Friden, Inc.



ELECTRONIC CALCULATOR 130

FIELD SERVICE MANUAL

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FRIDEN EC 130 CALCULATOR

FIELD SERVICE MANUAL

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SECTION 1 GENERAL DESCRIPTION

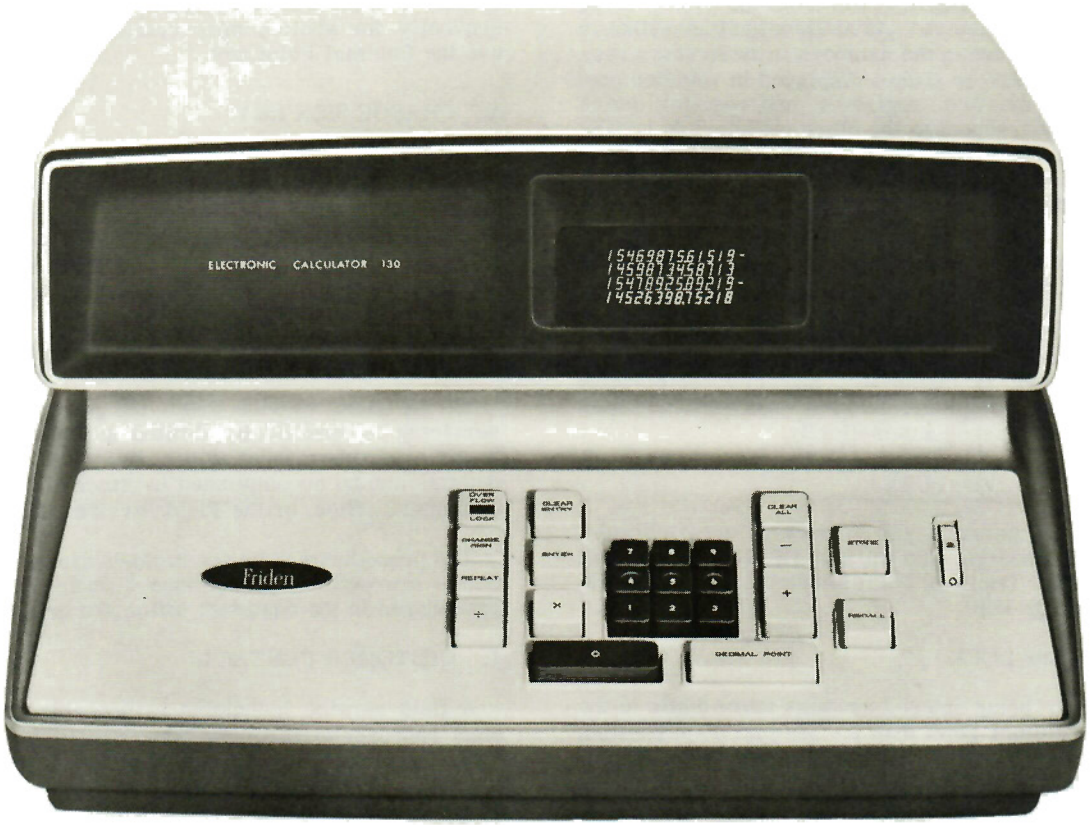


FIGURE 1-1. ELECTRONIC CALCULATOR 130

A. SCOPE OF MANUAL.

This manual covers the maintenance of the EC-130 (See Figure 1-1) at the FIELD SERVICE level.

There are two levels of maintenance: Depot Service level, and Field Service level. The depot service level is the major repair of machines not repairable at the Field Service level. The field service level is limited to specific replacements, adjustments, and tests as covered in Sections 3 and 4.

B. DESCRIPTION OF MACHINE.

The major components of the EC-130 are a 10-key keyboard, 4 solid-state plug-in circuit cards, an ultrasonic delay line, and a cathode ray tube (CRT) display.

The EC-130 operates on 115V ± 10% AC, 50-60 cycles, and may be connected to any standard AC outlet.

C. GENERAL OPERATION.

The general operations of the EC-130 are those that are under the control of, and in the view of, the operator of the machine.

1. KEYBOARD.

The keyboard has two main classes of keys and additional keys. The main classes are: Functions and Digit keys. The digit keys enter numbers in the machine; the function keys initiate machine functions such as Add, Subtract, etc.

The additional keys are: Overflow Lock, Decimal Point, Change Sign, and Decimal Point Selector. The OVERFLOW LOCK key has a built-in red light that, when lit, indicates an entry or an answer that exceeds machine capacity. The DECIMAL POINT key is used during the entering of a number to establish proper decimal placement of the number on the display. The CHANGE SIGN key enables changing the algebraic sign of the number in register one for arithmetic operations. The Decimal Point Selector switch determines the column position of the decimal point on the display, and, internally in the machine, controls placement of the data in the proper decimal location on the display.

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2. DISPLAY.

The display on the EC-130 (See Figure 1-3) consists of 13 digit columns and one sign column. There are four registers displayed; the first two from the bottom being called "working registers". An arithmetical operation is always performed using the numbers in the first two registers. The answer is always displayed in register one, the lowest of the four registers, and register one is brightened with respect to the other registers to accentuate the fact. The upper two registers are used for storage of intermediate answers or numbers that will be used in later arithmetical operations.

All unused columns to the left of numbers in the machine are automatically displayed with zeros. During digit entry (placing numbers in the machine), when entering a number containing zero, the 0 key is used. Any unused columns to the right of the decimal point after digit entry is completed, and internal machine operations have completed decimal alignment, will also be displayed with zeros automatically.

D. ADDITIONAL FEATURES.

For ease of operation and to prevent errors special features are incorporated in the EC-130. They are: Overflow Lock, Decimal Point Interlock, Decimal Point key, Change Sign key.

1. OVERFLOW LOCK.

If a number being entered contains more digits to the left of the decimal point than the decimal point position will permit, the OVERFLOW LOCK signal lights and all keys are "locked up" to prevent further usage. For example; if the Decimal Point Selector switch is set at 7, there are six possible digit positions to the left of the decimal point on the display. At this time, if a seven-digit number is entered, OVER-FLOW LOCK lights and indicates that this number is beyond the machine capacity as set by the Decimal Point Selector. Furthermore, if a developed answer exceeds the possible number of digits to the left of the chosen decimal point, OVERFLOW LOCK lights and the keyboard locks up.

The keyboard can be freed for further use by pressing any one of three keys: OVERFLOW LOCK, CLEAR ENTRY, or CLEAR ALL.

2. DECIMAL INTERLOCK.

A decimal interlock is provided to prevent entering more digits to the right of the decimal point than the machine can display after decimal alignment of the number around the chosen decimal position. That is, if the Decimal Point Selector is set at 2, there are two possible digit positions to the right of the decimal point on the display. At this time, if a number containing three digits after the decimal point is entered, the machine accepts and displays only the first two digits entered after the decimal point key is pressed during the number entry.

3. DECIMAL POINT KEY.

If the Decimal Point Key is not used during entering of a number, the entry is sensed as a whole number and displayed to the left of the chosen decimal position. Consequently, for whole number entries it is not necessary to use the Decimal Point key.

4. CHANGE SIGN KEY.

The EC-130 performs all calculations in accordance with the rules of algebra in regard to signs. Since all entries are positive, a Change Sign key is provided to make entries negative when desired. Also, answers with a negative sign may be made positive. The Change Sign key will reverse the sign of the number in register one.

E. PRELIMINARY SERVICE PROCEDURES.

At the field service level, the permitted amount of servicing is specifically limited as outlined in Sections 3 and 4 of this manual. The permissible servicing procedures can be accomplished in either of two places; the customers office, or the Field Service Office.

The procedures to be accomplished in the Field Service Office are outlined in Sections 3 and 4. In this section, procedures in the customer office are briefly discussed.

1. CUSTOMER CONTACT.

A field service technician is probably the most often seen representative of Friden, especially at the office "working" level as distinguished from "management". As such, it is important that the service technician be neat, well-groomed, and courteous.

Competition is keen in the office equipment field. Often, the choice between competing machines is the service factor. As a part of the service organization, the field service technician is an important representative of Friden, and should look, act, and conduct himself as such. It is not enough just to be a good technician; to know the machine; or to be able to adjust the machine satisfactorily. It is also very important to leave the customer satisfied, not only that the machine is working well, but also that he has been treated with respect; his wishes have been courteously received and complied with to the maximum practical extent; and that the whole servicing procedure was conducted by a neat, efficient, courteous, and well-trained Friden representative.

As a part of customer contact, the technician must find out, as courteously and expeditiously as possible, the cause of customer complaint. Very often, courteous listening to the machine operator, even if not directly applicable to machine malfunction, will leave a very good impression. The first step in service procedure is to find out what is wrong from the stand point of the customer.

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2. MACHINE CHECKOUT.

Machine checkout is a series of semi-standardized steps used in determining a machine malfunction. Necessarily, experience with the EC-130 will enable each service technician to develop his own checkout procedures. The following is a guide to be used if desired.

a. STANDARD PROBLEM. Following is a standard problem that will check most of the functions of the EC-130; Decimal Point Selector on 0:

(1) Press CLEAR ALL
(2) Press digit 1-1-1-1-1-1-1
(3) Press ENTER
(4) Press STORE
(5) Press RECALL
(6) Press REPEAT
(7) Press Multiply (X)

Register one shows: 1 2 3 4 5 6 7 6 5 4 3 2 1 Enter, Store, Recall, Repeat, and Multiply are checked in the above procedure.

(8) Press RECALL
(9) Press Divide (÷)

Register one shows: 0 0 0 0 0 0 1 1 1 1 1 1 1
Divide is checked.

(10) Press REPEAT
(11) Press Add (+)

Register one shows: 0 0 0 0 0 0 2 2 2 2 2 2 2
Add is checked.

(12) Press RECALL
(13) Press Subtract (-)

Register one shows: 0 0 0 0 0 0 1 1 1 1 1 1 1
Subtract is checked.

(14) Press "0"
(15) Press Divide (÷)

Display remains blanked.
Unsolvable problem, answer would be infinity.

(16) Press CLEAR ALL
(17) Move Decimal Point Locator to 7 on dial.
(18) Press digit: 1-1-1-1-1-1-1
(19) Press ENTER

OVERFLOW LOCK light, keyboard locks up.
Entering of too many whole number digits is checked.

(20) Press CLEAR ENTRY
(21) Move Decimal Point Locator to 2 on dial.
(22) Press digit: 1-1-1-DECIMAL POINT-1-1-1
(23) Press ENTER

Register one shows: 00000000111.11
Entering of too many digits after decimal point is checked.

b. VISUAL INSPECTION. Visual inspection of the display can reveal malfunctions such as character malformation, displacement, and abnormal height or width. There are two purposes in the design of the display. One is to provide a means of visually checking the numbers to be operated with, and the second is to provide a clear and pleasing visual presentation. Certain aspects of the visual presentation are adjustable to customer satisfaction if desired. Visual display adjustments are covered in Section 3 of this manual.

c. AC POWER. Since the EC-130 is an electronic machine, it must be furnished with AC power at 115V, 50-60 cycles from a convenient 3-wire, grounded, AC outlet. One of the first steps in a checkout is to determine if power is being furnished to the machine, especially if the preliminary inspection reveals a blank display.

On the right hand side of the machine, beneath the top cover, are two fuses. The best check of the fuses is to replace them with two known good fuses of the same type and current rating.

A further check of whether AC power is available in the machine is to visually inspect at the base of the CRT for filament glow. However, lack of filament glow in itself would not necessarily indicate lack of AC to the machine; it might just be that the CRT filaments are burned out necessitating CRT replacement.

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SECTION 2. OPERATION

A. GENERAL FUNCTIONAL OPERATION.

The function of the EC-130 is to arrange arithmetical data that has been entered in the machine so that a desired arithmetical problem may be performed, and then to perform that problem.

The operation of the EC-130 consists of entering arithmetical data in the machine by means of the Keyboard, arranging the data in the machine, and performing an arithmetical operation on the data.

In the performance of machine operation, the circuits and components are grouped into major functional blocks. (See Figure 2-1)

1. KEYBOARD.

The Keyboard enables the entering of numbers, determines the arrangement of the data, and specifies the arithmetical function to be performed.

2. FUNCTION CONTROL.

When the Keyboard has specified a function, a number of internal machine operations are necessary to accomplish that function. The function control circuits specify the internal operations, and ensure that they occur in proper time relationship.

3. TIMING.

The timing circuits develop signals that are used to specify the time relationships of machine operations.

4. COUNTERS.

The counter circuits perform several functions. They are used, with the delay line, to hold data until needed to shift data in time relationship to other data; to convert numbers from the Keyboard into data for internal machine use; or to extract desired data from the data sequence for display.

5. DELAY LINE.

The delay line is a mechanical means of delaying data, often called storing, for a period of time that is long in comparison with internal machine operations. The delay line is the part of the machine that, together with the counter circuits, stores data in the machine.

6. DISPLAY.

Numbers which exist in the machine in electronic form must be converted to a visible equivalent on the face of the CRT. The display circuits accomplish this conversion, and arrange the display on the CRT.

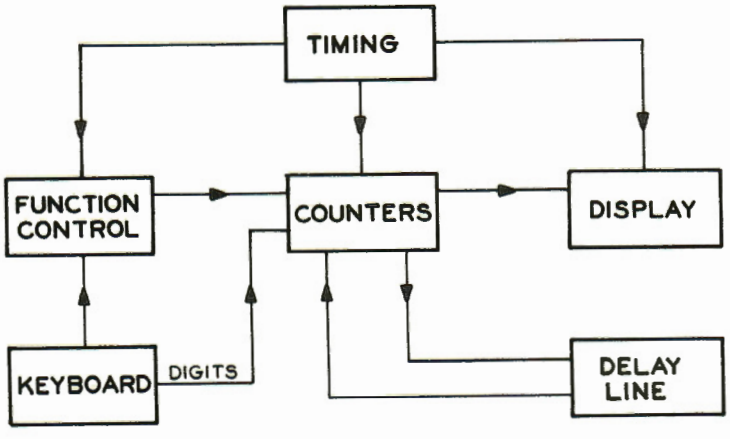


FIGURE 2-1. FUNCTIONAL BLOCK DIAGRAM

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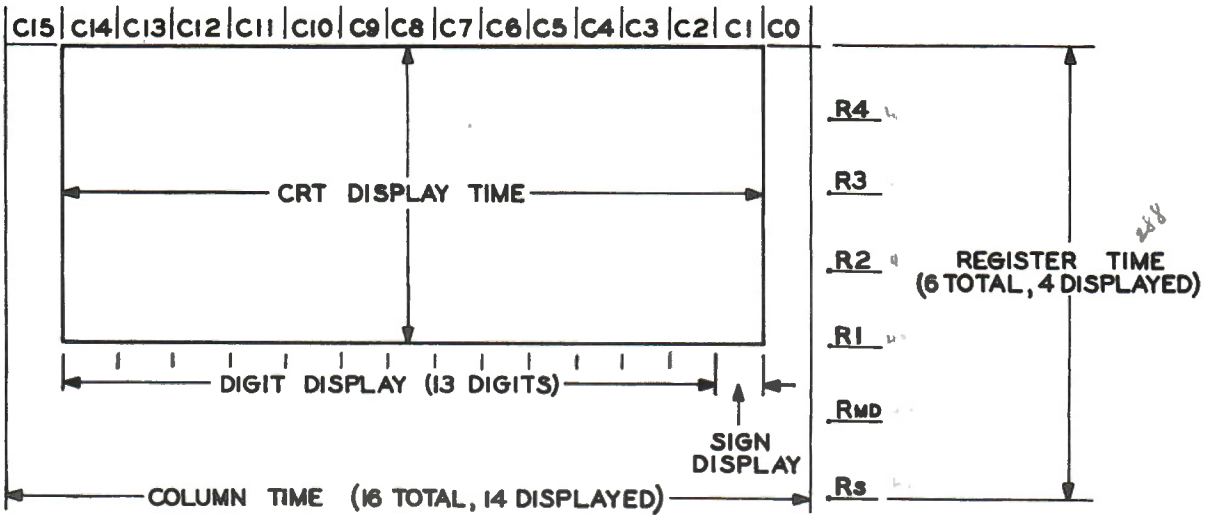


FIGURE 2-2. DISPLAY ORGANIZATION

B. DETAILED FUNCTIONAL OPERATION.

This discussion will cover the detailed operation of the major functional blocks of the EC-130.

1. DATA ORGANIZATION.

The data is organized in the machine by the action of timing chain signals on the counters. The action of the counters controls the placement of data on the delay line, and on the CRT display. The CRT displays data in a specific pattern (See Figure 2-2). Some of the data relationships in the machine are not displayed but are used for necessary arithmetical, storage, or timing operations. The major time relationships in the machine are: Register time, Column time, Word time, and Bit time.

a. REGISTER TIME. There are six register (R) times, of which four are displayed (See Figure 2-3). Each R time is equal to 48 μsec. Each register time can contain one digit of a number. Hereafter in the discussion, R1 will mean Register one, R2 will mean Register two, etc. The term "Display" will mean the four display registers: R1, R2, R3, and R4.

b. COLUMN TIME. There are a total of sixteen (16) column (C) times, of which fourteen are displayed on the CRT. Each column time is equal to 288 μsec. One column (C1) is reserved for displaying the algebraic sign of the register. Columns two (C2) through fourteen (C14) display digits for each register. Thus, a total of thirteen (13) digits may be displayed in each register. Column fifteen (C15) is used in a divide operation, and column zero (C0) is not used.

c. WORD TIME. Word time is used to identify the total time available for a sequence of data. Word time consists of the six register times multiplied by fifteen column times. One word time is equal to 4320 μsec.

d. BIT TIME. Each R time is composed of sixteen (16) Bit (B) times, of which nine (9) are used for pulses that represent digits. One B time is equal to 3 μsec.

2. TIMING.

The organization of the data on the delay line, the positioning of the data on the display, and the sequence of internal machine operations are all related exactly by timing signals from the timing circuits (See Figure 2-4).

a. START PULSE. To maintain the relationship between the delay line and the timing circuits, the timing chain is stopped at the end of C15 time. This begins a period of time designated as "Home". When the machine is prepared for the entry of data after having first been turned on, or whenever all data has been cleared from the machine by CLEAR ALL key, a "start" pulse is placed on the delay line by the first function initiated by the keyboard. This start pulse is timed to occur just before C1 time, and turns on the timing chain just before data is available at the output of the delay line. This ensures that the timing chain is always in step with the data, and thus the data can be identified correctly by timing chain signals.

b. CLOCK CONTROL. The basic time element is the frequency of the oscillator. The oscillator output drives the clock circuit, which puts out one pulse each Bit (B) time. While the oscillator runs continuously, the output of the clock is stopped at the end of C15 time. The clock is started again at the time the first data is available at the output end of the delay line. This keeps the timing chain and the data synchronized so that the timing chain signals can be used to exactly identify the data by time as it comes off the delay line; and also while it is in the counter circuits.

c. BIT TIME COUNTER. The B time counter circuits count the clock down by sixteen and provide an output pulse to the Register (R) time counter every sixteen (16) B times.

d. REGISTER TIME COUNTER. The R time counter circuits count down the output of the B time counter circuits by six, and provide an output pulse to the column (C) counter circuits every six (6) R times.

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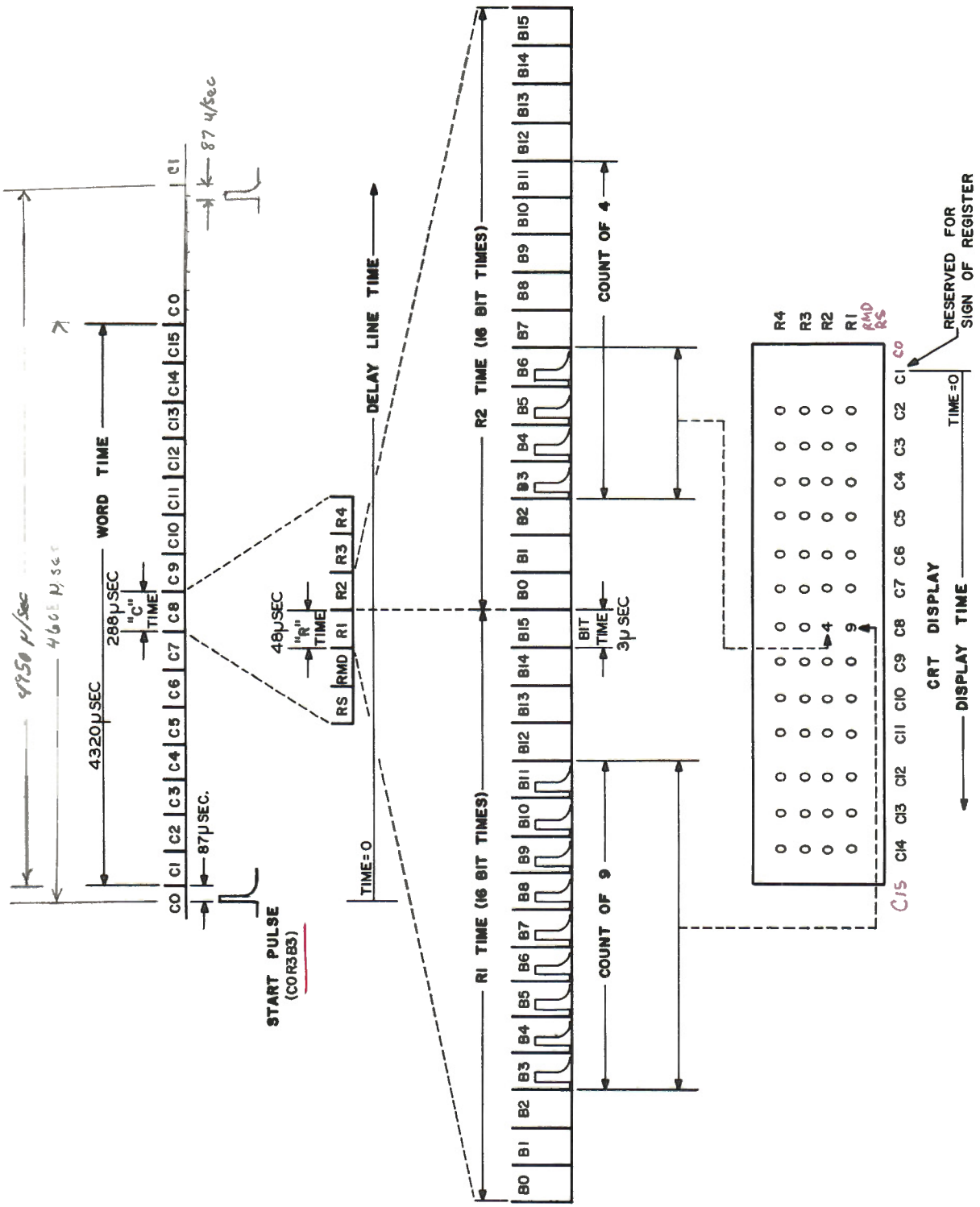


FIGURE 2-3. DATA ORGANIZATION

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e. COLUMN TIME COUNTER. The column (C) time counter circuits count down the output of the R time counter circuits by 16, and provide an output pulse every sixteen (16) C times.

f. DISPLAY CONTROL COUNTER. The display counter provides signals to the display circuitry that enable each register to be displayed at the necessary time and proper position on the CRT. Register one (R1) is displayed twice for extra brightness and this is desirable, since the answer to an arithmetical operation always appears in this register.

3. COUNTING.

The counter circuits perform two functions: counting and shifting (See Table 2-1). Both are basic to machine operation. Counting means to progressively change the setting of a counter by the one-by-one addition of pulses, which is called "Serial Entry". There are two similar types of counters: Up Counter and Down Counter. They are capable of ten possible counts (settings).

a. UP COUNTER. The addition of a pulse to an up counter causes the setting to change in an upward direction from zero toward nine. Thus, one pulse into an up counter already set to three (3) results in a new setting representing four (4).

b. DOWN COUNTER. The addition of a pulse into a down counter will cause the setting to change in a downward direction from zero (representing 10) toward one. Thus, one pulse into a down counter already set to three (3) results in a new setting representing two (2).

TABLE 2-1

COUNTER CIRCUIT FUNCTIONS

COUNT OR SHIFT	A COUNTER	B COUNTER	C COUNTER	D COUNTER	USES (PARTIAL)
LINE TO A	SERIAL INPUT				DATA INTO A COUNTER (COUNT UP -READ)
LINE TO D				SERIAL INPUT	DATA INTO D COUNTER (COUNT DOWN)
A TO B	PARALLEL OUTPUT	PARALLEL INPUT			PART OF IDLE
A TO D	PARALLEL OUTPUT			PARALLEL INPUT	PART OF SHIFT UP, SHIFT LEFT (DELAY IN TIME)
D TO A	PARALLEL INPUT			PARALLEL OUTPUT	PART OF ARITHMETICAL OPERATIONS
D TO B		PARALLEL INPUT		PARALLEL OUTPUT	PART OF SHIFT UP, SHIFT LEFT
A TO C	PARALLEL OUTPUT		PARALLEL INPUT		PART OF SHIFT DOWN (ADVANCE IN TIME)
B TO C		PARALLEL OUTPUT	PARALLEL INPUT		PART OF IDLE
C TO LINE			SERIAL OUTPUT		DATA INTO LINE (WRITE)

Parallel Output - Direct transfer of data
Parallel Input - Direct reception of data
Serial Output - Sequential (one by one) transfer of data
Serial Input - Sequential (one by one) reception of data

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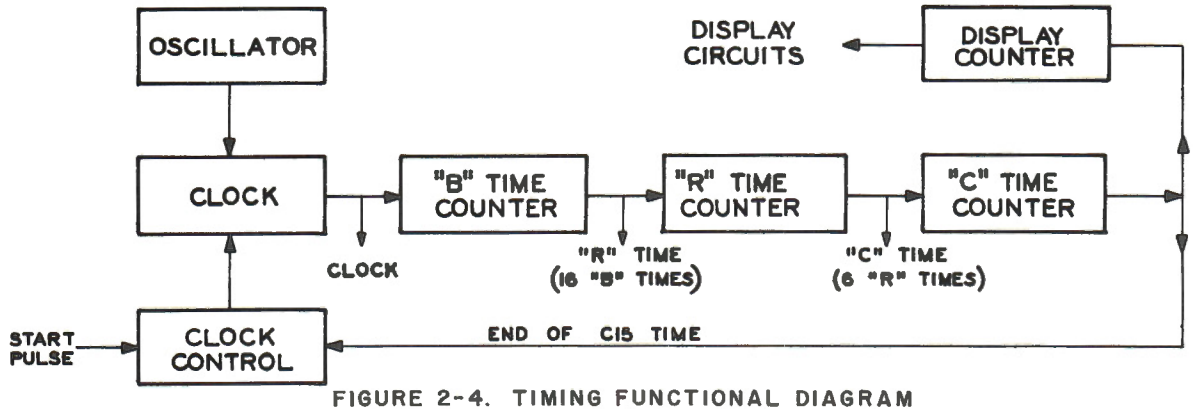


FIGURE 2-4. TIMING FUNCTIONAL DIAGRAM

4. SHIFTING.

Shifting means to change the position of data with respect to time. To shift is to transfer the setting of one counter into another counter. Since the shift (transfer) of data is controlled with respect to time, the data can be moved with respect to time by shifting into specified counters.

Before explanation can be made of the specific shifts used in machine operation, reference must be made to data organization with specific application to shifting.

a. DATA SEQUENCE. The data organization, called "data sequence", is by register time and column time, both on the display (Figure 2-5) and on the delay line (Figure 2-6). Note that all R times in C2 occur before the R times in C3, the R times in C3 before the R times in C4, etc.

To move data from R1 to R2, the data must be stored (delayed) until R2 time occurs. To move data from R2 to R1, the data must be moved ahead in time (advanced) because R1 occurs before R2. To move data from a register in C2 time to the same register in C3 time, the data must be delayed (stored) until that C3 time occurs. The delay or advance in time is determined by the type of shift.

b. IDLE. Idling is the progression of data from the delay line, through the counters, and back onto the delay line with no change in data sequence. The machine is said to be "idling" when no function is being performed. Data progression through the counters in idle is: Line to A, A to B, B to C, C to line. Since the data sequence is preserved, there is no change in time relationships between the data.

Periodically during idle, the data in display registers R1 through R4 is copied in the D counter. The display circuits then convert the D counter data into a visual equivalent for display. Display occurs only during idle. The data sequence for display is: R1 data for all C times, R2 data for all C times, R3 data for all C times, and R4 data for all C times.

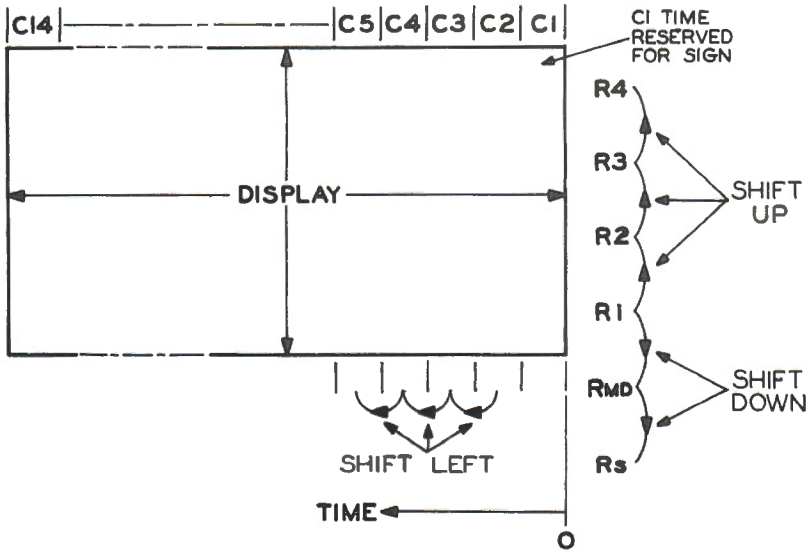


FIGURE 2-5. DISPLAY DATA AND SHIFTING

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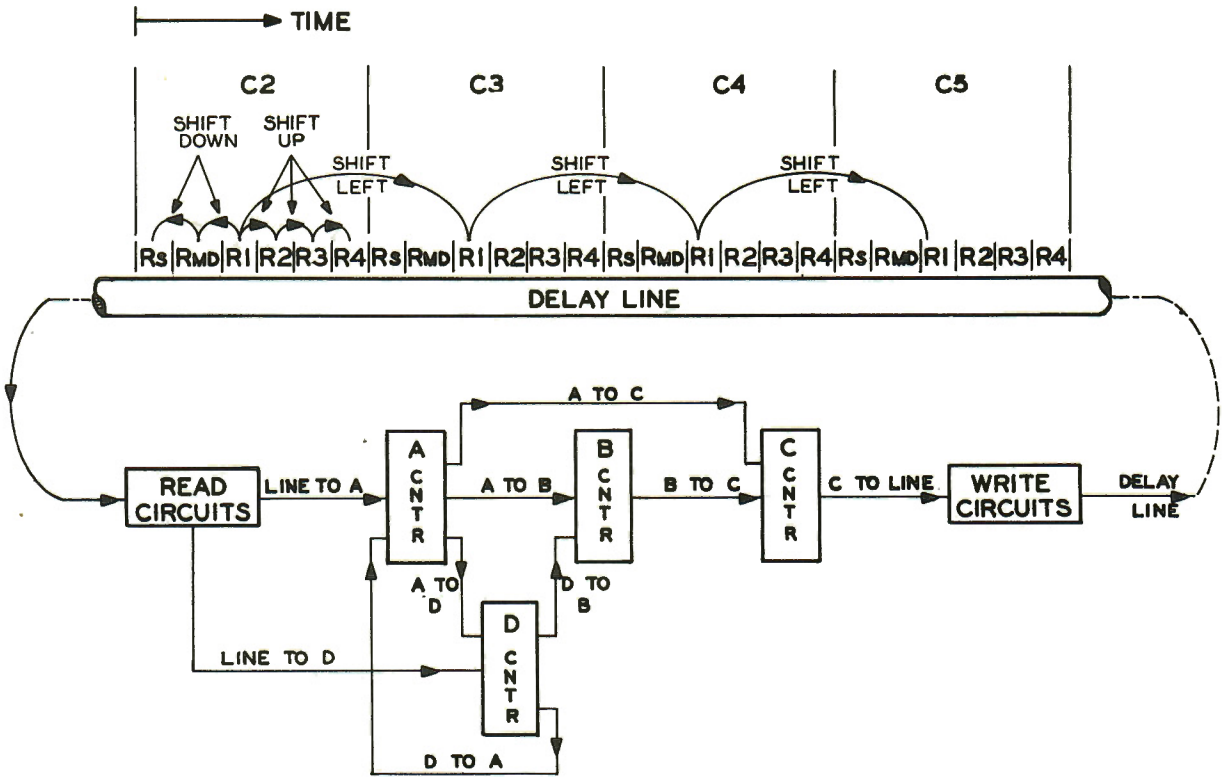


FIGURE 2-6. DELAY LINE DATA AND COUNTER SHIFTING

For example; assume R1C2 data from the delay line has been counted into the A counter. When an A to B shift occurs during idle, an A to D shift also occurs, which copies the R1 data into the D counter. While the rest of the C2 data progresses through the counters, and until R1C3 data has been counted into the A counter, the R1C2 data in the D counter is being converted and displayed. Then, when R1C3 data is shifted A to B, an A to D shift occurs, which copies the R1C3 data into the D counter. Again, while the rest of the C3 data is progressing through the counters, R1C3 data in the D counter is being converted and displayed. This progression continues until the R1 data in all display C times has been converted and displayed. Then R2 data will be displayed in the same manner, followed by R3, and finally R4.

c. SHIFT UP. To shift up means that on the display (See Figure 2-5) the registers will move up: R1 data to R2, R2 data to R3, R3 data to R4, and R4 data will be lost. However, in terms of data sequence, each register data is delayed one register time and the data placed in the next succeeding register (See Figure 2-6).

Shift up is done by shifting A to D, holding the data in D for one register time, then shifting D to B, which places each register data in turn into the next succeeding R time. Since R1 time is displayed ahead of R2 time, if R1 data is placed in R2 time, it will appear as shifted up on the display. However, placing R1 data in R2 time places it later (delayed) in the data sequence on the delay line.

d. SHIFT LEFT. Shift left is very similar to shift up and uses the same sequence of shifts, but at different times and for a longer delay. Shift left, limited to R1 and R2 by the function control circuits, is done by shifting the selected register A to D, holding for one C time, and shifting D to B at the corresponding R time in the next C time. Since R1C2 time is displayed ahead of R1C3 time, if R1C2 data is placed in R1C3 time, it will appear as shifted left on the display. However, placing R1C2 data in R1C3 time places it later (delayed) in the data sequence on the delay line.

e. SHIFT DOWN. To shift down means that on the display the registers will move down; R4 data to R3, R3 data to R2, R2 data to R1. However, in terms of data sequence, each register data will be advanced one register time and the data is placed in the next preceding register.

Shift down is accomplished by shifting A to C, instead of A to B. Since one R time in B counter has been bypassed, data effectively moves ahead in the data sequence, and will be written on the delay line sooner. Since R1 time is displayed ahead of R2 time, if R2 data is placed in R1 time, it will be shifted down on the display. However, placing R2 data in R1 time places it earlier (advanced) in the data sequence on the delay line.

Note that in Shift Up and Shift Down two undisplayed registers will be affected; Rmd and Rs. This effect will be covered in FUNCTION CONTROL discussion.

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5. DELAY LINE CIRCUITS.

The delay line is a storage device. Together with the counters, the delay line keeps numbers in the machine as long as the machine is idling. The delay line also provides storage for data during the steps and operations necessary for the completion of a function.

The delay line circuit (Figure 2-7) is electromechanical. That is, a portion of the circuit is mechanical in nature, and the rest of the circuit is electrical. The two portions work together to produce a finite time delay for the extremely fast, (by comparison) electronic data operations. This delay in time effectively stores the data for the time of delay, approximately five (5) milliseconds, (.005 seconds).

a. DELAY LINE. The delay line is made of alloy steel wire about the diameter of a mechanical pencil lead. A physical twist (torsion) of one end of the wire takes a definite amount of time to reach and affect the other end. The amount of time is primarily determined by the length of the wire, which is approximately fifty (50) feet. To save space, the delay line is coiled up and mounted in such a manner that movement of the mechanical waves along the wire are not affected.

b. TRANSDUCERS. The transducers are components that change electrical pulses into mechanical movements (twists) of the delay line, and, conversely, change mechanical twists into electrical pulses.

A transducer (Figure 2-8) is mounted at and connected to each end of the delay line. They are designated as: Launch or Write transducer and Receive or Read transducer.

(1) Write Transducer. The action of the Write transducer is dependent on the fact that the element nickel changes physical length when subjected to a change of magnetic field. This is called "magnetostriction".

The Write transducer consists of two nickel ribbons mounted in the centers of two coils of wire. A pulse of current (data pulse) from the write amplifier causes a proportional change in the magnetic field of the coils. This magnetic field change causes the nickel ribbons to change dimension lengthwise. One ribbon shrinks, the other ribbon expands. This gives a push-pull effect on the wire of the delay line, and thus gives more twist for each pulse than if one ribbon were used. The effective result of each pulse of current is to produce a momentary twist in the delay line that will travel to the other end at a finite speed.

(2) Read Transducer. The Read transducer is basically the same as the Write transducer. However, while the function of the Write transducer is to convert electrical pulses to mechanical twists of the delay line, the function of the Read transducer is to convert delay line twists to electrical pulses.

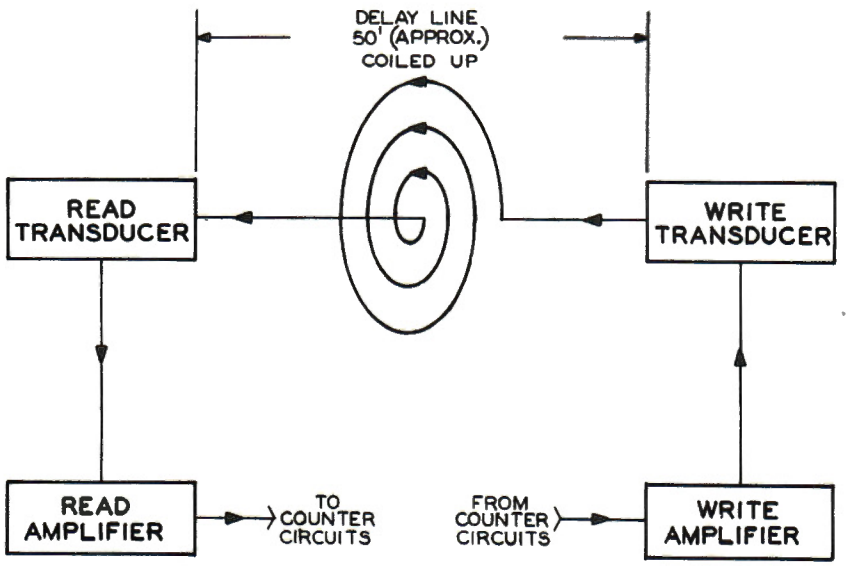


FIGURE 2-7. DELAY LINE FUNCTIONAL DIAGRAM

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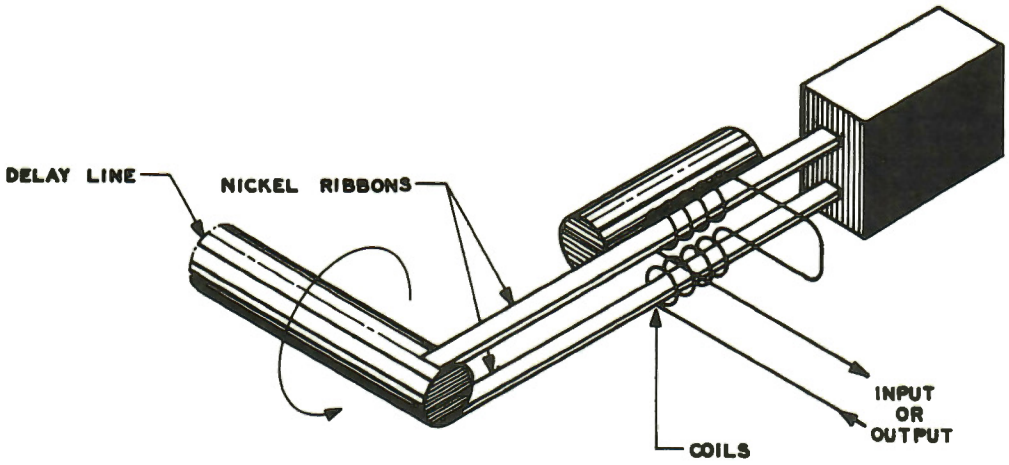


FIGURE 2-8. TRANSDUCER SIMPLIFIED DIAGRAM

The delay line twists at the Read transducer (Figure 2-8) momentarily distort the shape of the nickel ribbons. One ribbon will be stretched, the other compressed, and together they give a push-pull action that gives more effect on the coils for each delay line twist than if one ribbon were used. The change of shape of the nickel ribbons induces a voltage in the coils surrounding the ribbon. This voltage is the output of the Read transducer.

c. AMPLIFIERS. The delay line circuitry contains two amplifiers; a Write amplifier and a Read amplifier.

(1) Write Amplifier. The purpose of the Write amplifier is to convert (data) pulses of voltage to current pulses of a value adequate to actuate the Write transducer.

(2) Read Amplifier. The purpose of the Read amplifier is to build up voltage pulses from the Read transducer (that represent data on the delay line) to a value adequate to actuate the counter circuits.

6. FUNCTION CONTROL.

A function is a series of internal machine operations that produce a specified result. An internal machine operation consists of one or more steps that occur at times that are specified by the function control circuits. The time relationships are established by signals from the timing circuits.

The functions of the EC-130 are initiated from the keyboard by the function keys. There are two classes of functions: Operational functions and Arithmetical functions. Operational functions can be designated as those functions that arrange the data for the arithmetical functions that will take place. The operational functions are: Digit Entry, Store, Recall, Repeat, Clear Entry and Clear All. The arithmetical functions are: Add, Subtract, Multiply, and Divide.

a. DIGIT ENTRY. A digit is a single numeral. A number is one or more digits. Digit Entry is the process of placing numbers in the machine, digit by digit (See Table 2-2). Numbers are displayed left to right but are placed in the machine, one by one, in the extreme right hand portion (C2) of register one (R1). As each new digit is entered, the already-entered digits are shifted to the left to clear R1C2 for the entry of the new digit. This process preserves the arithmetical order of the digits.

When all digits of a desired number have been entered, Enter key is pressed to signify to the machine that the number is complete. Had the Enter key not been pressed, entering another digit would simply add a digit to the number already entered. When the machine has been cleared of all data by CLEAR ALL, the ENTER key must be used after the first "Digit Entry". After the first "Digit Entry". use of the ENTER key is usually optional, because using any other function key signifies to the machine that the digit entry is complete.

During Digit Entry, pressing DECIMAL POINT key during the entering of a number specifies two operations to the machine. First, during "Decimal Align" that all digits entered after the DECIMAL POINT key has been pressed will appear to the right of the chosen decimal point position. Second, that when the register spaces available to the right of the decimal point have been utilized, the machine will accept no more digits. For example; if the Decimal Point Selector switch is set at two (2), there are spaces for only two digits to the right of the decimal point. If a number with three digits to the right of the decimal point is entered, such as .025, the machine will accept only .02, and the digit "5" will not be entered. This prevents entering more digits to the right of the decimal than can be utilized when the entered number is decimally aligned.

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TABLE 2-2

DIGIT ENTRY FUNCTION

ACTION	RESULT	REMARKS
a. Press "4" key.	D counter sets to 4.	Digit keys set D counter.
b. Shift R1 left, AND Shift D to B at R1C2 time.	R1C2(0) moves to R1C3, R1C3(0) moves to R1C4, etc. D counter data (4) enters R1C2 time.	See Shift Left. R1C2 becomes 4. See D to B Shift, Table 2-1
c. Press "6" key.	D counter sets to 6.	See Step a.
d. Shift R1 Left, AND Shift D to B at R1C2 time.	R1C2(4) moves to R1C3, R1C3 to R1C4, etc. D counter data (6) enters R1C2 time.	See Shift Left. R1C2 becomes 6. See Step b.
e. Press DECIMAL POINT	Any further digits entered will be placed to the right of the decimal point.	See Digit Entry.
f. Press "5" key.	D counter sets to 5.	See step a.
g. Shift R1 Left, AND Shift D to B at R1C2 time.	R1C2(6) moves to R1C3, R1C3(4) moves to R1C4, R1C4 to R1C5, etc. D counter data (5) enters R1C2 time.	See Shift Left. R1C2 becomes 5. See step b.
h. Press ENTER key.	Entered digits align around decimal position 2.	Display R1 reads: 00000000046.50
NOTE: The first action that will occur upon initiation of a new digit entry will be a Shift Up that will clear R1 for the entry of the new number. See Shift Up.		

b. STORE. The Store function enables a number in R1 to be transferred to Rs, which is an undisplayed storage register.

Once data has been placed in Rs, it will be undisturbed by any function except Clear All, or replacement with new data using the STORE key.

The STORE key initiates internal machine operations that shift R1 data down into Rs in two steps. The first step shifts R1 data into Rmd; and the second step shifts the Rmd data (previous R1 data) into Rs.

In terms of specific machine action, the internal operations for Store function are as follows. Press STORE Key:

(1) Internal operations perform an A to C shift every R time during C1 through C14 time. This shifts all registers down by one. Thus, R1 shifts to Rmd, R4 to R3, R3 shifts to R2, and R2 shifts to R1.

(2) When step (1) is completed, internal operations perform another A to C shift for Rmd time only. This places Rmd (previous R1 data) into Rs.

c. RECALL. The Recall function enables data placed in Rs to be recalled to R1. Note that recalling Rs data does not remove the data from Rs, but only repeats the Rs data in R1.

In terms of specific machine action, the internal operations for Recall function are as follows; press RECALL key:

(1) At Rs time for C1 through C14 times, internal operations perform an A to D shift, as well as an A to B shift. The A to D shift stores Rs data in D counter temporarily, and the A to B shift preserves the Rs data in the proper sequence.

(2) At R1 through R4 times for C1 through C14 times, internal operations Shift Up R1 through R4. The Shift Up operation effectively clears R1 time for the insertion of Rs data.

(3) At R1 time for C1 through C14 times, internal operations perform a D to B shift. The D to B shift inserts D counter data (previous Rs data) into R1 time.

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d. REPEAT. The Repeat function enables R1 data to be repeated in R2 without the necessity of reentering the same digits.

In terms of specific machine action, the internal operations for Repeat function are as follows; press REPEAT key:

(1) At R1 time for C1 through C14 times, internal operations perform an A to D shift, as well as an A to B shift. The A to D shift stores R1 data in D counter temporarily, and the A to B shift preserves R1 data in the data sequence.

(2) At R2, R3, and R4 times for C1 through C14 times, internal operations Shift Up R2, R3 and R4. The Shift Up operation clears R2 time for the insertion of R1 data.

(3) At R2 time for C1 through C14 times, internal operations perform a D to B shift. The D to B shift inserts D counter data (previous R1 data) into R2 time.

e. CLEAR ENTRY. The Clear Entry function effectively erases R1 data, usually to permit a new number entry.

Clear Entry shifts R1 through R4 down one register. This places R1 information in Rmd. This is of no consequence because initiation of any arithmetical function will place new data in Rmd, replacing whatever data is already there. Initiation of an operational function such as Digit Entry, Recall, or Repeat will then put new data in R1.

In terms of specific machine action, the internal operations for Clear Entry function are as follows; Press CLEAR ENTRY key:

(1) At R1 through R4 times for C1 through C14 times, internal operations perform an A to C shift. This places R2, R3, R4 data down one register on the display; and places R1 data in Rmd, which is undisplayed.

(2) Internal operation remains set to Shift Up R1 through R4 upon the initiation of a new Digit Entry. The Shift Up operation clears R1 for the insertion of new data.

f. CLEAR ALL. The Clear All function removes all data from the machine, usually to prepare the machine after first "Turn On"; or to prepare for the insertion of completely new data.

The CLEAR ALL key initiates internal machine operations that disable the input to the Write amplifier. Since the Write amplifier has no input, no data will be rewritten on the line, and the machine is cleared. After Clear All function has been accomplished, the display shows all zeros (0's), and no data is in the machine.

g. ADD. There is a distinction between an Add function chosen by pressing Add (+) key on the keyboard and internal "machine add". The internal machine decision to add or subtract is decided by comparing the algebraic signs of the two numbers. The machine may, on the basis of the algebraic signs, subtract in an add function, or add in a subtract function. The algebraic rules are: If the signs are the same, add; if the signs are different, subtract and give the answer the sign of the largest number.

In the machine, in a machine add operation (See Table 2-3), the addition is done by counting data into the A counter; holding that data setting in the A counter while simultaneously transferring the data to the B counter; then counting new data into the A counter "on top of" the setting left by the previous data.

During the "add" count into A counter, if the counter setting advances past 9 (representing 10 or more), a carry of 1 is placed into the next column add cycle. When all columns have been added in turn, the answer has been developed, and will be displayed in Register one.

The OVERFLOW LOCK lights and the keyboard "locks up" if the last column (C14) addition develops a carry. The carry is a valid part of the answer and there is no further column in which to place the carry; therefore, machine capacity to display the answer has been exceeded. By pressing OVERFLOW LOCK key the operator may release the keyboard lockup, which signifies that the condition of overflow is recognized. OVERFLOW LOCK may also be released by Clear Entry, which erases register one; or by Clear All, which erases all data in the machine.

TABLE 2-3

ADD FUNCTION

In terms of specific machine action, internal operations for an Add function are explained step by step below with reference to ADD FLOW CHART, Figure 2-9, and the problem as illustrated.

C5 C4 C3 C2	C5 C4 C3 C2	C5 C4 C3 C2
0 9 1 6 R2	0 0 0 0 R2	0 0 0 0 R2
0 1 1 3 R1	0 9 1 6 R1	1 0 2 9 R1
0 0 0 0 Rmd	0 1 1 3 Rmd	0 1 1 3 Rmd
BEGIN PROBLEM	AFTER SHIFT DOWN	END OF PROBLEM; ANSWER IN R1.

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ACTION	RESULT	REMARKS	FLOW CHART STEP
a. Press Add (+) key.	Display blanks.	Initiation of any arithmetic operation blanks display.	1 & 2
b. Decimal Align.	Number in R1 aligns around decimal position.	Decimal Point Selector is on 0.	3
c. Are R1 and R2 signs same? Yes.	Proceed to Step 5.	Signs are the same; machine performs "machine add"	4
d. Shift Down.	R1 through R4 shift down one register.	See Shift Down.	5
e. Count RmdC2(3) into A counter.	A counter sets to 3.	Rmd pulses from delay line count A counter up to 3.	6
f. Shift A to B, AND Block reset A.	RmdC2 data moves to B counter. RmdC2(3) setting remains in A counter	See A to B shift, Table 2-1. A counter is normally reset after each shift. This reset is blocked to leave Rmd setting in A counter.	6
g. Is Carry set? No.	Proceed to step 9.		7
h. Count R1C2(6) into A counter	A counter sets to 9.	R1(6) counts on top of Rmd(3) setting left in A counter in step f.	9
i. Did R1 plus Rmd advance A past 9? No.	Proceed to step 12.	Rmd(3) plus R1(6) equals 9.	10
j. Are All columns added? No.	Proceed to Step 6.	Only C2 has been operated upon.	12
NOTE: R1 through R4 shift A to B to C to Line. C2 add cycle is completed.			
k. Count RmdC3(1) into A counter.	A counter sets to 1.	See step e.	6
l. Shift A to B, AND Block reset A.	RmdC3 data moves to B counter. RmdC3(1) setting remains in A counter.	See step e. See step e.	6
m. Is Carry set? No	Proceed to step 9	C2 add cycle did not produce a carry.	7
n. Count R1C3(1) into A counter.	A counter sets to 2.	Rmd(1) plus R1(1) equals 2.	9
o. Did R1 plus Rmd advance A counter past 9? No.	Proceed to step 12.	See step n.	10
p. Are all columns added? No.	Proceed to step 6.	Only C2 and C3 have been operated upon.	12

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NOTE: R1 through R4 shift A to B to C to Line. C2 and C3 add cycle is completed.			
q. Count RmdC4(1) into A counter.	A counter sets to 1.	See Step e.	6
r. Shift A to B AND Block reset A.	RmdC4 data moves to B counter. RmdC4(1) setting remains in A counter.	See Step e. See Step e.	6
s. Is Carry set? No.	Proceed to step 9.	C3 add cycle did not produce a carry.	7
t. Count R1C4(9) into A counter.	A counter sets to 0.	Rmd(1) plus R1(9) equals 10, which becomes 0 plus carry 1.	9
u. Did R1 plus Rmd advance A counter past 9? Yes.	Proceed to step 11.	See step t.	10
v. Set Carry.	Proceed to step 12.		11
w. Are all columns added? No.	Proceed to step 6.	Only C2, C3, and C4 have been operated upon.	12
NOTE: R1 through R4 shift A to B to C to Line. C2, C3, and C4 add cycles are completed.			
x. Count RmdC5(0) into A counter.	A counter sets to 0.	See Step e.	6
y. Shift A to B, AND Block reset A.	RmdC5 data moves to B counter. RmdC5(0) setting remains in A counter.	See Step e. See Step e.	
z. Is Carry set? Yes.	Proceed to step 8.	See Step v.	7
aa. Add 1 to A counter, and reset Carry.	A counter sets to 1.	If Carry is set, Add 1 to A counter at end of Rmd time, and reset Carry.	8
ab. Count R1C5(0) into A counter.	A counter remains set to 1.	RmdC5(0) plus Carry (1) plus R1C5(0) equals 1.	9
ac. Did Rmd plus R1 advance A past 9? No.	Proceed to step 12.	See Step ab.	10
ad. Are all columns added? Yes.	Proceed to step 13.	All significant columns in this problem have been added.	12
NOTE: R1 through R4 shift A to B to C to Line. All significant columns are added.			
ae. Is Carry set? No.	Proceed to step 15.	See step aa.	13
af. Unblank Display	Display shows answer: 0000000001029	Add function complete. Answer displayed in R1.	15

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h. SUBTRACT. As in the Add function, there is a distinction between a Subtract function chosen by pressing the Subtract (-) key on the keyboard and an internal "machine subtract". Machine decision to subtract is made on the basis of the algebraic signs (see Add function).

In the machine, in a machine subtract operation, the subtraction is done by "complementary addition". An arithmetic operation sometimes used is to subtract one number from another by adding the complement of one of the numbers to the other number. The complement of a one-digit number is the difference between that number and ten; the complement of a two-digit number is the difference between that number and 100; the complement of a three-digit number is the difference between that number and 1000, etc.

An important fact to be remembered is this: to take a complement, a borrow must be used from the next left column. To illustrate:

12	12
-06	94
06	06
NORMAL SUBTRACT	MACHINE SUBTRACT

In the example of machine subtract, the 10's complement of 06 is added to 12, one digit at a time, starting with the rightmost digit. The 10's complement of 6 is 4 with a borrow. The two is now added to the 4. resulting in 6. The operation on this column is now complete. On the next left column, because of the borrow, the 9's complement is taken instead of the 10's complement. In this example, the 9's complement of 0 is 9. The 1 in this column is added to the 9, resulting in 0 and a carry. This carry cancels the existing borrow. The result is the answer 06, with no carry or borrow left over, therefore this is a final answer.

The basic machine operation in a machine subtract is done by counting Rmd into the D counter; shifting the D counter setting, which is the complement of Rmd, to the A counter, then counting R1 into A counter "on top of" the D counter setting. Counting Rmd into D counter initiates a borrow, and, if the count in A advances past 9, the borrow is cancelled. If the borrow is not cancelled, the next count in D will start from 9, thus giving the 9's complement. The borrow will not be cancelled until a count in A results in a carry.

If the borrow is not cancelled when the last column (C14) is operated upon, the machine complements the answer and changes the sign. For example, when subtracting a larger number from a smaller number, such as 12 from 6, by machine subtract (complementary add), the answer would be 94, which is obviously wrong. However, if the developed answer is again complemented to become 06, it is a correct answer. The second complement develops a negative sign that is displayed to show that it is a negative number. The machine recognizes the fact that the answer must be complemented and displayed with a changed sign by the presence of a borrow when all columns have been subtracted.

TABLE 2-4

SUBTRACT FUNCTION

A step-by-step analysis of machine internal operations is given below in terms of SUBTRACT FLOW CHART, Figure 2-10, and the problem illustrated.

C4 C3 C2	C4 C3 C2	C4 C3 C2
1 1 6	0 0 0	0 0 0 R2
0 9 5	1 1 6	0 2 1 R1
0 0 0	0 9 5	0 9 5 Rmd
BEGIN PROBLEM	AFTER SHIFT DOWN	END OF PROBLEM, ANSWER IN R1.

SUBTRACT PROBLEM

ACTION	RESULT	REMARKS	FLOW CHART STEP
a. Press Subtract (-) key.	Display Blanks.	Initiation of any arithmetic function blanks display.	1 & 2
b. Decimal Align.	Number in R1 aligns around decimal point.	Decimal Point Selector switch on 0.	3
c. Are R1 and R2 signs same? Yes.	Proceed to step 5.	Signs same; Machine performs "machine subtract".	4

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d. Shift Down.	R1 through R4 registers shift down one register.	See Shift Down.	5
e. RmdC2(5) counts into D counter.	D counter sets to 5, and Borrow sets.	D counter counts down thus complementing Rmd. Borrow sets because of "count in D"	6
f. Shift D to A.	A counter sets to 5.	D counter setting (5) moves to A counter.	7
g. Count R1C2(6) into A counter.	A counter sets to 1, plus carry 1.	R1(6) plus D counter setting (5) equals 1 plus carry 1.	8
h. Did R1 plus "D" advance A counter past 9? Yes.	Proceed to Step 10.	See step g.	
i. Reset Borrow.	Proceed to step 11.	Carry (step g) cancels Borrow (step e).	10
j. Are all columns subtracted? No.	Proceed to Step 12.	Only C2 has been operated upon.	11
NOTE: R1 through R4 shift A to B to C to Line. C2 subtract cycle complete.			
k. Is Borrow set? No.	Proceed to step 6.	See step i.	12
l. Count RmdC3(9) into D counter.	D counter sets to 1, Borrow sets.	See step e.	6
m. Shift D to A.	A counter sets to 1.	See step f.	7
n. Count R1C3(1) into A counter.	A counter sets to 2.	R1(1) plus D counter setting (1) equals 2.	8
o. Did R1 plus "D" advance A counter past 9? No.	Proceed to step 11.	See step n.	9
p. Are all columns subtracted? No.	Proceed to step 12.	Only C2 and C3 have been operated upon.	11
NOTE: R1 through R4 shift A to B to C to Line. C2 and C3 subtract cycle complete.			
q. Is Borrow set? Yes.	Proceed to Step 13.	See step 1.	12
r. Add 1 to D counter.	D counter sets to 9.	Next "count in D" will take 9's complement.	13
s. Count RmdC4(0) into D counter.	D counter remains set to 9. Borrow is set.	9's complement of 0 is 9.	6
t. Shift D to A.	A counter sets to 9.	See step f.	7
u. Count R1C4(1) into A counter.	A counter sets to 0, plus carry 1.	R1(1) plus D counter setting (9) equals 0 plus carry 1.	8
v. Did R1 plus "D" advance A counter past 9? Yes.	Proceed to step 10.	See step u.	9
w. Reset Borrow.	Proceed to step 11.	Carry (step u) cancels Borrow (step 1).	10
x. Are all columns subtracted? Yes.	Proceed to step 14.	C2, C3, and C4 have been operated upon.	11

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NOTE: R1 through R4 shift A to B to C to Line. All significant columns in this problem have been subtracted.			
y. Is Borrow set? No.	Proceed to step 16.	See step w.	14
z. Unblank Display.	Display reads: 0000000000021	Subtract function is completed. Answer is displayed in R1.	16

i. MULTIPLY. Multiplication can be described as a series of additions. Six multiplied by two can be described as: six added twice will give 12; or two added six times will give 12.

In the machine, in a multiply operation, the multiplication is done by adding R1 on the display, digit by digit, a number of times that is specified by R2 on the display.

Before proceeding, certain terms not yet encountered are defined: the most significant digit (MSD) of a register is in the farthest left column (C14); the least significant digit (LSD) of a register is in the farthest right digit column (C2). In this problem, for simplification, only three of the possible thirteen digit columns will be used, thus the MSD of the problem will be in C4, and the LSD in C2.

A functional diagram of a sample multiplication problem is shown in Figure 2-11. Note that D counter is shown twice for clarity, although there is only one D counter in the machine. During the multiplication operation the D counter is used part of the time to shift the MSD of R1 to the LSD of R2; during other parts of the operation, the D counter is used to specify the number of times Rmd will be added in R1.

A multiply operation consists of shifting R1 to Rmd, thus clearing R1 for the add cycle; then shifting R2 left and using the MSD of R2 in D counter to specify the number of times Rmd (previous R1 data) will be added in R1. When that add cycle is completed, R1 is shifted left to multiply by 10; and the MSD of R1 is placed in D counter. At the next shift R2 left, the MSD of R1 in D counter becomes the LSD of R2. When all columns, C2 through C14, have been operated upon, the answer has been developed and the machine performs a decimal align step that places the whole answer in R2 and aligns the number around the decimal point. Then the answer is shifted down to R1 and displayed.

The machine is capable of displaying a 13-digit whole number answer. If the answer developed in the machine contains more than 13 whole number digits, the OVERFLOW LOCK lights, and the keyboard locks up preventing further operation. The keyboard can be released by pressing OVERFLOW LOCK, CLEAR ENTRY, or CLEAR ALL.

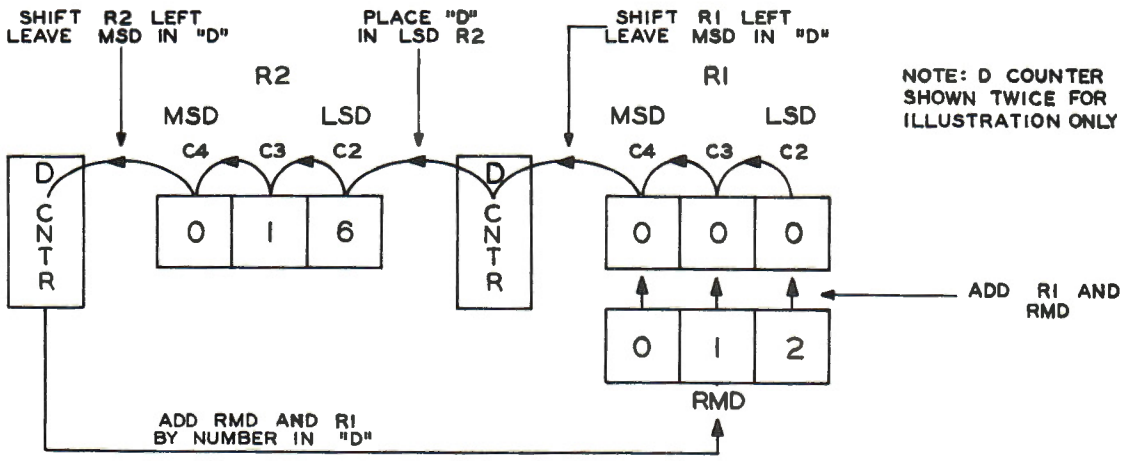


FIGURE 2-11. MULTIPLY FUNCTIONAL DIAGRAM

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TABLE 2-5

MULTIPLY FUNCTION

Machine operation operation step-by-step is given below in terms of the Multiply Flow Chart, Figure 2-12, and the sample problem as illustrated.

C4 C3 C2	C4 C3 C2	C4 C3 C2	C4 C3 C2
0 1 6	0 1 6	1 9 2	0 0 0 R2
0 1 2	0 0 0	0 0 0	1 9 2 R1
0 0 0	0 1 2	0 1 2	0 0 0 Rmd
BEGIN PROBLEM	AFTER SHIFT R1 DOWN TO Rmd	ANSWER IN R2	AFTER SHIFT DOWN R1 THROUGH R4. ANSWER IN R1.

a. Press Multiply (x) key.	Display blanks.	Initiation of any arithmetical operation blanks display.	1 & 2
b. Decimal align.	Number in R1 aligns around decimal position.	Decimal Point Selector is on 0.	3
c. Shift R1 down to Rmd.	R1 moves down one register to Rmd.	See Shift Down.	4
d. Shift R2 left. AND Place R2 MSD in D counter.	R2 digits move one column left. R2 becomes 160. D counter sets to 0.	See Shift Left. MSD of R2(C4) was 0.	5
e. Are all columns multiplied? No.	Proceed to step 7.	Only C4 has been operated upon.	6
f. Is D counter zero? Yes.	Proceed to Step 9.	See step d.	7
g. Shift R1 left. AND Place R1 MSD in D counter.	R1 digits move one column left. D counter sets to 0.	See Shift Left. MSD of R1(C4) was 0.	9
h. Shift R2 left. AND Place D counter setting in LSD of R2. AND Place R2 MSD in D counter.	R2 digits move one column left. R2 becomes 600. R2 remains 600. D counter sets to 1.	See Shift Left. D counter was 0, see step g. MSD of R2 was 1.	5
i. Is answer complete and decimal aligned in R2? No.	Proceed to step 7.	Only C4 and C3 have been operated upon.	6

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j. Is D counter Zero? No.	Proceed to step 8.	D counter is 1, See step h.	7
k. Add Rmd(012) to R1(000), AND Count D counter down 1.	R1 becomes 012. D counter sets to 0.	 D counter was 1.	8
l. Is D counter Zero? Yes.	Proceed to step 9.	See step k.	7
m. Shift R1 left. AND Place MSD of R1 in D counter.	R1 digits move one column left. R1 becomes 120. D counter sets to 0.	See Shift Left. MSD of R1 was 0.	9
n. Shift R2 left, AND Place D counter setting in LSD of R2, AND Place MSD of R2 in D counter.	R2 digits move one column left. R2 becomes 000. R2 remains 000. D counter sets to 6.	See Shift Left. D counter was 0, See step m. MSD of R2 was 6, See Step h.	5
o. Is answer complete and decimal aligned in R2? No.	Proceed to step 7.	C4, C3, and C2 have been shifted but multiplication is not complete.	6
p. Is D counter zero? No.	Proceed to step 8.	D counter is six, see step n.	7
q. Add Rmd(012) to R1(120). AND Count D counter down 1.	R1 becomes 132. D counter sets to 5.	R1 was 120, see step m. D counter was 6, see step n.	8
r. Is D counter zero? No.	Proceed to step 8.	D counter is 5, see step q.	7
s. Add Rmd(012) to R1(132), AND Count D counter down 1.	R1 becomes 144. D counter sets to 4.	R1 was 132, see step q. D counter was 5, see step q.	8
t. Is D counter 0? No.	Proceed to step 8.	D counter is 4, see step s.	7
u. Add Rmd(012) to R1(144), AND Count D counter down 1.	R1 becomes 156. D counter sets to 3.	R1 was 144, see step s. D counter was 4, see step s.	8
v. Is D counter 0? No.	Proceed to step 8.	D counter is 3, see step u.	7

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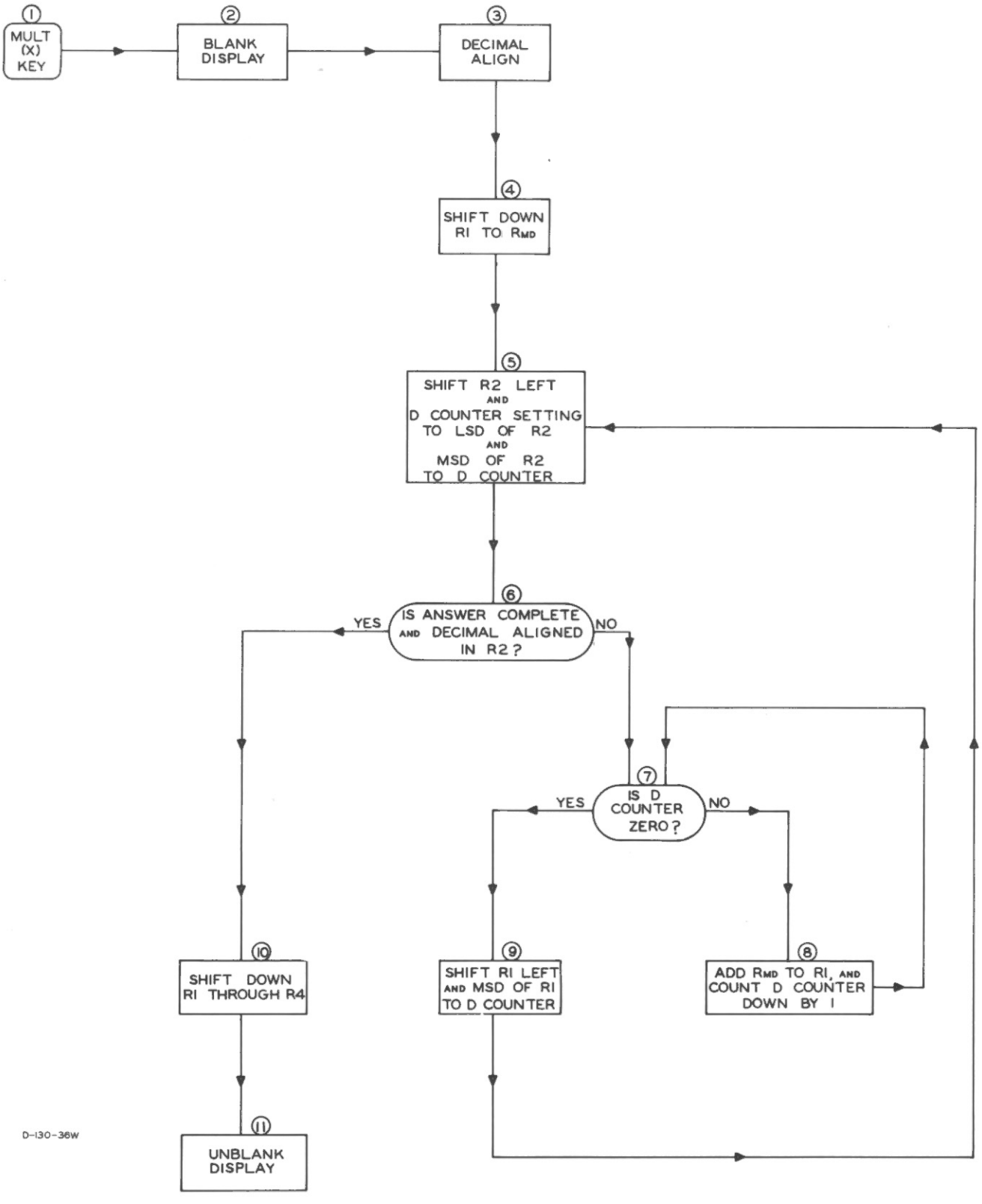


FIGURE 2-12. MULTIPLY FLOW CHART

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w. Add Rmd(012) to R1(156), AND Count D counter down 1.	R1 becomes 168. D counter sets to 2.	R1 was 156, see step u. D counter was 3, see step u.	8
x. Is D counter 0? No.	Proceed to step 8.	D counter is 2, see step w.	7
y. Add Rmd(012) to R1(168), AND Count D counter down 1.	R1 becomes 180. D counter sets to 1.	R1 was 168, see step w. D counter was 2, see step w.	8
z. Is D counter 0? No.	Proceed to step 8.	D counter is 1, see step y.	7
aa. Add Rmd(012) to R1(180), AND Count D counter down 1.	R1 becomes 192 D counter sets to 0.	R1 was 180, see step y. D counter was 1, see step y.	8
ab. Is D counter 0? Yes.	Proceed to step 9.	D counter is 0, see step aa.	7
ac. Shift R1 left, AND Place MSD of R1 in D counter.	R1 digits move one column left. R1 becomes 920. D counter sets to 1.	See Shift Left. MSD of R1 was 1.	9
ad. Shift R2 left, AND Place D counter setting in LSD of R2. AND Place MSD of R2 in D counter.	R2 digits move one column left. R2 becomes 000. R2 becomes 001. D counter sets to 0.	See Shift Left. D counter was 1, see step ac. MSD of R2 was 0.	5
ae. Is answer complete and decimal aligned in R2? Yes.	Proceed to step 10.	All significant columns in this problem have been operated upon.	6
af. Shift R1 through R4 down.	Registers R1 through R4 move down one register.	Answer in R2 shifts down to R1.	10
ag. Display unblanks.	Display shows answer: 0000000000192.	Multiply function completed. Answer in R1.	11

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j. DIVIDE. Divide can be described as a series of subtractions. 36 divided by 12 can be described as "how many times can 12 be subtracted from 36", and the answer is 3.

In the EC-130 the number displayed in R1 is subtracted from the number displayed in R2 and the number of subtractions becomes the answer developed in R2, which, when shifted down, is the answer displayed in R1.

As in multiply, an answer beyond the capacity of the machine to display will light OVERFLOW LOCK. In addition, a problem that is impossible to solve, such as a zero divided by zero, will keep the machine in an operational loop that prevents the display from being unblanked.

A functional representation of R1, R2, Rmd and D counter is shown in Figure 2-13. In a divide operation, R2 is shifted digit by digit into R1 via D counter until enough of R2 is in R1 for a successful subtract to take place. For each successful subtract (no overdraft), 1 is added to the LSD of R2. After all possible successful subtracts have been accomplished for this step, another shift of R2 places the next decimal place into R1, and more subtracts attempted. Again, for each successful subtract 1 is added to the LSD of R2. Meanwhile, the last R2 left shift moved the number representing the first set of subtracts one place to the left. The answer, in the form of successful subtracts accomplished is accumulated in R2, then shifted down to R1 to appear as the answer when the display unblanks.

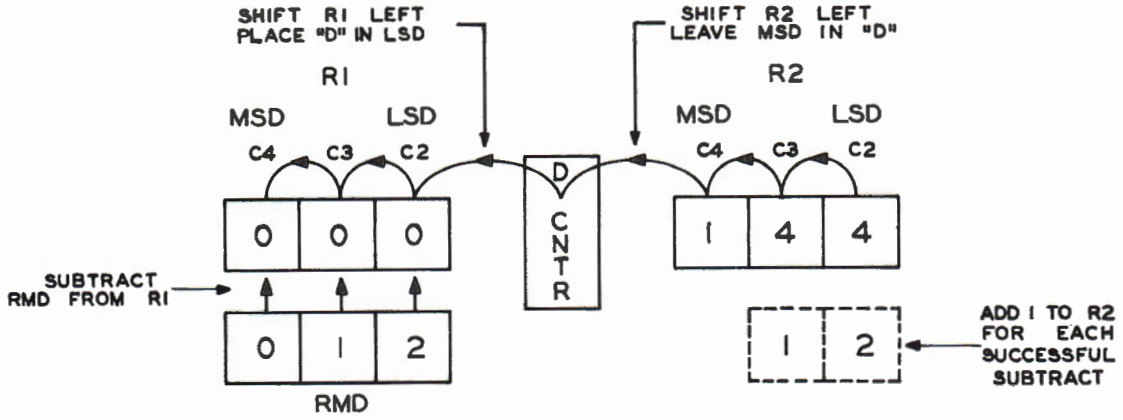


FIGURE 2-13. DIVIDE FUNCTIONAL DIAGRAM

TABLE 2-6

DIVIDE FUNCTION

Machine action step-by-step is covered below with reference to the problem illustrated, and the Divide Flow Chart, Figure 2-14.

C4 C3 C2	C4 C3 C2	C4 C3 C2	C4 C3 C2
1 4 4	1 4 4	0 1 2	0 0 0 R2
0 1 2	0 0 0	9 8 8	0 1 2 R1
0 0 0	0 1 2	0 1 2	9 8 8 Rmd
BEGIN PROBLEM	SHIFT R1 DOWN TO Rmd	ANSWER IN R2	SHIFT DOWN, ANSWER IN R1

ACTION	RESULT	REMARKS	FLOW CHART STEP
a. Press Divide (÷) key.	Display blanks.	Initiation of any arithmetical function blanks display.	1 & 2

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b. Decimal align.	Number in R1 aligns around decimal position.	Decimal Point Selector on 0.	3
c. Shift R1 down to Rmd.	Register R1 moves down into Rmd. Rmd becomes 012, R1 becomes 000.	See Shift Down.	4
d. Subtract Rmd(012) from R1(000).	Overdraft (unsuccessful subtract). R1 becomes 988.	Rmd is larger than R1.	5
e. Is there an overdraft? Yes.	Proceed to step 8.	See step d.	6
f. Is answer complete and decimal aligned in R2? No.	Proceed to step 9.	No columns operated upon as yet.	8
g. Add Rmd(012) to R1(988).	R1 becomes 000.	Overdraft corrected.	9
h. Shift R2 left, AND Place MSD of R2(1) in D counter.	R2 digits move one column left. R2 becomes 440. D counter sets to 1.	See Shift Left. MSD of R2 was 1.	10
i. Shift R1 left. AND Place D counter (1) in LSD of R1.	R1 digits move one column left. R1 becomes 000. R1 becomes 001.	See Shift Left. D counter was 1.	11
j. Subtract Rmd(012) from R1(001).	Overdraft. R1 becomes 989.	Rmd is larger than R1.	5
k. Is there an overdraft? Yes.	Proceed to step 8.	See step j.	6
l. Is answer complete and decimal aligned in R2? No.	Proceed to step 9.	Only C4 has been operated upon.	8
m. Add Rmd(012) to R1(989).	R1 becomes 001.	Overdraft corrected.	9
n. Shift R2 left, AND Place MSD of R2(4) in D counter.	R2 digits move one column left. R2 becomes 400. D counter sets to 4.	See Shift Left. MSD of R2 was 4.	10
o. Shift R1 left, AND Place D counter setting (4) in LSD of R1.	R1 digits move one column left. R1 becomes 010. R1 becomes 014.	See Shift Left. D counter was 4, see step n.	11
p. Subtract Rmd(012) from R1(014).	Successful subtract. R1 becomes 002.	Rmd is smaller than R1.	5
q. Is there an overdraft? No.	Proceed to step 7.	See step p.	6

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r. Subtract Rmd(012) from R1(002), AND Add 1 to LSD of R2.	Overdraft. R1 becomes 990. R2 becomes 401.	Rmd is larger than R1. R2 was 400, see step n.	7
s. Is there an overdraft? Yes.	Proceed to step 8.	See step r.	6
t. Is answer complete and decimal aligned in R2? No.	Proceed to step 9.	Only C4 and C3 have been operated upon.	8
u. Add Rmd(012) to R1(990).	R1 becomes 002.	Overdraft corrected.	9
v. Shift R2 left, AND Place MSD of R2(4) in D counter.	R2 digits move one column left. R2 becomes 010. D counter sets to 4.	See Shift Left. MSD of R2 was 4.	10
w. Shift R1 left, AND Place D counter setting (4) in LSD of R1.	R1 digits move one column left. R1 becomes 020. R1 becomes 024.	See Shift Left. D counter was 4.	11
x. Subtract Rmd(012) from R1(024).	Successful subtract. R1 becomes 012.	Rmd is smaller than R1.	5
y. Is there an overdraft? No.	Proceed to step 7.	See step x.	6
z. Subtract Rmd(012) from R1(012), AND Add 1 to LSD of R2.	Successful subtract. R1 becomes 000. R2 becomes 011.	Rmd is same as R1. R2 was 010, see step v.	7
aa. Is there an overdraft? No.	Proceed to step 7.	See step z.	6
ab. Subtract Rmd(012) from R1(000), AND Add 1 to LSD of R2.	Overdraft. R1 becomes 988. R2 becomes 012.	Rmd is larger than R1. R2 was 011, see step z.	7
ac. Is there an overdraft? Yes.	Proceed to step 8.	See step ab.	6
ad. Is answer complete and decimal aligned in R2? Yes.	Proceed to step 12.	All significant columns in this problem have been operated upon.	8
ae. Shift Down.	Registers R1 through R4 move down one register.	See Shift Down.	12
af. Unblank display.	Register one displays: 0000000000012	Divide problem complete. Answer displayed in R1.	13

NOTE: In step ab, the overdraft left R1 as 988. In step ad, R1(988) shifts down to Rmd, which becomes 988. This is of no consequence since initiation of any arithmetical function that uses Rmd will replace this 988 with new data.

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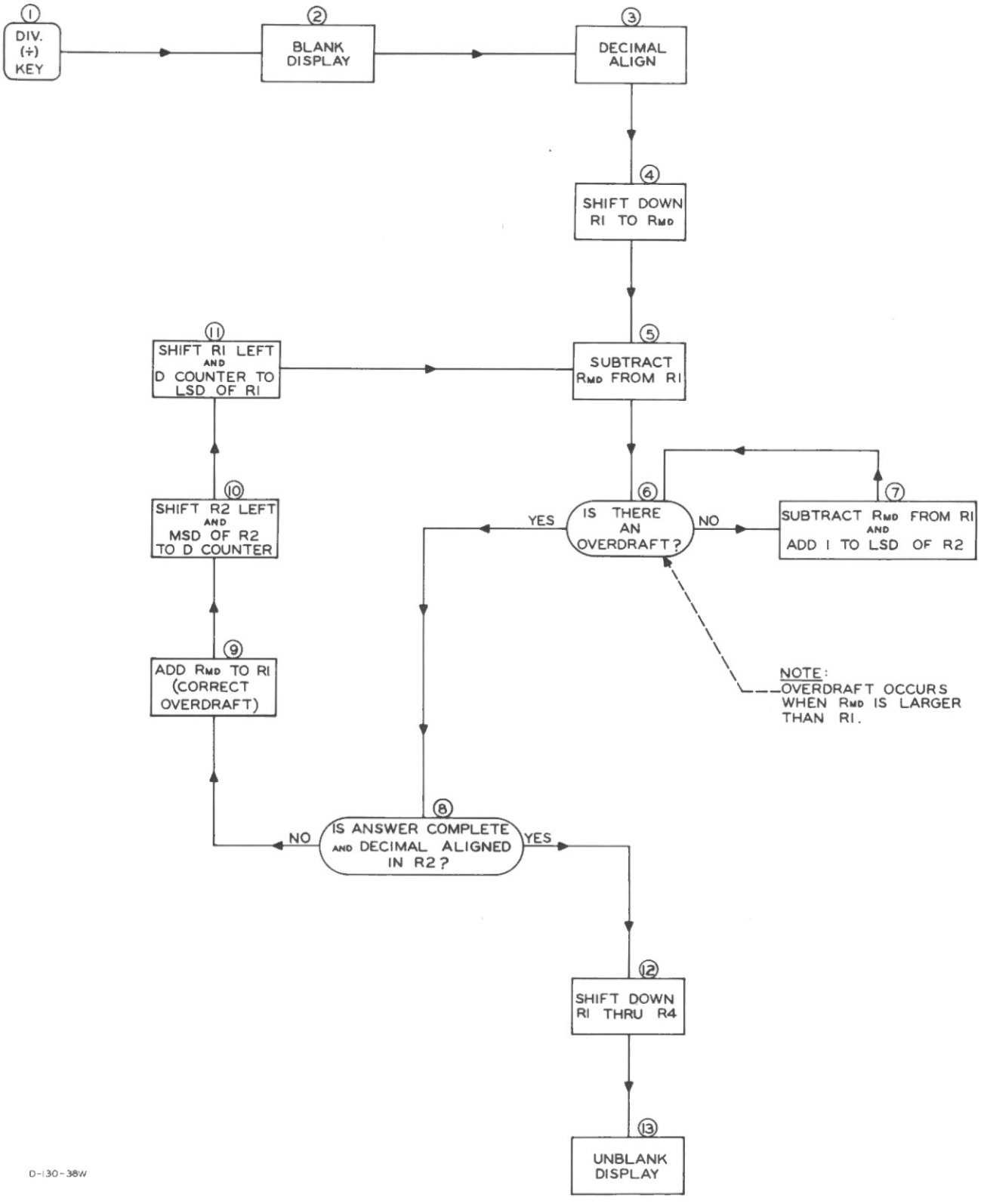


FIGURE 2-14. DIVIDE FLOW CHART

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7. DISPLAY CIRCUITS.

Numbers which exist in the machine in electronic form must be converted to their visual equivalent correctly placed on the display. The display circuitry converts the numbers to a visual equivalent and provides for proper placement on the face of the CRT.

a. CATHODE RAY TUBE (CRT). The CRT (Figure 2-15) in the display circuitry is the device that converts electron energy into a visual equivalent. The CRT is composed of three functional sections: the electron gun, the deflection plates, and the phosphor coating (screen) on the inside of the face of the tube.

(1) Electron Gun. The electron gun in the CRT is the source of electrons that, when they strike the screen, generate visible light. The gun consists of a cathode, which is the source of electrons; a grid, which controls the number of electrons; and anodes that focus the electrons into a thin, pencil-like beam.

There are three controls associated with the functioning of the electron gun. They are: Intensity, Focus, and Astigmatism. The Intensity control, which is connected to the grid, establishes the brightness of the trace on the CRT. The Focus control, which is connected to the anodes, establishes that the beam is at its smallest diameter at the CRT screen. The Astigmatism control, which is also connected at the anodes, establishes the "roundness" of the electron beam. Adjustment of these controls is covered in section 3 of this manual.

(2) Deflection Plates. The deflection plates control the instantaneous position of the electron beam (spot) on the face of the CRT. Control is exercised by the voltage relationship between the plates of each set of plates. The Horizontal plates control the horizontal position, and the Vertical plates control the vertical position. Together, their action can place the spot caused by the electron beam at any position on the screen.

(3) CRT Screen. The coating on the inside of the face of the CRT is called a "Phosphor". The phosphor has the property of changing the energy of the electron beam into visible light. The amount of light (brightness) is determined by the average number of electrons in the beam, and that, in turn, is controlled by the Intensity control.

The phosphor has a further quality called "persistence". Persistence is the continued emission of light for a period of time after the beam has moved. This quality permits the "writing" and viewing of a complete display that looks as if it were drawn instantly even though it is developed by the rapid movement of a single spot.

b. HIGH VOLTAGE SUPPLY. In order that visible light be produced by the phosphor when struck by electrons, the electrons must have a certain energy level, or speed. They are accelerated to this speed by a high potential (2400 volts) between the cathode, the accelerating anodes, and the face of the tube. The high voltage supply develops this voltage.

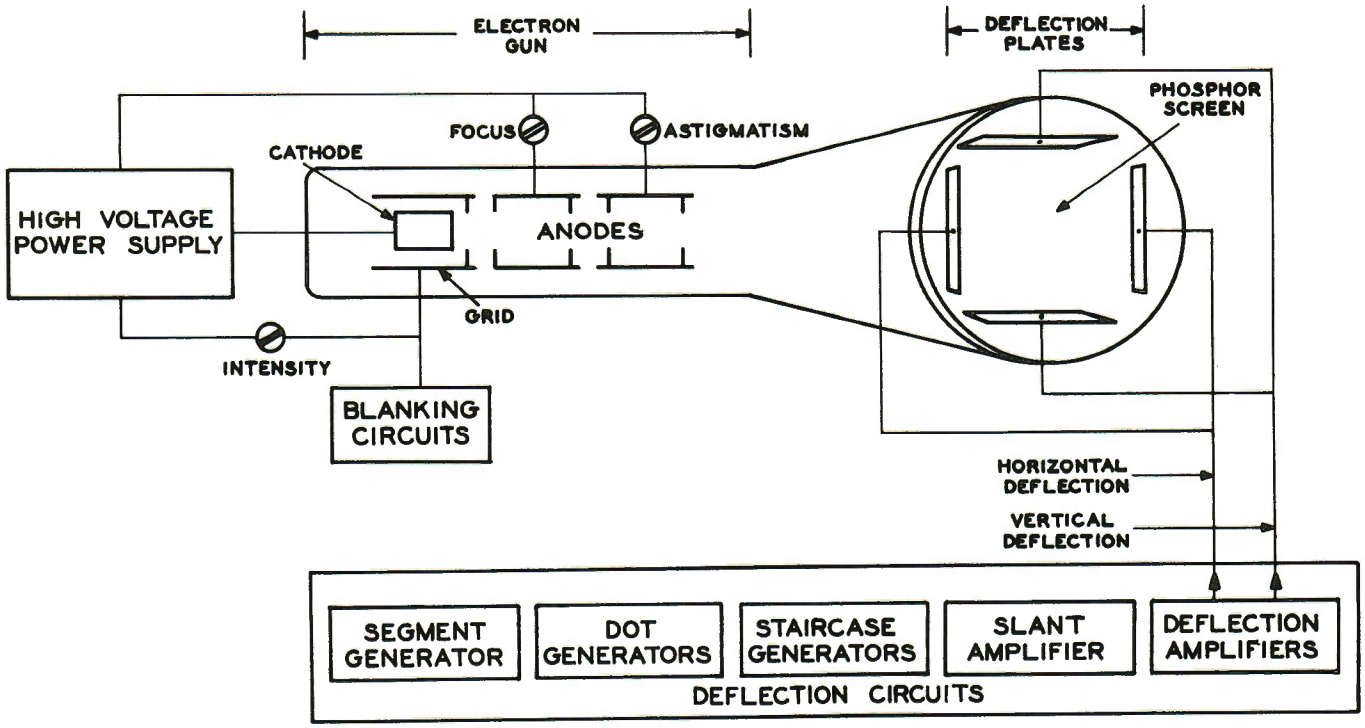


FIGURE 2-15. DISPLAY CIRCUITS BLOCK DIAGRAM

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c. CHARACTER FORMATION. All of the characters displayed are derived from a basic figure eight composed of several portions called "Segments" (See Figure 2-16). Each segment is identified by a number that refers to the technical manner of segment generation. In this discussion, the number will be used only for identification of the segment. Not all of the segments are used. Of those that are used, the Blanking circuits control which segments will be displayed and thus which character appears on the display. For example; 0 is the basic figure eight with segments 7 and 14 kept blanked. Character 2 is the basic figure 8 with segments 0, 3, and 14 kept blanked.

For a more pleasing and readable display, certain characters are modified. Figure 1 is offset to the right; figure 7 is slightly offset to the left; segment 7, when used as a part of figure 3, is slightly shortened; Decimal Point is segment 13 modified to appear as a dot; and Minus Sign is Segment 14 drawn in place of segment 7, with all other segments blanked.

d. DEFLECTION CIRCUITS. The deflection circuits develop the voltages that are applied to the deflection plates to move the spot caused by the electron beam and form the characters on the screen in their proper position (See Figure 2-15). The voltages applied to the deflection plates are developed by combining separate voltages from the Segment Generator, Horizontal and Vertical Dot Generators, and Horizontal and Vertical Staircase Generators (See Figure 2-17). The horizontal deflection voltage is slightly modified by the slant amplifier. To attain necessary voltage levels at the deflection plates, the horizontal and vertical deflection voltages are amplified by horizontal and vertical deflection amplifiers after development.

(1) Segment Generator. The segment generator produces the basic deflection voltage that will draw a segment of a character on the CRT screen. There are twelve (12) segments produced, not all of which are used. Of those that are used, not all are used at the same time during the formation of a character, but certain ones are left blank to form the desired characters. While each segment is 24 usec long, only 18 usec is used.

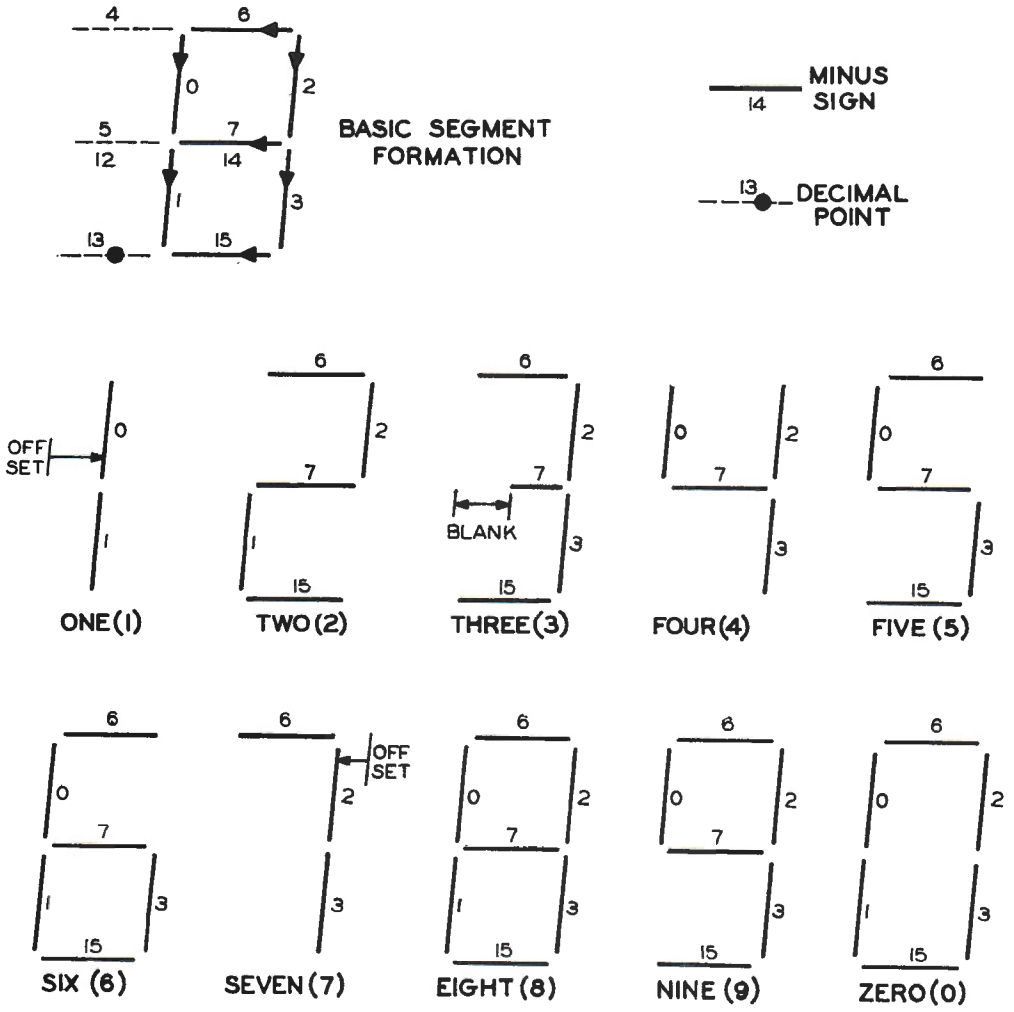


FIGURE 2-16. CHARACTER FORMATION

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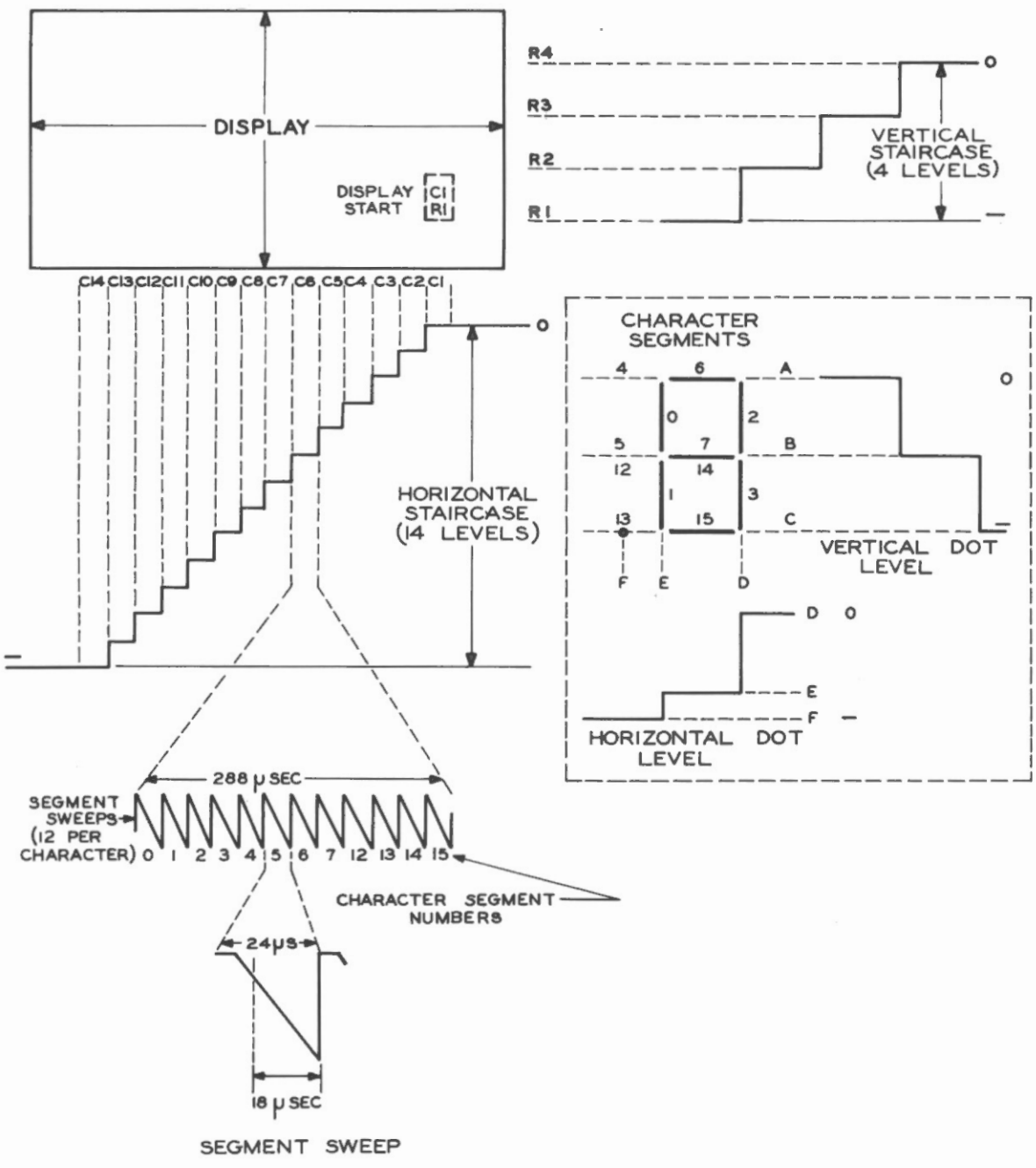


FIGURE 2-17. DEFLECTION VOLTAGE FORMATION

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(2) Dot Generators. The horizontal and vertical dot generators develop voltage levels that position the CRT beam for the beginning of a segment trace.

A vertical segment may begin at vertical level A or B (See Figure 2-17), and at horizontal level D or E. Thus, there are four possible starting points for drawing a vertical segment. For example; Segment 0 would start at vertical level A, horizontal level E; segment 3 would start at vertical level B, horizontal level D; etc.

A horizontal segment may begin at vertical levels A, B, or C and horizontal levels D, E, or F. Thus there are six possible starting points for drawing a horizontal segment. For example; segment 6 would start at vertical level A, horizontal level D; segment 15 at vertical level C, horizontal level D; etc.

(3) Staircase Generators. The vertical and horizontal staircase generators develop voltage levels that position the characters in the proper register and in the proper column on the display.

The vertical staircase generator develops four (4) voltage levels that position the characters in the proper register. The horizontal staircase generator develops fourteen (14) voltage levels that correspond to the character columns on the display. The combination of horizontal and vertical staircase voltage levels at the deflection plates position the characters in the proper column and in the proper register.

(4) Slant Amplifier. The slant amplifier provides an offset voltage, derived from the vertical deflection and applied to the horizontal deflection, to slant each vertical segment for a more pleasing display. Each vertical segment is slightly offset at the bottom compared to the top.

(5) Deflection Amplifiers. When the respective voltage levels of the Segment generator, the Dot generators, the Staircase generators, and the Slant amplifier have been combined to give the desired character formation and placement, the combination is amplified to the necessary voltage levels for the deflection plates by the deflection amplifiers.

e. BLANKING CIRCUITS. Each segment for each character space on the CRT is developed for all possible character spaces every time a display is called for by the internal machine timing. However, some segments are never drawn on the CRT, and for different characters certain segments are not used. (See Figure 2-16). The Blanking circuits determine which segments will be displayed, thus what character will be "written" on the CRT. The time relationships between the blanking circuits and the deflection circuits determine "what" character will appear "where" on the CRT. The timing relationships are specified and controlled by the basic machine timing circuits.

The blanking circuits also keep the entire CRT blanked while a function is being performed, since any display that appeared while data shifted or changed would be meaningless.

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SECTION 3 ADJUSTMENTS

A. SCOPE OF SECTION.

This section contains the adjustments necessary for maintenance of the EC-130. The adjustments are covered in four groups: Keyboard, CRT, Character, and Display.

B. KEYBOARD ADJUSTMENTS.

The Keyboard adjustments are those adjustments necessary for the proper functioning of the keys on the keyboard. These adjustments should not be made unless thorough checking has established that the machine malfunction is definitely in the keyboard.

1. EQUIPMENT REQUIRED.

Special items of equipment as well as normally available tools are required to adjust the Keyboard. They are as follows: (See Figure 3-1.)

a. Keyboard Tester.

b. Keyboard Spacers (4): .059, .032, .020, .141.

NOTE: The .141 spacer is included for a keytop adjustment that will not be made in the field and therefore will not be covered.

c. Screwdriver, 3/16" tip.

d. Soldering Iron, 12 watt.

e. Long-nose pliers, 6".

2. INITIAL PROCEDURE.

Before proceeding with any keyboard adjustment, perform the following:

a. Turn machine to "OFF".

b. Remove bottom cover plate (Refer to Section 4).

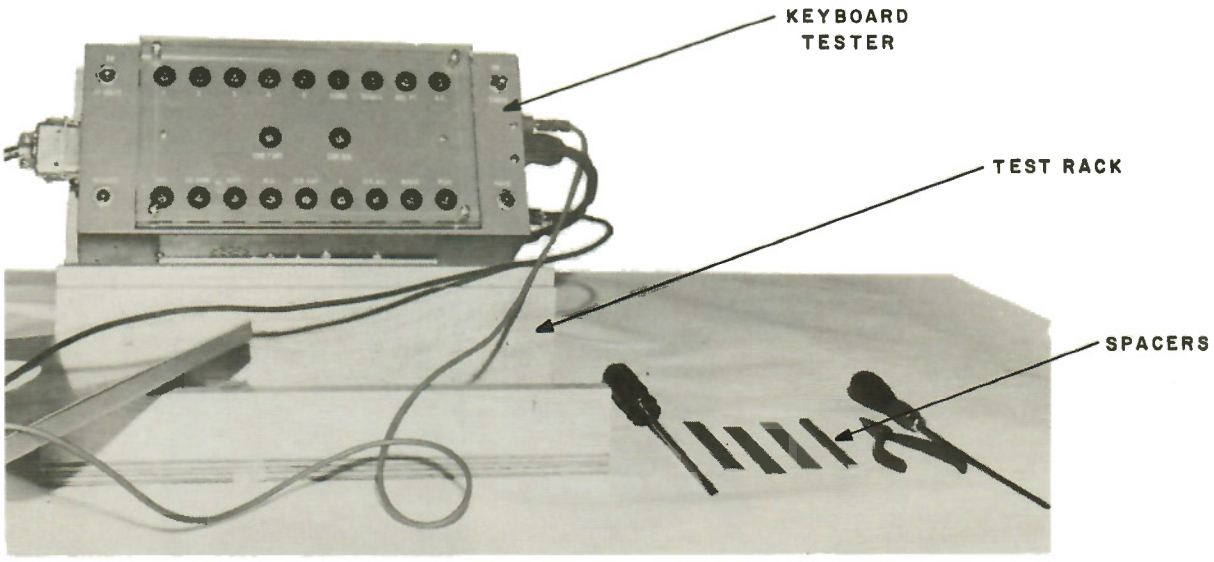
c. Disconnect wires on taper pins on bottom of keyboard (See Figure 3-2).

d. Connect Keyboard Tester Cable to taper pins on keyboard, carefully observing tester cable to taper pin number coding.

e. Connect alligator clip leads from Tester to pins 20 and 21 on keyboard. No cable color to pin number correlation is necessary.

NOTE: Owing to the size of Tester alligator clips and the spacing of pins 20 and 21, it is advisable to use two extra wires with taper pin connectors on one end and the other ends bare, then connect bare ends to alligator clips.

f. Connect Tester to AC line, and turn Tester POWER switch to ON.



P-130-53

FIGURE 3-1. KEYBOARD TESTER, SPACERS, AND TOOLS

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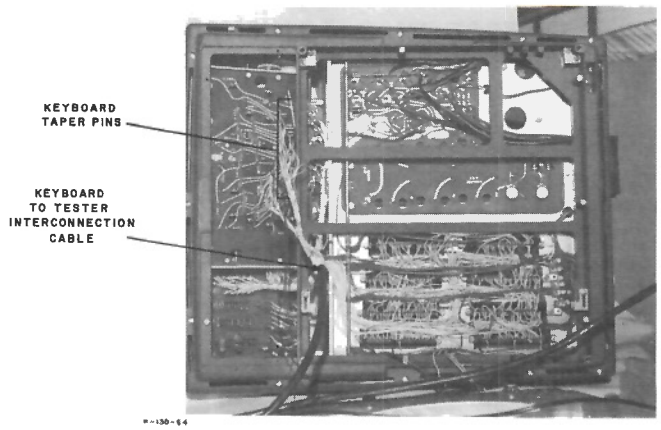


FIGURE 3-2. KEYBOARD TESTER, CONNECTED TO KEYBOARD

3. PRELIMINARY KEYBOARD CHECKOUT.

Before proceeding with any keyboard adjustments, make the following checkout to determine specific adjustments necessary, with machine positioned as in Figure 3-3.

a. Press digit keys 1 through 5 in turn, and observe that associated lamp numbers (1-5) come on before Common Digit (COM DIG) light comes on (See Figure 3-4).

b. Press digit keys 6 through 9 in turn, and observe that associated lamp numbers (1-5) go off before COM DIG light comes on.

c. Press 0 key and observe that lamps numbered 1-5 on Tester go off before COM DIG lamp comes on.

NOTE: During testing of digit keys, check that COM DIG lamp comes on last during depression of a key, and goes off first during release.

d. Press, in turn, the following sequencing function keys: Store, Recall, Repeat, Change Sign, Add, Subtract, Multiply, and Divide.

e. When pressing a sequencing function key, observe for the following:

(1) That associated lamp on tester comes on first during depression, and goes off last during release.

(2) That Common Function (COM FUNC) lamp on tester comes on last during depression, and goes out first during release.

(3) That COM FUNC lamp on Tester comes on before key bottoms. This is called "over-travel", and there should be a small amount.

f. Press, in turn, the following non-sequencing function keys: Overflow Lock, Clear Entry, Clear All, Decimal Point.

g. When pressing a non-sequencing function key, observe that the associated lamp on the Tester comes on before bottoming of the key.

h. Press Enter key and observe that COM FUNC lamp on Tester comes on before bottoming of the key.

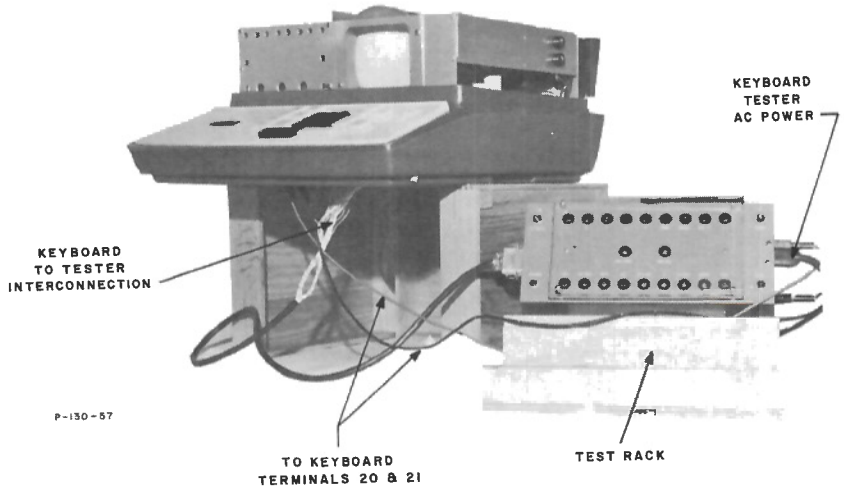


FIGURE 3-3. EC-130 AND KEYBOARD TESTER, TEST SETUP

Courtesy of The Old Calculator Museum
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KEYBOARD KEYS	COM. DIG.	COM. FUNC.	1	2	3	4	5	DEC. PT.	CLR. ENT.	CLR. ALL	OFL.	RPT.	STORE	RECALL	CH. SIGN	PLUS	MINUS	X	DIV.
0	ON																		
1	ON		ON																
2	ON		ON	ON															
3	ON		ON	ON	ON														
4	ON		ON	ON	ON	ON													
5	ON		ON	ON	ON	ON	ON												
6	ON			ON	ON	ON	ON												
7	ON				ON	ON	ON												
8	ON					ON	ON												
9	ON						ON												
DECIMAL POINT								ON											
CLEAR ENTRY									ON										
CLEAR ALL										ON									
OVERFLOW LOCK											ON								
ENTER		ON																	
REPEAT		ON										ON							
STORE		ON											ON						
RECALL		ON												ON					
CHANGE SIGN		ON													ON				
ADD (+)		ON														ON			
SUBTRACT (−)		ON															ON		
MULTIPLY (X)		ON																ON	
DIVIDE (÷)		ON																	ON

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FIGURE 3-4. KEYBOARD TESTER LAMP CHART

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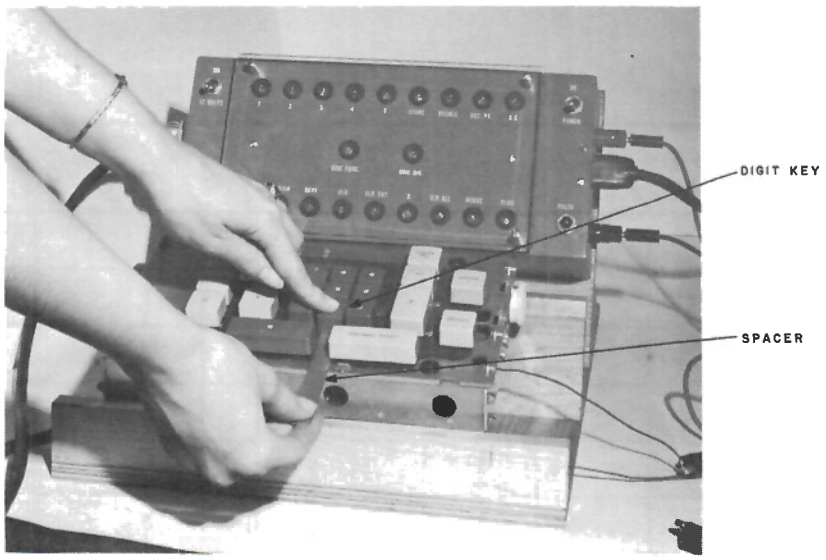


FIGURE 3-5. KEYBOARD AND TESTER, TEST SETUP

4. DIGIT KEY ADJUSTMENT.

The adjustment of a digit key is to ensure that the lamp, or lamps, on the Tester associated with that key come on before COM DIG lamp, and the COM DIG lamp comes on before key bottoming (giving overtravel). To adjust a digit key proceed as follows:

a. Remove keyboard from machine (Refer to Section 4).

b. Set keyboard and Tester up as shown in Figure 3-5.

c. Place .020 spacer under digit keytop.

d. Press key lightly but firmly against spacer, and hold in that position.

CAUTION: Do not press key firmly enough to compress rubber keytop pad.

e. On underside of keyboard, unsolder cradle slide specified CD (See Figure 3-6).

f. Move cradle gently right or left until COM DIG lamp on Tester just comes on.

g. Resolder cradle slide in new position, being very careful not to change cradle position.

h. Release key, and remove .020 spacer.

i. Check that digit key has overtravel after COM DIG lamp comes on.

j. Place .059 spacer beneath keytop.

k. Press key lightly but firmly against spacer, and hold in that position.

l. On underside of keyboard, unsolder cradle slide designated for the lamp, or lamps, on Tester (1-5) that is failing to come on, or go off.

NOTE: Digit keys 1-5 light specific lamps on tester, while keys 6-9 extinguish specific lamps, and 0 key extinguishes all lamps (See Figure 3-4).

m. Gently move cradle slide to the right or left until specified lamp, or lamps, come on or go off, as applicable.

n. Resolder cradle slide in new position, being very careful not to change cradle position.

o. Release key, and remove .059 spacer.

CAUTION: After making each adjustment, make the final check of that adjustment with the keyboard in a normal horizontal position.

5. FUNCTION KEY ADJUSTMENT.

There are two types of function keys: Sequencing and non-sequencing. Sequencing function keys close two switches in a specific sequence, while non-sequencing function keys close only one switch. Only the adjustment of sequencing function keys will be covered because non-sequencing function keys have no adjustment.

The adjustment of a sequencing function key is to ensure that the lamp on the Tester associated with that key comes on before Common Function (COM FUNC) lamp, and that COM FUNC lamp comes on before bottoming of the key (thus giving overtravel).

To adjust a function key, proceed as follows:

a. Complete steps of Initial Procedure.

b. Place .020 spacer under function keytop.

c. Press key lightly but firmly against spacer, and hold in that position.

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d. On underside of keyboard, unsolder cradle slide specified CF.

e. Move cradle slide gently to right or left until COM FUNC lamp on Tester just comes on.

f. Resolder cradle slide in new position, being very careful not to change cradle position.

g. Release key, and remove spacer.

h. Check that function key has overtravel after COM FUNC lamp comes on.

i. Place .032 spacer beneath keytop.

j. Press key lightly but firmly against spacer, and hold in that position.

k. On underside of keyboard locate keystem associated with that key.

l. With screwdriver, loosen eccentric cam locking-screw (See Figure 3-7).

m. With screwdriver, turn eccentric cam until lamp on Tester specified for that key just comes on.

n. Retighten eccentric cam locking-screw, being careful that cam adjustment does not change.

CAUTION: After making each adjustment, make the final check of that adjustment with the keyboard in a normal horizontal position.

6. CODE BAR ADJUSTMENT.

There are seven (7) code bars that are actuated by the keys on the keyboard. Occasionally, one of the keys cannot be depressed because of wear, or displacement, of a code bar.

To adjust a code bar, proceed as follows:

a. Proceed as in steps 4a and 4b.

b. Hold keyboard on edge so that the malfunctioning key can be pressed while observing code bars through access hole (Figure 3-6) on underside of keyboard.

c. While holding finger pressure on malfunctioning key, use long-nose pliers to move each code bar, in turn, through the access holes until the code bar is found that is keeping the key from being depressed.

d. On each end of the keyboard assembly are seven (7) screws, one on each end for each code bar. When the malfunctioning code bar is found in step c, move one of the two positioning screws associated with that code bar until a reposition of the code bar is found that frees the key.

CAUTION: Do not move screws associated with any other code bar except the one under adjustment. Make final check of keyboard with the keyboard in a normal horizontal position.

e. Replace keyboard in machine (refer to Section 4).

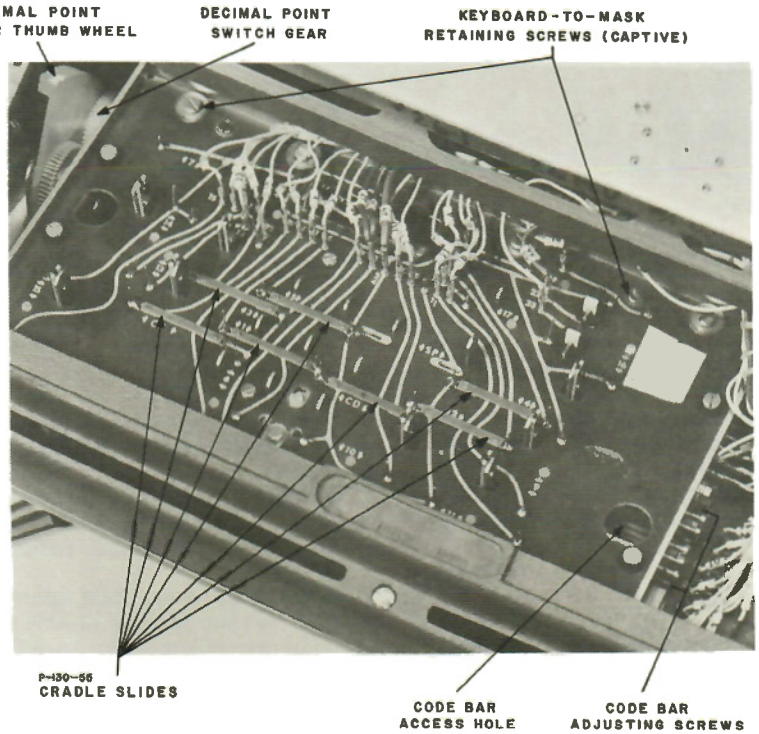


FIGURE 3-6. KEYBOARD, CRADLE SLIDE LOCATION

Courtesy of The Old Calculator Museum
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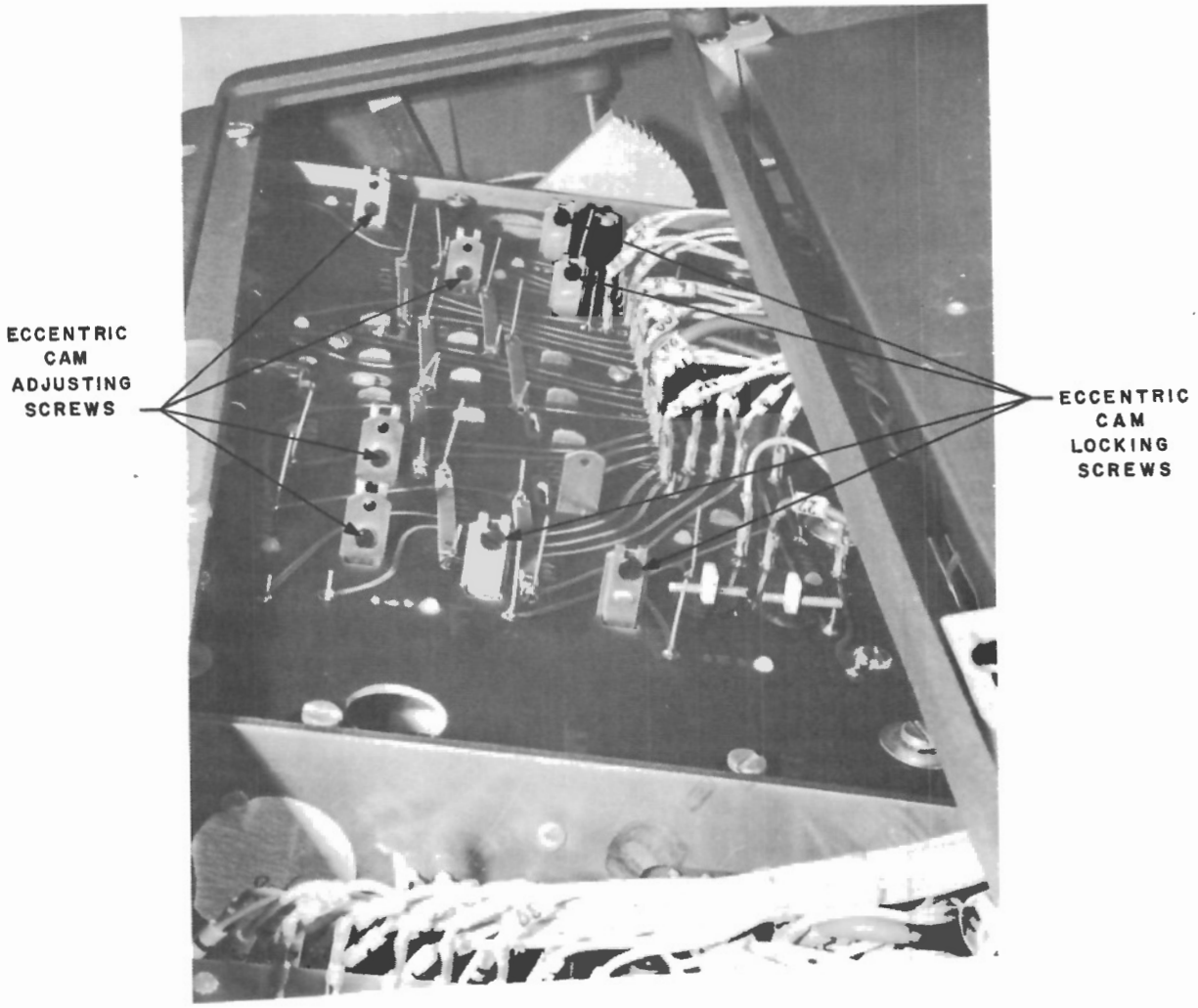


FIGURE 3-7. KEYBOARD, KEYSTEM ADJUSTMENT LOCATION

C. CATHODE RAY TUBE (CRT) ADJUSTMENTS.

The CRT adjustments are those that directly affect the electron gun in the cathode ray tube. They are: Intensity, Focus, and Astigmatism.

Table 3-1 lists all display adjustments, and gives figure number references for ease of location in the machine.

1. INTENSITY.

The Intensity control (Figure 3-8) adjusts the brightness of the trace on the CRT screen. INTENSITY control is adjusted as follows:

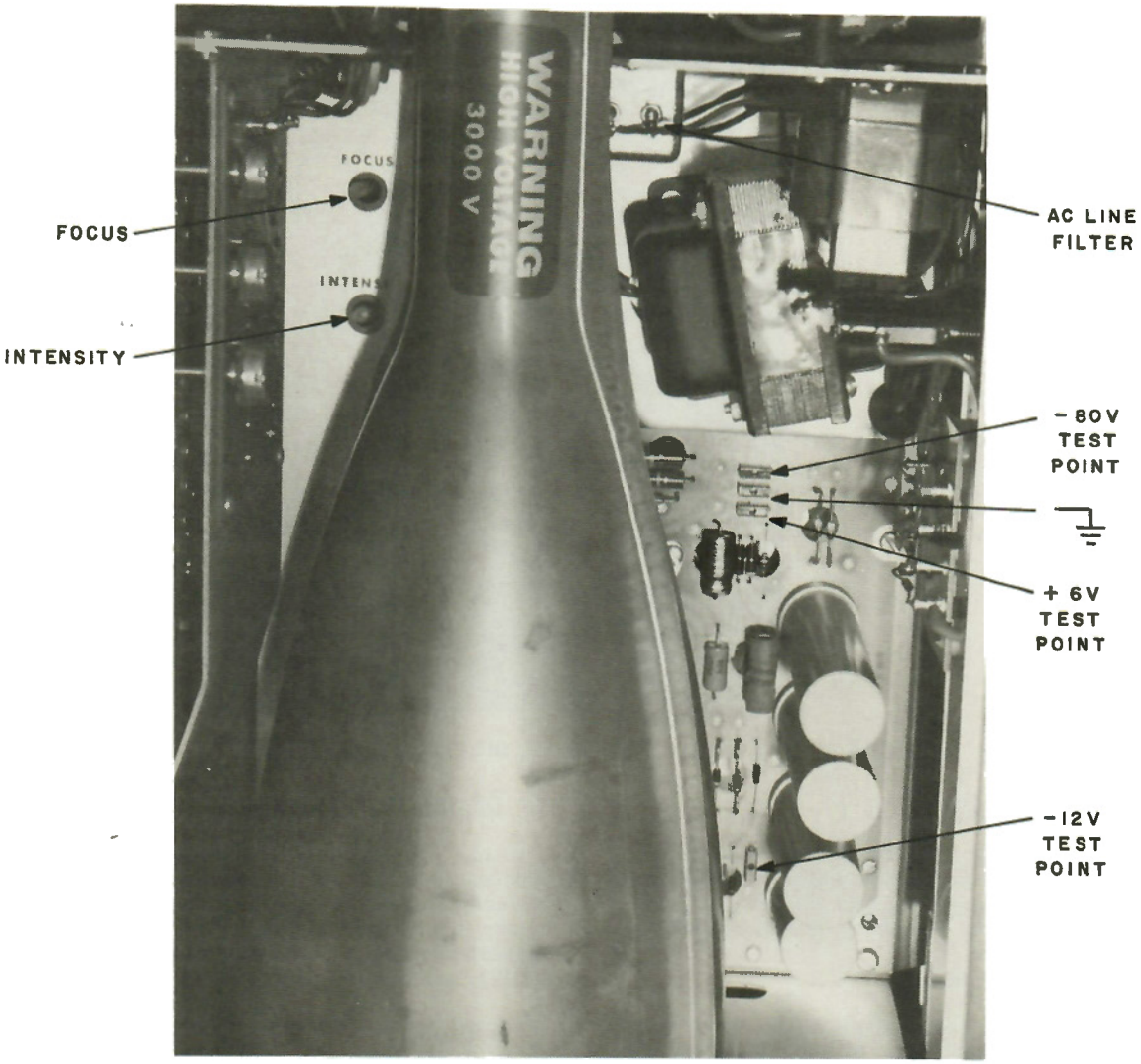
a. Rotate control fully counterclockwise (CCW).

b. Rotate control clockwise (CW) until a clear, distinct trace is visible on the CRT screen.

NOTE: Do not adjust Intensity control any further clockwise than is necessary for clear viewing or customer satisfaction.

c. Record the final position of INTENSITY control on the Service Report form. This position should be with respect to fully CCW, such as 1/4 CW, 1/2 CW, etc. By referring to this setting at service intervals, a continued increase in the setting might indicate gradual failure of the CRT and give advance indication of a possible replacement.

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FIGURE 3-8. EC-130 CRT AREA, TOP VIEW

2. FOCUS.

The FOCUS control (Figure 3-8) adjusts the diameter of the electron beam at the face of the CRT. Fuzzy or unclear characters might indicate a misadjustment of the FOCUS control. To adjust the FOCUS control, proceed as follows:

a. Rotate FOCUS control fully CCW.

b. Rotate FOCUS control CW until clear, sharp characters are displayed.

c. Rotate FOCUS control slightly further CW until characters indicate fuzziness.

d. Rotate FOCUS control CCW until maximum sharpness of characters is again evident.

e. Record the final position of FOCUS control on the service report form. Reference to this setting, if a continued large change is necessary, might provide advance indication of high voltage power supply trouble.

3. ASTIGMATISM (ASTIG.)

The ASTIG. control (Figure 3-9) adjusts the "roundness" of the spot at the face of the CRT. ASTIG. control is best adjusted using a decimal point as indication. To adjust ASTIG. control proceed as follows:

a. Rotate ASTIG. control fully CCW.

b. Rotate ASTIG. control CW, while observing a decimal point, until the decimal point appears roundest.

c. Rotate ASTIG. control slightly further CW until the decimal point slightly loses roundness.

d. Rotate ASTIG. control CCW until the roundest decimal point is again observed.

NOTE: FOCUS and ASTIG. control affect each other. Adjusting FOCUS control may necessitate re-setting ASTIG. control, and vice-versa. Each control should be adjusted alternately for best focus and astigmatism.

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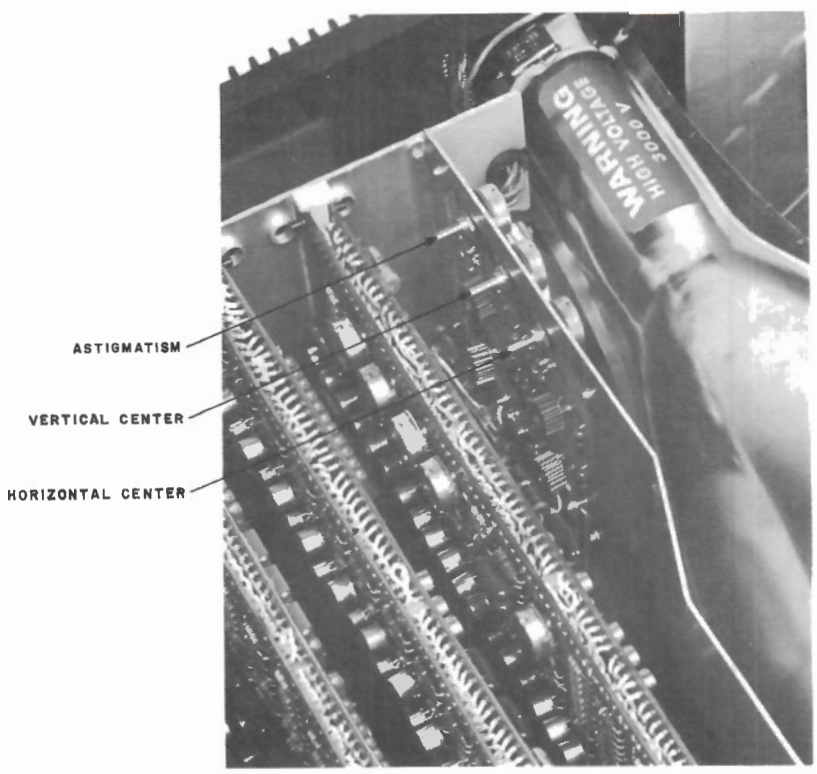


FIGURE 3-9. P-130-59 EC-130 TOP VIEW, DISPLAY CONTROLS

D. CHARACTER ADJUSTMENTS.

Character adjustments (Figure 3-10) are those adjustments that affect the size of the characters. Character adjustments are: Segment Length (SEG L), Character Width (CHAR W), and Character Height (CHAR H).

1. SEGMENT LENGTH (SEG L).

Segment length adjusts the length of the basic segments and thus the total size of the character. To adjust SEG L proceed as follows:

a. Enter a digit 8.

b. Adjust SEG L until the segments on the Figure 8 character just touch, with no extension or shortening (see Figure 3-11).

2. CHARACTER WIDTH (CHAR W).

Character width (CHAR W) adjusts the total width of a character. To adjust CHAR W, proceed as follows:

a. Enter a digit 8.

b. Adjust CHAR W until the character is approximately the width as shown in Figure 3-11.

3. CHARACTER HEIGHT (CHAR H).

Character height adjusts the total height of a character. To adjust CHAR H, proceed as follows:

a. Enter a digit 8.

b. Adjust CHAR H until character is approximately the height as shown in Figure 3-11.

E. DISPLAY ADJUSTMENTS.

Display adjustments are those that affect the total appearance of the display from the standpoint of display centering and character spacing. The display adjustments are: Horizontal character spacing (HCS), Vertical character spacing (VCS), Horizontal Centering (HORIZ CENT), and Vertical Centering (VERT CENT).

1. HORIZONTAL CENTERING (HORIZ CENT).

The Horizontal centering control (Figure 3-9) moves the whole display to the right or to the left. To adjust HORIZ CENT, proceed as follows:

a. Rotate HORIZ CENT control until the whole display appears approximately centered horizontally on the CRT.

NOTE: HORIZ CENT affects CHAR W. Adjustment of horizontal centering may necessitate readjusting CHAR W control.

2. VERTICAL CENTERING.

The vertical centering control (Figure 3-9) moves the whole display up or down. To adjust VERT CENT, proceed as follows:

a. Rotate VERT CENT control until the whole display appears approximately centered vertically on the CRT.

NOTE: VERT CENT affects CHAR H. Adjustment of the vertical centering may necessitate readjusting CHAR H control.

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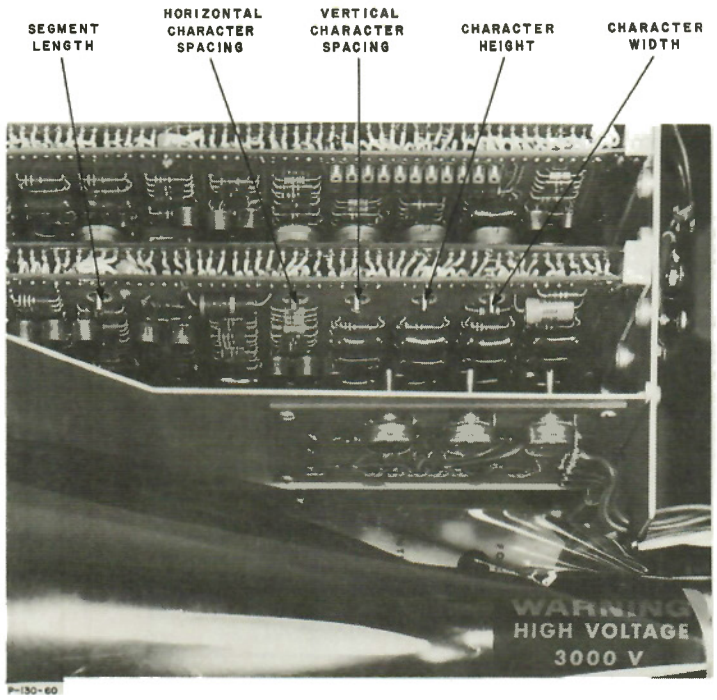
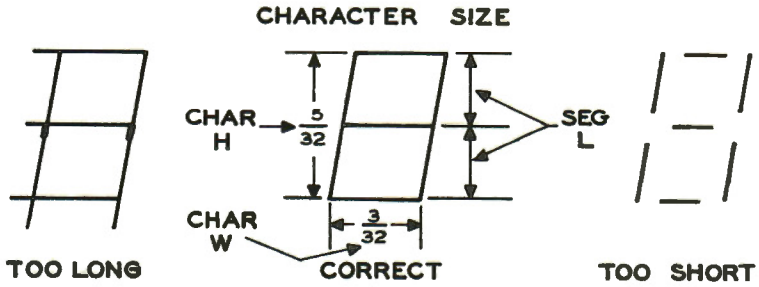


FIGURE 3-10. EC-130 TOP VIEW, CHARACTER CONTROLS



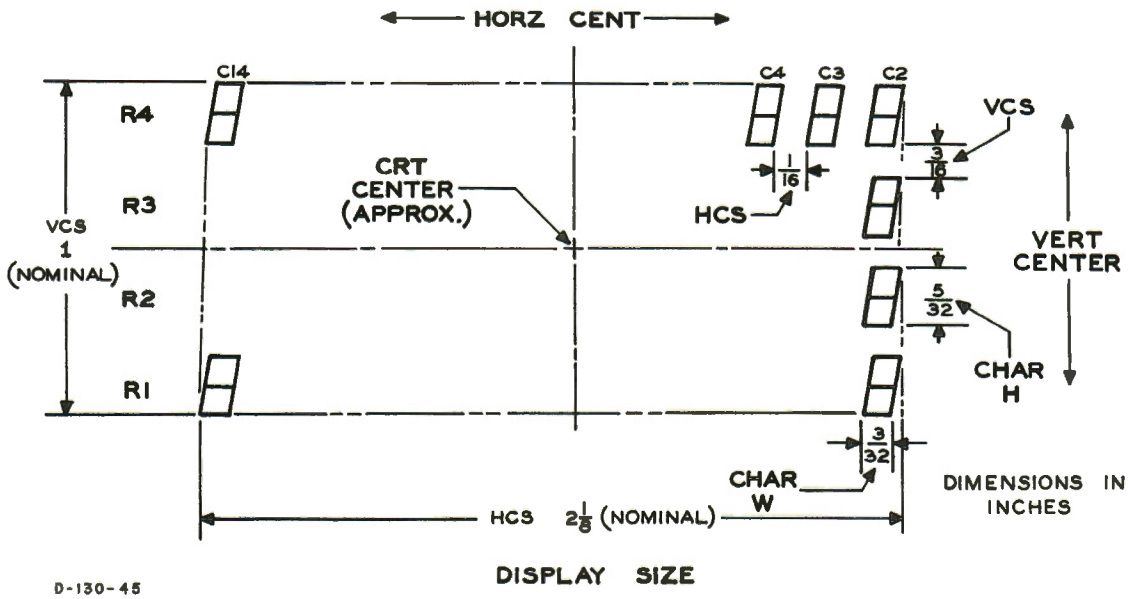


FIGURE 3-11. DISPLAY DIMENSIONS

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3. HORIZONTAL CHARACTER SPACING (HCS).

Horizontal character spacing (Figure 3-10) affects the total width of the display, as well as the horizontal spacing between the characters. To adjust HCS proceed as follows:

a. Rotate HCS control until the spacing between the characters is approximately 1/16", and the total width of the display is about 2 1/8".

NOTE: HCS affects HORIZ CENT and CHAR W. These controls should be adjusted alternately for best display.

4. VERTICAL CHARACTER SPACING (VCS).

Vertical character spacing (Figure 3-10) affects the total height of the display, as well as the vertical spacing between characters. To adjust VCS, proceed as follows:

a. Rotate VCS control until the spacing between registers is approximately 3/16", and the total height of the display is about 1".

NOTE: VCS affects VERT CENT and CHAR H. These controls should be adjusted alternately for best display.

TABLE 3-1

DISPLAY ADJUSTMENTS

NAME	FIGURE NO. REFERENCE	DESIGNATION	PURPOSE
Intensity	3-8	INTENSITY	To adjust the brightness of the display. (Interacts with FOCUS and ASTIG.)
Focus	3-8	FOCUS	To adjust the diameter of the electron beam at the CRT face. (Interacts with ASTIG.)
Astigmatism	3-9	ASTIG.	To adjust "roundness" of the electron beam at the CRT face. (Interacts with FOCUS)
Character Width	3-10	CHAR W	To adjust the width of the characters on display. (Interacts with HCS and HORIZ CENT)
Character Height	3-10	CHAR H	To adjust the height of the characters on display. (Interacts with VCS and VERT CENT)
Horizontal Character Spacing	3-10	HCS	To adjust the total width of display. (Interacts with HORIZ CENT)
Vertical Character Spacing	3-10	VCS	To adjust the total height of display. (Interacts with VERT CENT)
Vertical Centering	3-9	VERT CENT	To move the whole display up or down. (Interacts with VCS)
Horizontal Centering	3-9	HORIZ CENT	To move the whole display right or left. (Interacts with HCS)
Segment Length	3-10	SEG L	To adjust the length of the segments making up the characters.

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SECTION 4 MAINTENANCE

A. SCOPE OF SECTION.

This section contains information necessary for maintenance of the EC-130 at the field service level.

B. SCOPE OF FIELD SERVICE.

The maintenance of the EC-130 at the field service level is specifically limited to the following:

1. CHECK
   a. Power supply voltages (-12, +6, -80 VDC)
   b. Line voltage (115 VAC)
   c. Machine cleanliness
2. ADJUST (Refer to Section 3 of this manual)
   a. Keyboard
   b. Display
3. REPLACE
   a. Plug-in cards (4)
   b. Fuses
   c. Cathode Ray Tube (CRT)
   d. Keyboard

C. VOLTAGE CHECKS.

The following voltage checks will be made using the Triplett 310 Multimeter, and will agree with stated voltage levels within ± 10%.

1. +6 VDC CHECK, PROCEED AS FOLLOWS:
   a. Set meter to 12 on DCV scale.
   b. Place meter red lead to +6 V test point indicated in Figure 3-8.
   c. Place meter black lead to ground test point indicated in Figure 3-8.
   d. Read meter for 6 V ± 10%.
   e. Remove test leads.
2. -12 VDC CHECK, PROCEED AS FOLLOWS:
   a. Set meter to 12 on DCV scale.
   b. Complete steps "b" through "e" of +6 V check, except use -12V test point shown in Figure 3-8 and reverse meter leads.
3. -80 VDC CHECK, PROCEED AS FOLLOWS:
   a. Set meter to 300 on DCV scale.
   b. Complete steps "b" through "e" of +6 V check, except use -80 V test point shown in Figure 3-8 and reverse meter leads.
4. 115 VAC CHECK, PROCEED AS FOLLOWS:
   a. Set meter to 300 on ACV scale.
   b. Turn EC-130 to "ON".
   c. Place meter leads at two terminals (green wires) on top of the AC line filter in Figure 3-8.
   d. Read meter for 115 VAC ± 10%.

D. CLEANING.

Cleaning of the machine will be done during the 6-month maintenance inspection and during any service call if cleaning of a specific area is indicated. The EC-130 cooling depends on a flow of air through the machine. This air is taken from the room and will contain dust, smoke, and grease particles which will build up in the machine. To clean the EC-130, proceed as follows:

1. DUST REMOVAL.

With a soft brush, carefully brush plug-in cards and interior of machine and remove all loose dust. With an approved solvent and a soft, lint-free cloth, carefully clean any grease-filmed areas.

CAUTION: Do not saturate cloth with solvent, or allow solvent to drip into machine.

2. CRT FACE.

With an approved cleaning fluid and a soft, lint-free cloth, carefully clean film and dust from face of CRT.

3. PLUG-IN CARDS.

Remove plug-in cards and clean contact surfaces on bottom of cards with approved contact cleaner. Clean plug-in card jacks of loose dust with soft brush.

4. MACHINE EXTERIOR.

With soft, lint-free cloth and an approved cleaning solvent, clean machine exterior being careful not to use excess solvent.

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E. REPLACEMENT PROCEDURES.

In the event that trouble in the CRT or Keyboard, necessitates replacement, the necessary removal and replacement procedures are as follows:

1. TOP COVER.

To remove and replace the top cover, proceed as follows:

To Remove:

a. At bottom rear of machine, locate and unscrew two captive locking screws.

b. Slide cover forward carefully.

c. Lift up front edge of cover, and remove from machine.

To Replace:

d. Place cover carefully on machine.

e. Gently slide rearward into position.

f. Retighten two captive locking screws.

NOTE: Check ON-OFF switch for easy operation. If switch does not move freely, or move at all, rotate right rear cover-locking screw one-half turn.

2. PLUG-IN CIRCUIT CARDS.

There are four (4) plug-in circuit cards in the EC-130. Each card consists of two cards assembled together with a common base-plug. These cards contain the majority of the electronic circuits of the EC-130 and must be handled with care. To remove and replace a plug-in card, proceed as follows:

To Remove:

a. Remove top cover (Refer to Top Cover Removal).

b. Loosen screw in center of card-retaining plates, and remove plates.

c. Using special tool provided, place tool under removal pins at each end of plug-in card to be removed.

d. Carefully lift card straight up until plug is free from jack.

CAUTION: Do not rock card as damage to plug or jack may result.

e. Remove card carefully and place on a soft mat, or in approved package.

To Replace:

f. Place new card between card guides, being careful not to drop card into guides.

g. Lower card until jack just enters plug.

h. Press top of card evenly so that plug enters jack straight, and press firmly into jack.

CAUTION: Do not rock card into jack.

i. Replace card-retaining plates and retighten holding screws.

j. Replace top cover.

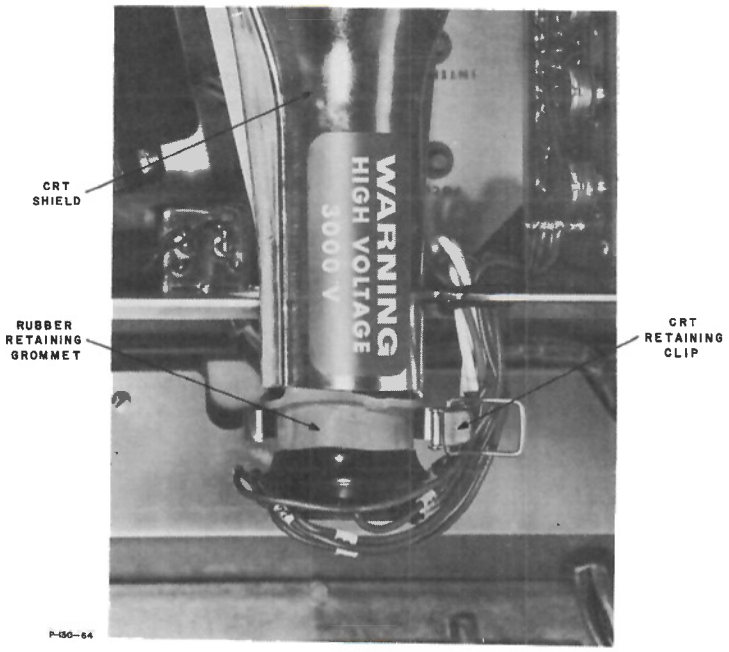


FIGURE 4-1. CRT REAR RETAINING CLIP

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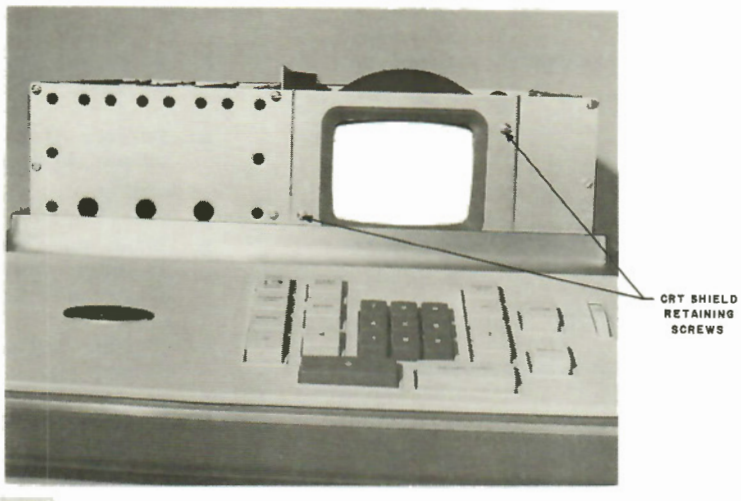


FIGURE 4-2. CRT SHIELD, FRONT RETAINING SCREWS

3. FUSES.

There are two fuses in the EC-130 and they are located on the rear, right hand side. The top cover of the machine must be removed to replace the fuses. The topmost fuse is electrically in the -12 volt output and is a 2-ampere, fast-blow type. The lower fuse is in the 115-volt AC line, and is a 1-ampere, slo-blow type. To replace a fuse proceed as follows; Turn ON-OFF switch to OFF:

To Remove:

a. Remove top cover.

b. Unscrew fuse plug from fuse-holder.

c. Remove fuse.

To Replace:

d. Replace with exact type.

e. Replace fuse plug, tighten finger-tight.

f. Replace top cover.

4. CATHODE RAY TUBE (CRT).

To remove and replace CRT, proceed as follows:

To Remove:

a. Remove top cover of machine.

b. Remove power plug from rear of machine.

c. Remove screws holding heat sink, and tilt heat sink back.

d. Unsnap CRT retaining clip (see Figure 4-1).

e. Remove CRT shield-holding screws (2) (see Figure 4-2).

f. Remove CRT plug from base of CRT.

g. Carefully remove CRT assembly (shield plus CRT).

h. Carefully remove CRT from shield.

To Replace:

i. Carefully place new CRT in shield.

j. Insert shield with CRT into machine.

k. Replace front shield-holding screws loosely.

l. Replace CRT base-plug.

m. Lift heat sink enough to replace power plug, and prop so that no strain is on plug.

n. Turn machine to "ON".

o. Observe that Display is level horizontally.

NOTE: A strip of masking tape, or a grease pencil mark, underlining register one will be of assistance.

p. Rotate base of CRT carefully until display is level horizontally.

q. Turn machine to "OFF".

r. Hook snap ring together, but do not tighten.

s. Push firmly on base of CRT to assure that tube and shield are as far forward as possible, and tighten snap lock.

t. Tighten front shield-holding screws.

u. Check that CRT face is held tightly by forward rubber grommet. If not, repeat steps r and s, being sure that display marker (see note after step o) stays level.

v. Replace heat sink retaining screws.

w. Replace top cover.

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5. KEYBOARD.

To remove and replace the keyboard, proceed as follows:

To Remove:

a. Remove top cover.

b. Turn machine bottom-side up on a felt pad, or soft surface.

c. Remove bottom cover plate.

d. Loosen delay line plastic retainers (see Figure 4-3).

e. Move delay line carefully aside.

f. Remove wiring from keyboard taper pins.

g. Remove keyboard mask retaining screws (5) (see Figure 4-4).

h. With D.P. locator thumbwheel at 0, secure with strip of masking or scotch tape on the keyboard side.

i. Unloosen keyboard-to-mask captive screws (4) (see Figure 3-6).

j. Remove D.P. switch taper pin wiring at side of keyboard.

k. Remove keyboard.

To Replace:

l. Place new keyboard into approximate position on mask.

m. Replace D.P. switch taper pin wiring, being careful to observe wire to taper pin number coding.

n. Make sure that D.P. switch gear (Figure 3-6) is fully counterclockwise (0 position), and engage with D.P. locator thumbwheel.

o. Tighten keyboard-to-mask retaining captive screws (4).

p. Replace and tighten keyboard-mask retaining screws (5).

q. Replace keyboard taper pin wiring, being careful to observe wire to taper pin number coding and ensuring that no taper pin connections are loose.

r. Replace delay line to proper position and tighten plastic retainers.

s. Check action of keyboard and make any necessary adjustments as per Section 3 of this manual.

t. Replace bottom cover (10 screws).

u. Place machine right-side up, and remove retaining tape from D.P. locator thumbwheel.

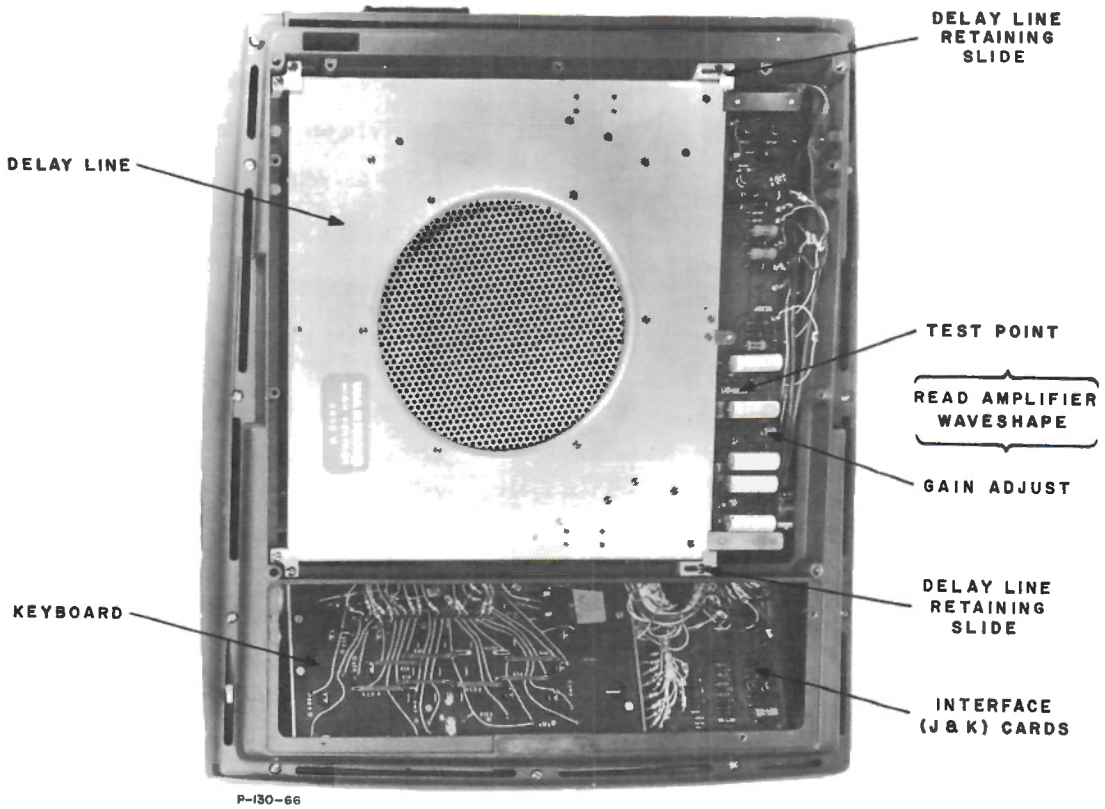


FIGURE 4-3. DELAY LINE RETAINING SLIDES

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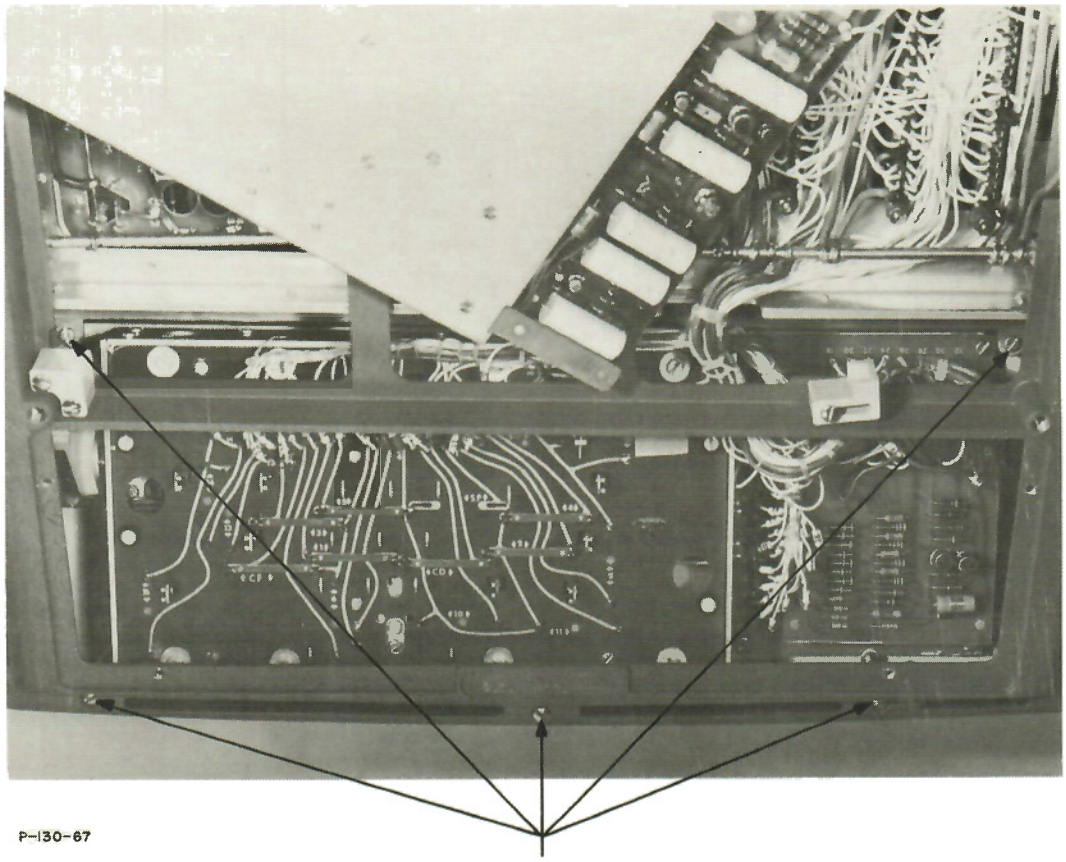


FIGURE 4-4. KEYBOARD MASK RETAINING SCREWS

F. SHIPPING INSTRUCTIONS.

The EC-130 is a fragile electronic device susceptible to damage if not handled carefully. In the course of maintenance assemblies such as the Keyboard and Plug-in cards may have to be removed and shipped to a Depot for repair. Also, repairs beyond the scope of field maintenance could necessitate shipping an entire machine. Whenever an assembly, part, or machine is to be shipped, special care will be used in packing. There is an approved package for Plug-in circuit cards and an approved package for the EC-130. Observe all packing instructions carefully. Small assemblies will be adequately protected by foam rubber, soft packing material, or other methods before shipping.

G. SERVICE REPORTS.

It is very important that a complete and detailed Service Report be filled out whenever the EC-130 is checked, adjusted, or repaired. At the present time, a standard Service Record form will be used.

H. LIST OF TOOLS AND EQUIPMENT.

The following tools and test equipment will be available locally, purchased locally, or supplied from San Leandro:

1. Oscilloscope, Tektronix Model 310A
2. Multimeter, Triplett Model 310 (or equivalent)
3. Soldering Iron, Oryx #12-6 (or equivalent)
4. Keyboard Tester, San Leandro supplied
5. Keyboard Spacers (4), San Leandro supplied
6. Plug-in Card Extractors (2), San Leandro supplied
7. Long-nose Pliers, 6"
8. Screwdriver, 3/16" tip
9. Soft brush, San Leandro supplied
10. Lint-free cloth, or Kimwipes

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