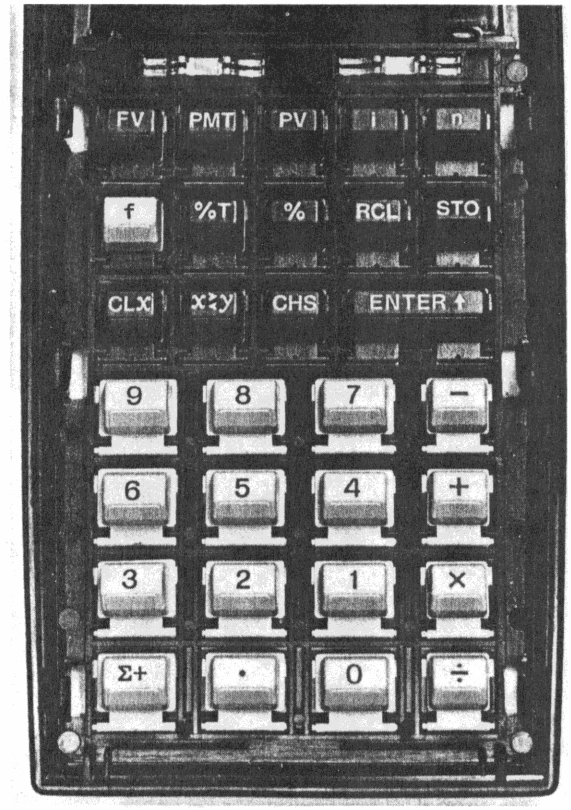
c. **To insert a key,** drop it into its hole from the inside. To find the proper location for each key, see the keyboard illustration for the calculator model being repaired. **These illustrations show the location of each key when viewed from the inside.** Note that these key locations are the reverse of those seen when the assembled calculator is viewed from above.



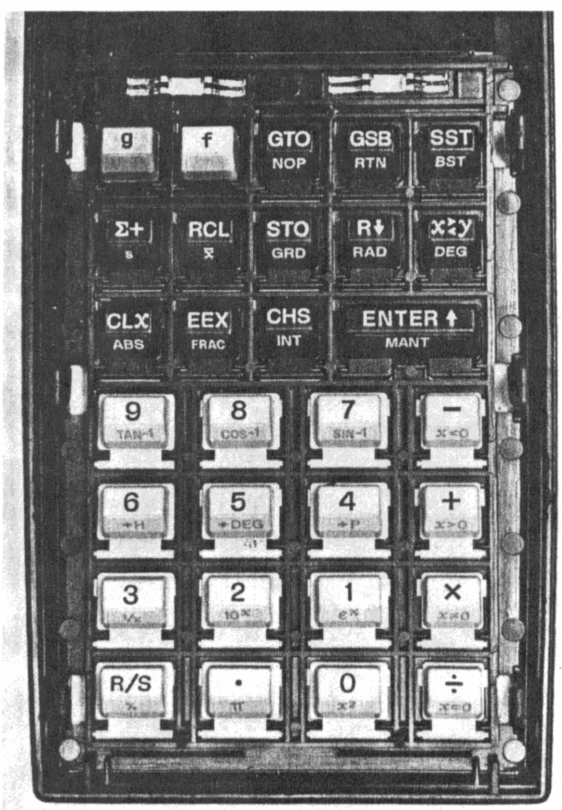
HP-31E Keyboard, Inside View



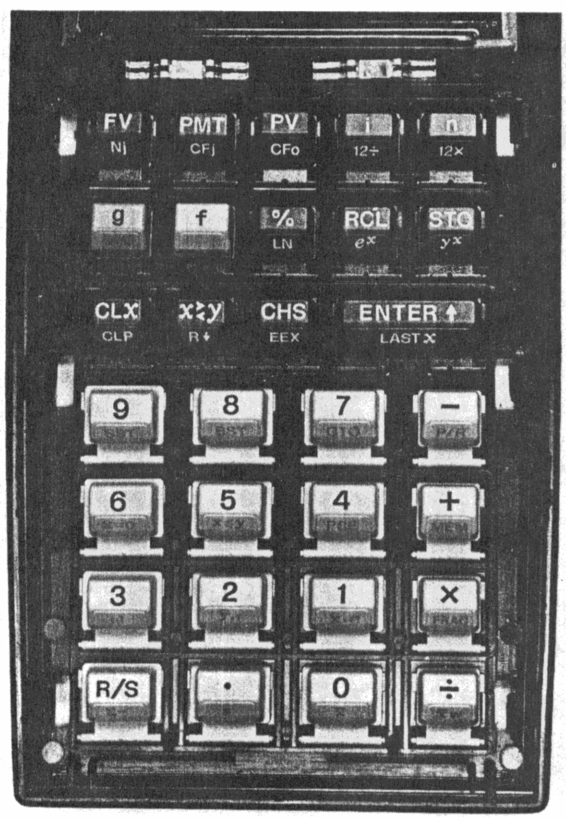
HP-32E Keyboard, Inside View



HP-37E Keyboard, Inside View



HP-33E Keyboard, Inside View



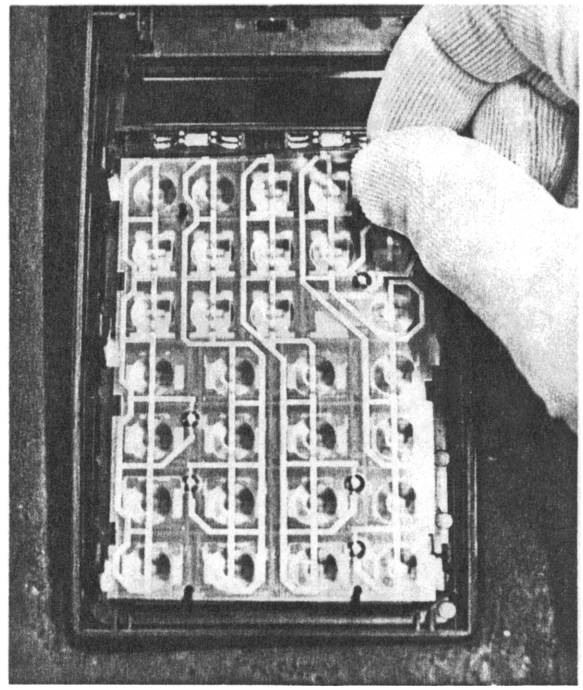
HP-38E Keyboard, Inside View

6

d. **To insert the key actuator,** grasp it by one of its corners. Hold the actuator over the keys such that the end *without* the two locating holes next to the edge is near the window and the large, clear bumps on the actuator are facing down *toward* the keys. Lower the actuator over the keys such that the locating pins from the top case protrude through their mating holes in the actuator. Gently press on the clear portions of the actuator—*not* on the traces—until the actuator is seated evenly over the keys.

e. **To insert the insulator,** grasp it by one of its corners. Hold the insulator over the actuator such that the end *without* the two locating holes next to the edge is near the window and the area of the insulator where a hole appears to be missing is over the area of the actuator without a bump, near the parallel diagonal traces.

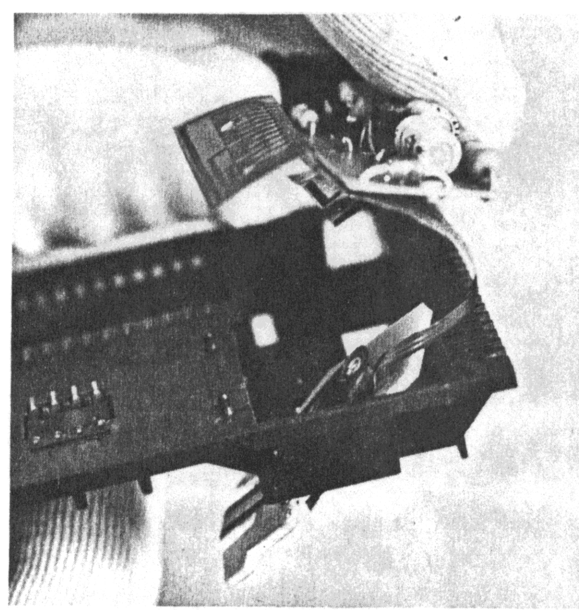
f. Lower the insulator over the actuator such that the locating pins from the top case protrude through their mating holes in the insulator. Ensure that the five small silver dimples facing up from the actuator are cleared by the small holes in the insulator; if they are not, the insulator is positioned backwards. When the insulator is located properly over the actuator, gently press it down until it is seated evenly over the actuator.



7 ASSEMBLING THE ELECTRONIC PACKAGE

a. Before the electronic package can be reassembled, the traces on the logic-keyboard assembly for the IC pins, display module pins, and power supply flex-cable must be cleaned. This should be done with a lint-free cloth dipped in isopropyl alcohol. Blow off any excess alcohol with filtered compressed air.

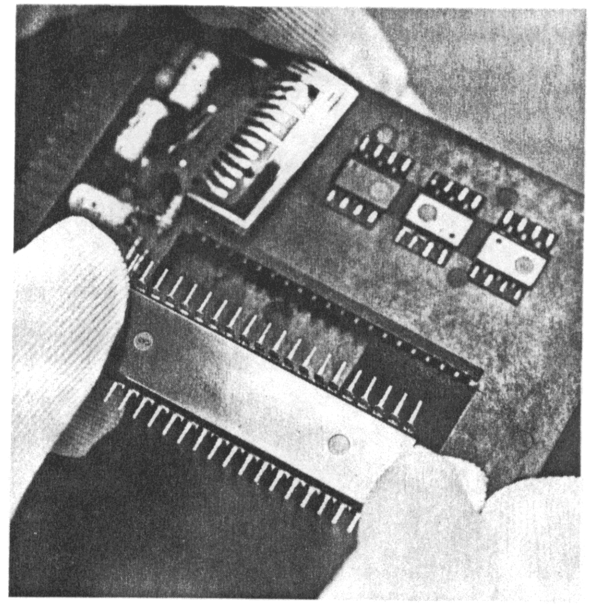
b. **To insert the power supply assembly into the support plate,** thread the power contact board through the slot in the power supply well. Place the power supply assembly into the well in the support plate with its flex-cable positioned over the locating pins there. Press the flex-cable onto the support plate until it is seated flat on the support plate around the locating pins.



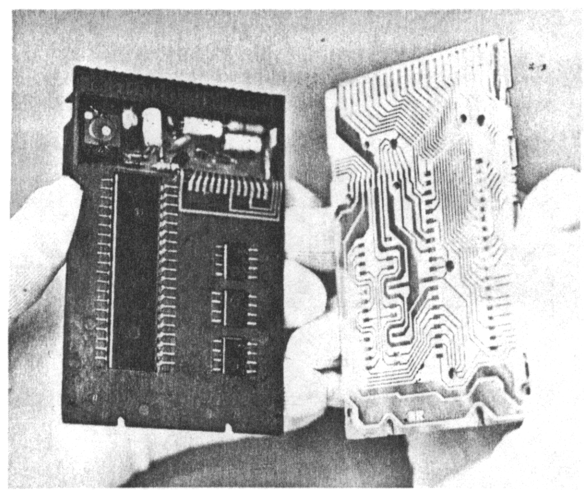
7

CAUTION

When you are inserting an IC into the support plate, the IC *must* be configured such that the dot on it (indicating pin 1) is aligned alongside the corresponding dot on the support plate. If this is not done, the calculator will not operate, and the IC may be damaged.



c. **To insert an IC,** hold the support plate and the IC as shown, and gently drop the IC into the proper hole. To determine the correct location of each IC, check the part number stamped on the IC, then look up the reference designation corresponding to the part number. This information is given in the table at the end of section III listing the self-check IC codes for the particular calculator being repaired. Figure 3-5 shows the correct locations of all IC's, which are labeled there with their reference designations.



d. **To connect the logic-keyboard assembly to the support plate,** first ensure that the flex-cable from the power supply and all IC pins are seated flat upon the support plate.

e. Hold the support plate and logic-keyboard assembly by their edges as shown. The exposed display connector traces on the logic-keyboard assembly should be held facing the end of the support plate near the power supply well.

f. Gently lower the logic-keyboard assembly over the support plate until they are flat against each other. The four locating pins from the support plate—one in each lower corner and two protruding through the power supply flex-cable—should be engaged into their mating holes.

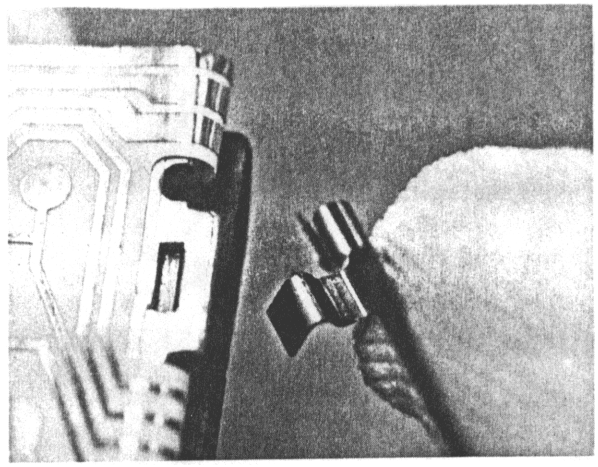
CAUTION

In the next two steps, be sure that the larger arms of the retaining clips engage the support plate rather than the logic-keyboard assembly. If the clips are attached the other way, you will not be able to insert the electronic package properly into the top case, and the keyboard will not work properly.

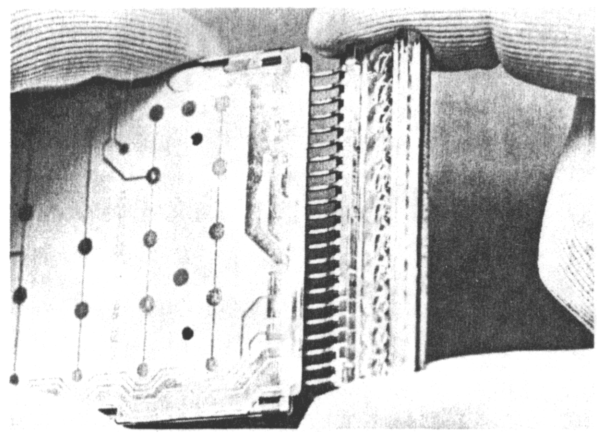
7

g. Press a new retaining clip over the edges of the support plate and logic-keyboard assembly as shown. The larger four arms of the clip should be down, engaging the support plate rather than the logic-keyboard assembly. Press each of the four sets of arms so that the clip firmly holds the edges of the support plate and logic-keyboard assembly together.

h. Using another new retaining clip, repeat the step above for the other side.



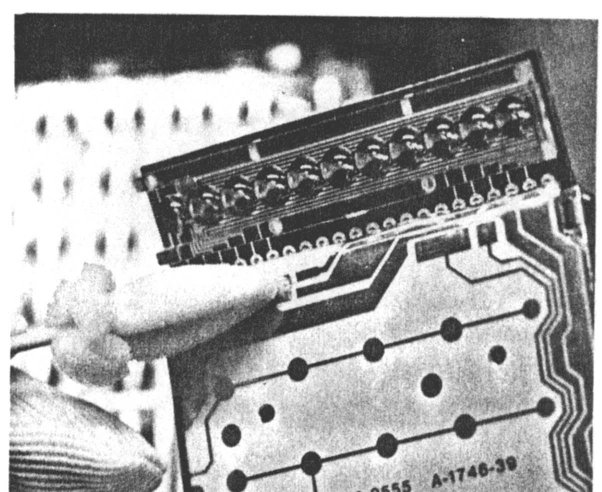
i. Hold the electronic package by its edges and carefully insert the display module into its top end. Ensure that the lens of the display module faces toward the logic-keyboard assembly side of the electronic package.



8 INSERTING THE ELECTRONIC PACKAGE INTO THE TOP CASE

a. Place the top case facedown in a molded support fixture (part number T-93328). Clean the exposed traces on the logic-keyboard assembly with a lint-free cloth dipped in isopropyl alcohol, and blow off any excess alcohol with filtered compressed air.

b. Using a foam swab (part number 9300-0468), apply a very light coating of mineral oil (part number 6040-0217) to the switch contact traces on the logic-keyboard assembly. On calculator models with only one switch, do not lubricate the traces under the unused switch position.



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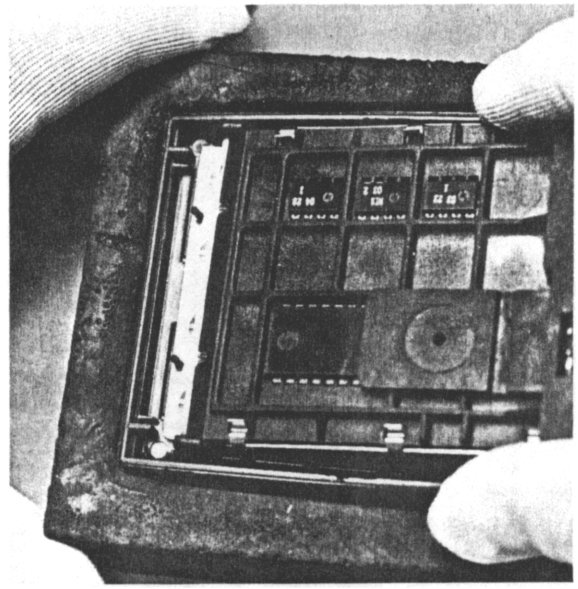
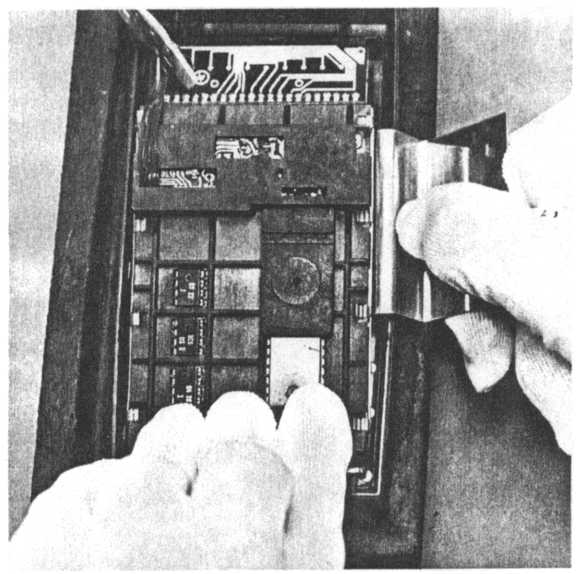
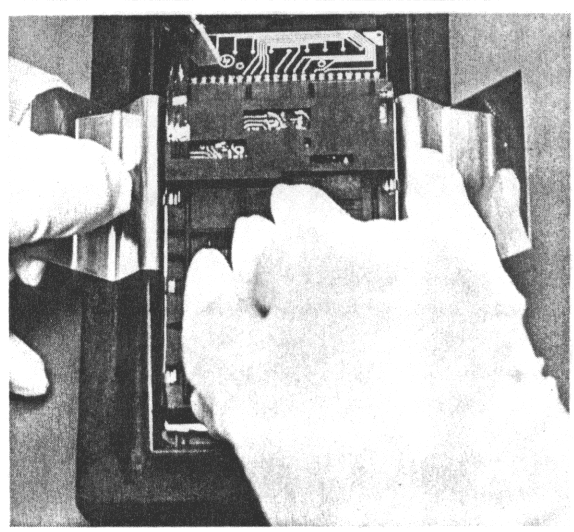
c. Slide the lower end of the electronic package under the two lower retaining tabs in the top case. The two locating pins at the lower end of the top case should slide into their mating channels in the electronic package.



d. Making sure that the lower end of the electronic package remains engaged beneath the two retaining tabs, slide an EPA assembly tool over the other two retaining tabs on one side of the top case.



e. Carefully holding both the lower end of the electronic package and also the tool in their positions, slide another EPA assembly tool over the two remaining retaining tabs on the other side of the top case.



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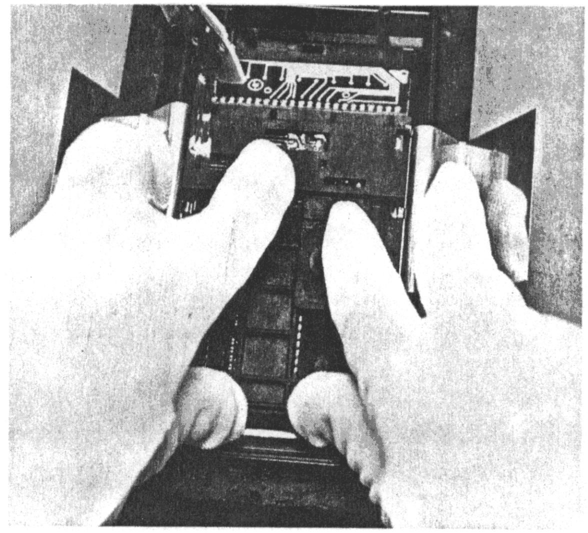
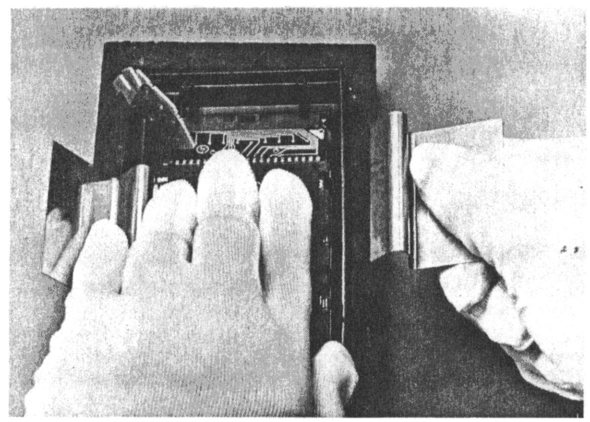
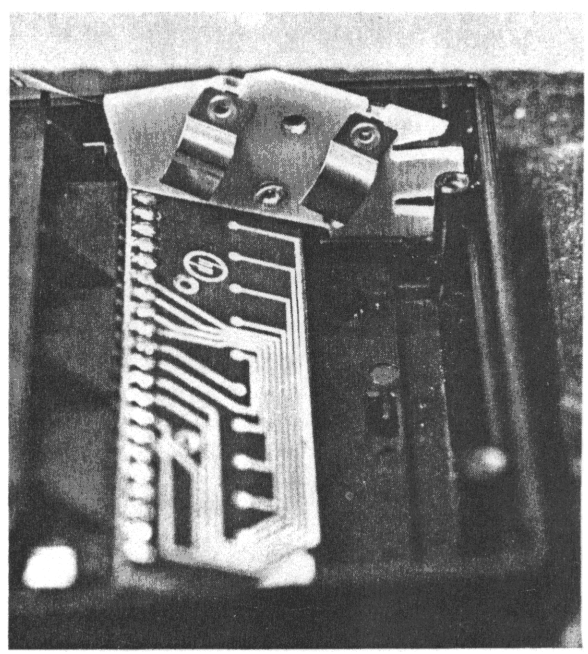
f. Making sure that both tools and also the lower end of the electronic package remain in their positions, firmly press the electronic package down into the top case.



g. While pressing the electronic package down in the top case, remove one of the EPA assembly tools, then remove the other. Ensure that the electronic package is firmly secured by all six retaining tabs in the top case.

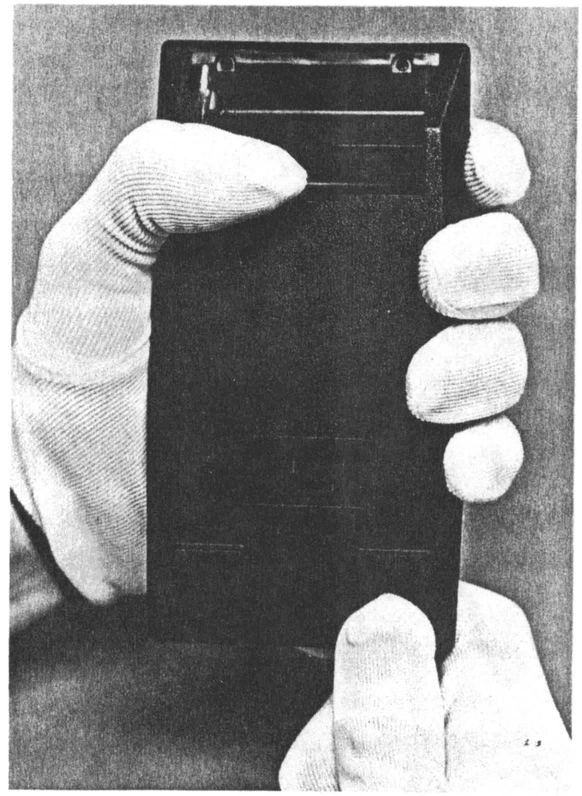


h. Place the power contact board into its slot in the top case as shown. Ensure that it fits snugly against the back of the display module.

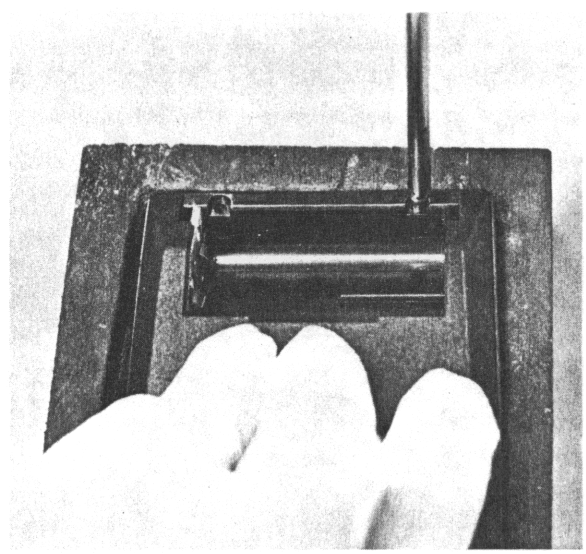


9 ATTACHING THE BOTTOM CASE TO THE TOP CASE

a. Place the bottom case over the top case and hold them as shown. Plase your thumb on the lower, beveled portion of the bottom case beneath one of the feet. Push down and forward with your thumb until the cases snap together. Move your thumb near the other foot and press again to make sure that both sides of the cases are secured together.

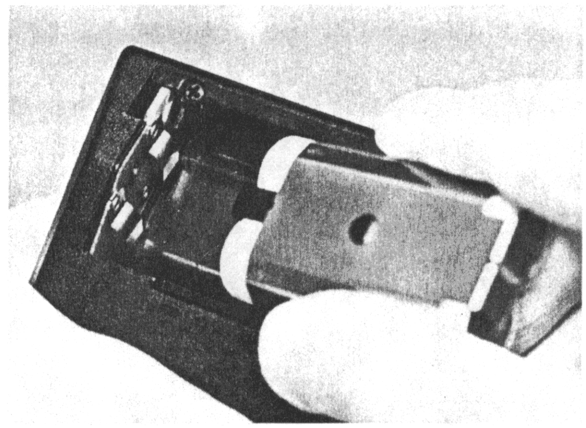


b. Holding the bottom case against the top case, insert and tighten the two screws at the top of the battery pack compartment.

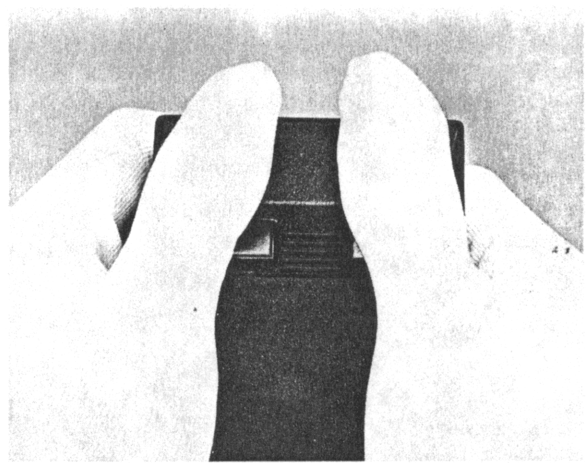


10 INSERTING THE BATTERY PACK AND DOOR INTO THE CALCULATOR

a. Hold the battery pack over its compartment in the bottom case such that the exposed ends of the battery cells point toward the power contact board and the flat side of the battery clip faces up. Carefully press the battery pack until it fits snugly in its compartment.



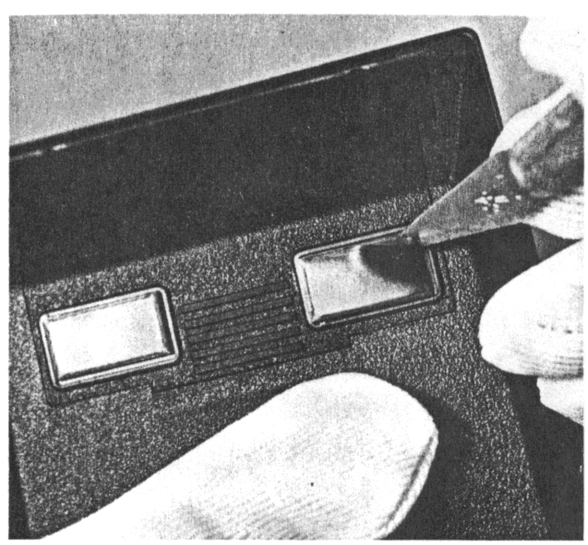
b. Insert the tab of the battery door into its slot in the bottom case. Hold the calculator with your thumbs on the battery door as shown, then pull the door back until it snaps securely in the case.



11 REPLACING A FOOT ON THE BOTTOM CASE

a. To remove a foot (11) from the bottom case, lift its corner with an X-acto knife and pull it off.

b. To attach a new foot, peel the foot off of its backing, place it in position, and press until it is secure.



Accessories

5-1. INTRODUCTION

5-2. This section identifies the electrical accessories available for use with Series E calculators. Also presented here are procedures for testing the battery pack. We recommend that defective accessories be replaced rather than repaired, since the cost of a new unit is usually less than the cost of repair.

5-3. HP 82109A BATTERY PACK

5-4. Figure 5-1 shows the HP 82109A Battery Pack.

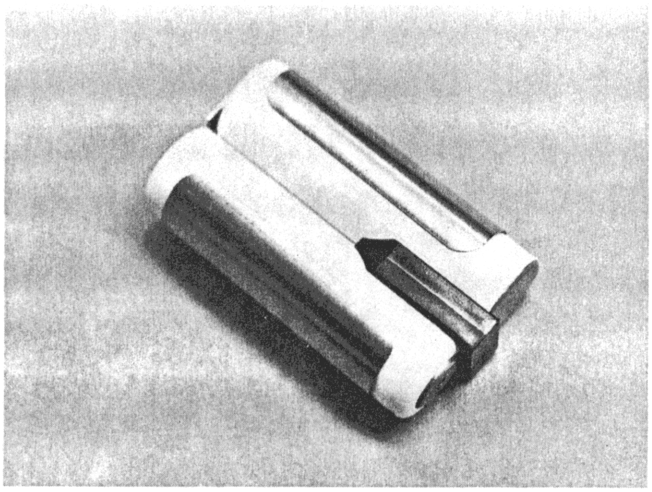


Figure 5-1. HP 82109A Battery Pack

5-5. If you fix a calculator with no display by replacing the battery pack, the pack could be bad or it could merely need charging. To determine which of these is the case, you can test the pack using the following procedures:

a. Charge the battery pack for at least 8 hours in a Series E calculator known to be operating properly.

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

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

Table 5-1. AC Adapter/Rechargers

HP MODEL NUMBER	VOLTAGE*	IDENTIFICATION
82087A	115	US
82088A	240	Australia
82089A	240	UK
82089A Opt 001	240	UK with RSA plug
82090A	240	Europe

* The voltage shown is nominal; acceptable ranges are 90 to 120 Vac and 210 to 250 Vac.

5-6. AC ADAPTER/RECHARGERS

5-7. Table 5-1 lists the various ac adapter/rechargers available for use with Series E calculators. Figures 5-2 through 5-6 show the plug configuration and location of the part number. The serial number engraved on each ac adapter/recharger indicates its date of manufacture. Its format is as follows:

YYMM

MM — Month manufactured.

YY — Year manufactured (YY = years since 1960).

5-8. Procedures for checking whether the ac adapter/recharger is operating properly are included in the troubleshooting procedures for Poor Charge Retention, paragraph 3-6.

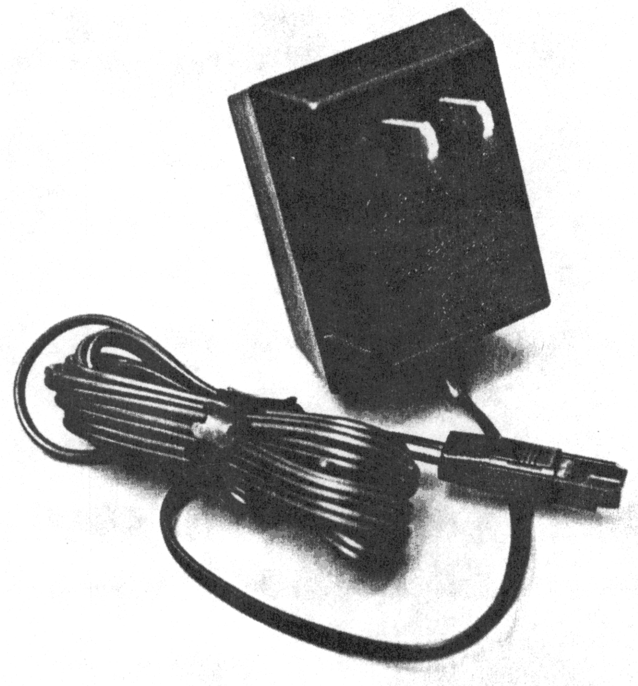


Figure 5-2. HP 82087A AC Adapter/Recharger

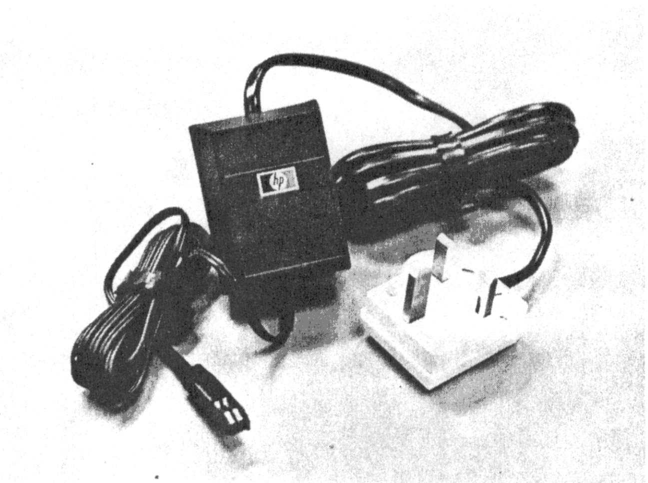


Figure 5-3. HP 82089A AC Adapter/Recharger

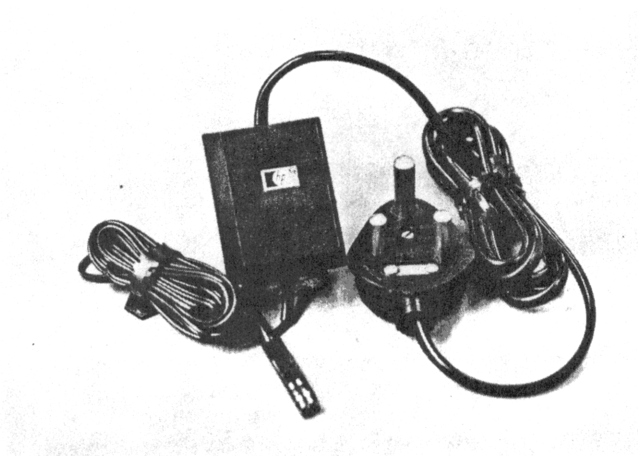


Figure 5-4. HP 82089A Opt 001 AC Adapter/Recharger

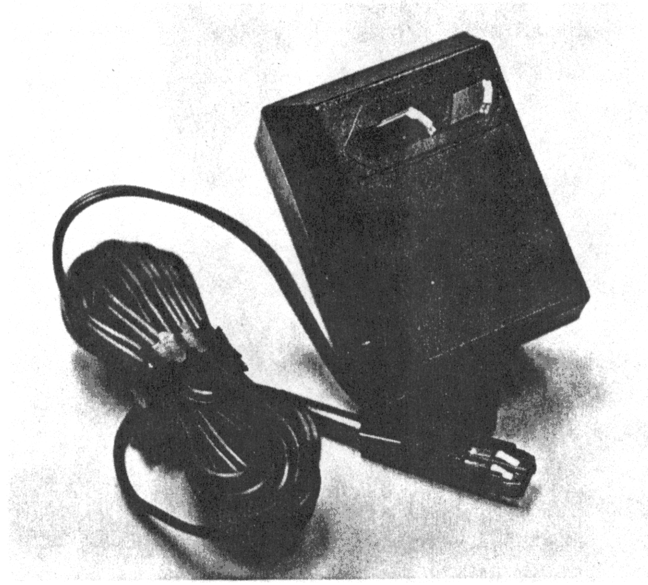


Figure 5-5. HP 82088A AC Adapter/Recharger

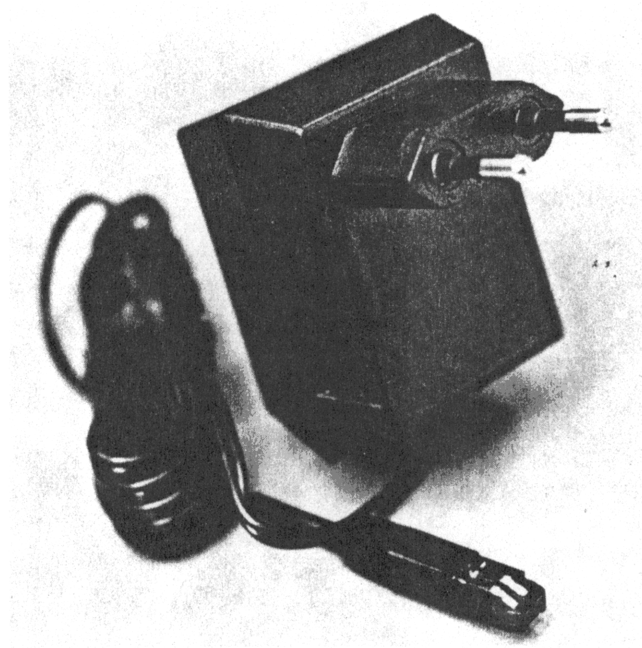


Figure 5-6. HP 82090A AC Adapter/Recharger