

1115 ELECTRONIC CALCULATOR

SERVICE MANUAL



SINGER
FRIDEN DIVISION

TPD-169SL

1115 ELECTRONIC CALCULATOR

PREFACE

The intent of this manual is to provide maintenance information to trained field personnel. When used for training purposes, this manual must be supplemented with a course curriculum. The manual itself is not designed for self instruction.

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GENERAL DESCRIPTION

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GENERAL DESCRIPTION

A. APPEARANCE

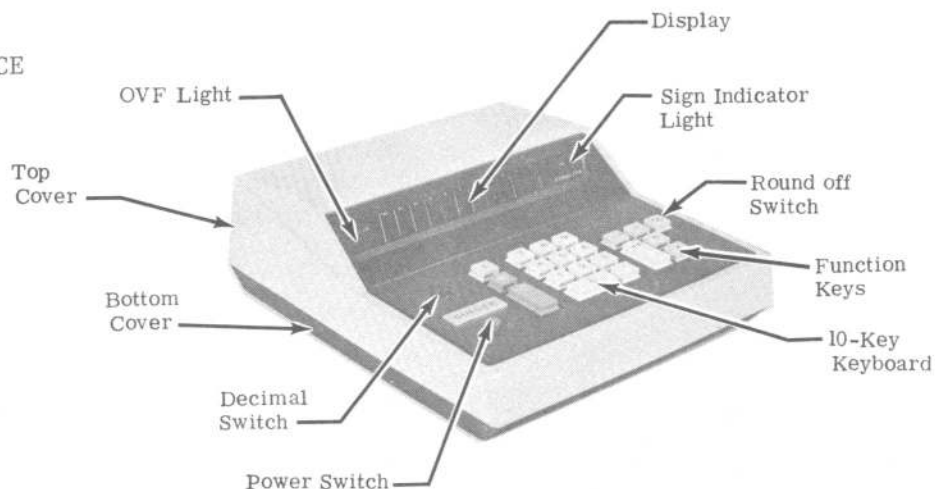


FIGURE 1-1

The 1115 Electronic Calculator (Figure 1-1) is a small, light weight, high speed portable desk calculator featuring: a 12-digit Nixie type, number indicating tube display, 10-key keyboard, and integrated (IC) electronic circuitry for long life and maximum reliability.

B. SPECIFICATIONS

Size: 10" wide, 13" deep, and 4" high (approx).

Weight: 10 lbs.

Keyboard: 10-key type. Any number can be entered (maximum of 12 digits) using the ten digit keys (0-9) and the Decimal Point key if applicable. The Function keys are arranged around the Digit keys in a manner that provides maximum operator facility and ease of operation.

Decimal System: Floating Input/Fixed Output (Decimal Switch Positions: 0, 2, 5)

Speed: The longest arithmetic problem in:

Addition and Subtraction	0.05 sec.
Multiplication	0.4 sec.
Division	0.4 sec.

Reliability: Use of the latest state of the art integrated circuit chips, transistors, and diodes insures maximum reliability and serviceability.

Power Source: The 1115 can be connected to any standard, grounded 115 VAC outlet. Transformer taps are provided for 100V, 110V, 117V, & 120V (50/60 Hz) operation. Optional voltages are available on special order.

Power Consumption: 12 watts

Ambient Temperature: 0-40° C (32-104° F)

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C. KEY FUNCTIONS

The Keyboard keys (Figure 1-2) can be grouped by function as: Digit, Arithmetic, and Data Handling. The Digit keys are used in entering numbers; the Arithmetic keys are used in operations which involve computations; and the Data Handling keys shift numbers between registers, or clear numbers from the machine.

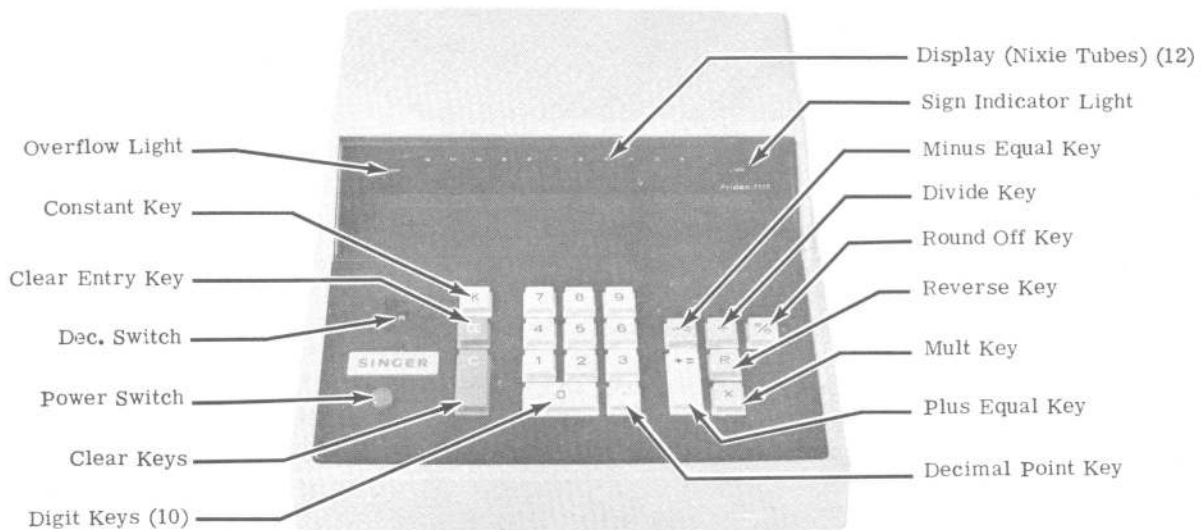


FIGURE 1-2

1. DIGIT KEYS

Numbers are entered into the 1115 data loop digit-by-digit by use of the digit keys. Since numbers can contain decimal digits, the decimal point key is also considered to be in the digit group because it is used for a decimal number entry.

2. ARITHMETIC KEYS

The arithmetic keys enable and initiate the arithmetic operations that will be performed with and on the numbers. Briefly their functions are:



a. PLUS EQUAL KEY. Depression of this key initiates the addition, multiplication, and division functions. In an Add function the contents of R2 are added to R3. In Mult or Divide, the answer is produced in R2 as a result of repeat addition or repeat subtraction.

When the machine is not conditioned to multiply or divide, depression of this key causes R2 to be added to R3 with the result in R2 and the 2nd Entry to be retained in R3. (Note: In the 1115, the 2nd Entry will always be retained in R3 following an Add, Subtract, Mult, or Divide.) If the machine is conditioned to multiply and no data has been entered into R2 since the multiply conditioning, depression of this key causes: R2 to transfer to R3 with R2 being unchanged; R3 to be multiplied by R2; the final product in R2 and the entered number retained in R3.

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If the machine is conditioned to multiply and data has entered R2 since the multiply conditioning, R3 is multiplied by R2 with the product in R2 and the 2nd Entry retained in R3. If the machine is conditioned to divide, depression of this key causes R2 to be divided by R3 with the quotient in R2 and the 2nd Entry retained in R3.



b. MINUS EQUAL KEY. Depression of this key initiates the subtraction, multiplication, and division functions. When the machine is not conditioned to multiply or divide, depression of this key causes R3 to be subtracted from R2 with the result in R2 and the 2nd Entry in R3. If the machine is conditioned to multiply, multiplication occurs as defined for Plus Equal, except prior to multiplication, the sign of R2 is changed. If the machine is conditioned to divide, division will occur as defined for the Plus Equal key except prior to division, the sign of R2 is changed.



c. MULT KEY. Depression of this key terminates the digit entry and conditions the machine to multiply. However, when the machine is already conditioned to multiply, or divide, by a prior Mult or Divide key depression, and the Mult key is again depressed following a digit entry, the machine will perform the function corresponding to its prior conditioning. This will also establish a Mult condition for the next machine operation.



d. DIVIDE KEY. Depression of this key terminates the digit entry and conditions the machine to divide. However, when the machine is already conditioned to multiply, or divide, by a prior Mult or Divide key depression, and the Divide key is again depressed following a digit entry, the machine will perform the function corresponding to its prior conditioning. This will also establish a Divide condition for the next machine operation.



e. DECIMAL SET SWITCH. This is a slide type switch having three positions for setting the decimal point at 0, 2, or 5. Decimal control of the final answer is defined by the setting of the Decimal Set Switch.



f. CONSTANT KEY (K). This is a latch down type key used for retaining a constant multiplier or a constant divisor. It also retains the command to multiply or divide until a Mult or Divide key is depressed to change the constant function. Briefly, the Constant key is used as follows:

$A \times B =$	$A \div B =$	B^2
$C \times B =$	$C \div B =$	B^3
$D \times B =$	$D \div B =$	B^4

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When the "K" key is in the latched position (down), the first step of each key function is normal as: A $\boxed{\times}$ B $\boxed{+=}$; A $\boxed{\div}$ B $\boxed{+=}$; B $\boxed{\times}$ $\boxed{+=}$. After the first mult or divide key function is completed, the key function in use is automatically retained and the "B" factor becomes a constant. Under this condition, entry of a new number (C or D) factor causes the contents of the previous product in R2 to be cleared and the new entry (C or D) goes into R2 while the constant factor "B" is retained in R3. Depression of the $\boxed{+=}$ key causes the second calculation to be performed. In other words, when the "K" key is latched down, depressing the $\boxed{+=}$ key or the $\boxed{-=}$ key always causes R3 to be multiplied by R2 (for the multiplication condition); or R2 to be divided by R3 (for the divide condition). The operation will continue in this manner until another Mult or Divide key is depressed. Then, the constant condition set up by the "K" key is cleared and normal machine operation is established even though the "K" key remains latched down.

$\boxed{R/O}$

g. ROUND OFF SWITCH. The Round Off Switch is a latch down type switch which enables a decimal round off of the LSD of the answer in R2 if necessary. When the R/O switch is latched down and the decimal number to the right of the LSD in R2 is greater than "4", a "1" is added to the LSD in R2.

3. DATA HANDLING KEYS

Using the data handling keys results in the shifting of numbers between registers; and the clearing of numbers from R2 and R3. The function of the Data Handling keys is explained briefly as follows:

$\boxed{R}$

a. REVERSE KEY. Depression of this key exchanges the contents of R2 and R3. The algebraic sign of a register is considered as part of its contents.

$\boxed{C}$

b. CLEAR KEY. Depression of this key causes R1, R2, and R3 to be cleared, and all control flip-flops will reset. If the machine is in an overflow condition, the overflow light will be turned off and the keyboard will be unlocked electrically.

$\boxed{CE}$

c. CLEAR ENTRY KEY. Depression of this key causes R2 and R1 to be cleared. If the machine is in an overflow condition, the overflow light will be turned off and the keyboard will be unlocked electrically.

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4. POWER SWITCH

A push-on, push-off type switch located in the lower left corner of the keyboard is used to turn the power on and off. Turning the machine power on automatically causes all registers to be cleared to zero, the sign of all registers to be positive, and the decimal position of all registers to be transferred to the right of the lowest displayed ordinal position.

5. INDICATING LIGHTS

a. OVERFLOW LIGHT. The Overflow light located at the left side of the display panel comes on:

- (1) When data entry to R2 exceeds 12 digits or 11 decimal digits.
- (2) When the integer portion of the answer developed in R2 minus the number of decimal places defined by the Decimal Switch exceeds 12 digits.

When the overflow condition is indicated, the keyboard is immediately interlocked electrically. The overflow condition is cleared by the Clear key or the Clear Entry key.

b. NEGATIVE LIGHT. The Negative Light located at the right side of the display panel comes on:

- (1) When the data is entered in R2 by the Minus Equal key.
- (2) When the output (answer) is negative (as governed by the rules of algebraic signs).

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SECTION 2

CALCULATING METHODS

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CALCULATING METHODS

A. GENERAL

This section of the manual describes the various calculations possible with the 1115 Electronic Calculator. Sample problems are provided to illustrate the process and to give the CSRep a working knowledge of the machine operation which is essential to understanding the machine logic and an aid in troubleshooting.

Listed below are several pertinent points that should be noted.

- (1) The machine has a floating decimal point input and a fixed point output system.
- (2) When an answer or an entry is negative, it is indicated with a minus sign.
- (3) The number recalled by the Reverse key is used the same as a digit entry.
- (4) Repeated depression of the Mult and Divide keys merely changes the order of the operation to coincide with the last depressed key,

B. ADDITION

Addition is accurate up to 12 digits. Depressing the Clear key is necessary before each calculation.

PROBLEMS:

- (1) Addition without decimals under decimal preset position of 2.

$$946 + 583 + 123 = 1652.00$$

SOLUTION	INDEX IN KEYBOARD	TOUCH FUNCTION KEYS IN SEQUENCE	DISPLAY
1) $946+583+123=1652$		 R/O ↓ C	
	946	 =	946.00
	583	 =	1529.00
	123	 =	1652.00

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B. ADDITION (Cont.)

(2) Addition with decimal under decimal preset position of 2.

$$2.63 + 0.574 + 0.02 = 3.22$$

SOLUTION	INDEX IN KEYBOARD	TOUCH FUNCTION KEYS IN SEQUENCE	DISPLAY
2) $2.63 + 0.57 + 0.02 = 3.22$		 R/O + C	
	2.63	+ =	2.63
	0.57	+ =	3.20
	0.02	+ =	3.22

C. SUBTRACTION

Subtraction is accurate up to 12 digits. Depressing the Clear key is necessary before each calculation.

PROBLEMS:

(1) Subtraction without decimals under decimal preset position of 2.

$$657 - 492 = 165.00$$

SOLUTION	INDEX IN KEYBOARD	TOUCH FUNCTION KEYS IN SEQUENCE	DISPLAY
1) $657 - 492 = 165$		 R/O + C	
	657	+ =	657.00
	492	- =	165.00

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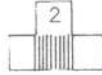
C. SUBTRACTION (Cont.)

(2) Subtraction and Addition under decimal preset position of 2.

$$-530 + 829 = 299.00$$

(3) Subtraction with True Credit Balance under decimal preset position of 2.

$$139 - 567 = -428.00$$

SOLUTION	INDEX IN KEYBOARD	TOUCH FUNCTION KEYS IN SEQUENCE	DISPLAY
2) $-530 + 829 = 299$		 R/O + C	
	530	--=	530.00-
	829	+=	299.00
3) $139 - 567 = -428$		 R/O + C	
	139	+=	139.00
	567	--=	428.00-

D. MULTIPLICATION

Multiplication is accurate up to 12 digits and depressing the Clear key is not necessary before each calculation. In chain multiplication (and regular multiplication) if the integer portion of the result developed by multiplying the previous product and the next multiplier exceeds 12 digits (minus the decimal preset number) it will be necessary to set the decimal set switch to "0".

In Chain Multiplication, successive products can be multiplied with or without using the Plus Equal key each time. For example:

$$123 \times 456 \times 789 += .$$

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CALCULATING METHODS

D. MULTIPLICATION (Cont.)

PROBLEMS:

(1) Multiplication without decimals

$$12 \times 24 = 288$$

(3) Chain multiplication

$$3.69 \times 65.41 \times 1.479 = 356.97572$$

(2) Multiplication with decimals

$$6.123 \times 47.89 = 293.23047$$

(4) Multiplication with negatives

$$-369 \times 682 \times (-34) = 8556372$$

SOLUTION	INDEX IN KEYBOARD	TOUCH FUNCTION KEYS IN SEQUENCE	DISPLAY
1) $12 \times 24 = 288$	12 24	 R/O ↓ X +=	12. 288.00
2) 6.123×47.89	6.123 47.89	 R/O ↓ X +=	6.123 293.23
3) $3.69 \times 65.41 \times 1.479$ = 356.9757291	3.69 65.41 1.479	 R/O ↓ X X +=	3.69 241.36 356.97
or another way $3.69 \times 65.41 = 241.36$ $241.36 \times 1.479 = 356.97$	3.69 65.41 1.479	 R/O ↓ X += X +=	3.69 241.36 241.36 356.97
4) $-369 \times 682 \times (-34) = 8556372$	369 682 34	 R/O ↓ C --= X X --=	369.00 369.00 251658.00 8556372.00

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E. CONSTANT MULTIPLICATION

The Constant key "K" is used for this calculation. Normal operation, except Add and Subtract, can be accomplished even though the "K" key is latched down. See page 1-3 for an explanation of the "K" key operation.

PROBLEMS:

GROUP 1

(1) $123 \times 4.56 = 560.88$

(2) $563 \times 4.56 = 2567.28$

(3) $213 \times 4.56 = 971.28$

Note: The number "4.56" is the constant multiplier

GROUP 2 (Involution)

(1) $25^2 = 625$

(2) $25^3 = 15625$

(3) $25^4 = 390625$

Note: In this case, the constant multiplier is "25".

SOLUTION	INDEX IN KEYBOARD	TOUCH FUNCTION KEYS IN SEQUENCE	DISPLAY
1) $123 \times 4.56 = 560.88$	123	 R/O ↓ K ↓	123.
	4.56	X	560.88
$563 \times 4.56 = 2567.28$	563	+=	2567.28
$213 \times 4.56 = 971.28$	213	+=	971.28
2) $25^2 = 625$	25	X	25.
		+=	625.00
$25^3 = 15625$		+=	15625.00
$25^4 = 390625$		+=	390625.00

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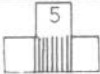
CALCULATING METHODS

F. DIVISION

Division is accurate up to 12 digits. Touching the Clear key is not necessary before each calculation. In chain division, successive quotients can be divided without using the Plus Equal key each time.

PROBLEMS:

- | | |
|-------------------------------|-----------------------------------|
| (1) Division without decimals | $145 \div 12 = 12.08333$ |
| (2) Division with Decimals | $4962.184 \div 13.2 = 375.92303$ |
| (3) Chain Division | $369 \div 123 \div 456 = 0.00658$ |

SOLUTION	INDEX IN KEYBOARD	TOUCH FUNCTION KEYS IN SEQUENCE	DISPLAY
1) $145 \div 12 = 12.08333$	145 12	 R/O ↓ ÷ +=	145. 12.08333
2) $4962.184 \div 13.2$ $= 375.923030$	4962.184 13.2	÷ +=	4962.184 375.92303
3) $369 \div 123 \div 456$ $= 0.006578$	369 123 456	÷ ÷ +=	369. 3.00000 0.00658
Or another way $369 \div 123 = 3$	369 123	÷ +=	369. 3.00000
$3 \div 456 = 0.006578$	456	÷ +=	3.00000 0.00658

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G. CONSTANT DIVISOR

The Constant key "K" is used for this calculation. Normal operation, except Add and Subtract may be accomplished even though the "K" key is latched down. See Page 1-3 for an explanation of the "K" key function.

PROBLEMS:

(1) $297 \div 1364 = 0.21774$

(2) $6428 \div 1364 = 4.71261$

(3) $1000 \div 1364 = 0.73314$

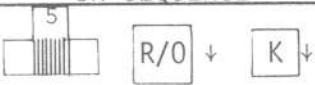
Note: The number "1364" is the constant divisor.

(4) $\frac{12367}{12} = 1030.58333$

(5) $\frac{12367}{12^2} = 85.88194$

(6) $\frac{12367}{12^3} = 7.15683$

Note: The number "12" is the constant divisor.

SOLUTION	INDEX IN KEYBOARD	TOUCH FUNCTION KEYS IN SEQUENCE	DISPLAY
1) $297 \div 1364 = 0.21774$	297 1364	 R/O ↓ K ↓ ÷ +=	297 .21774
2) $6428 \div 1364 = 4.71261$	6428	+ =	4.71261
3) $1000 \div 1364 = 0.73314$	1000	+ =	.73314
4) $\frac{12367}{12} = 1030.58333$	12367 12	÷ + =	12367. 1030.58333

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G. CONSTANT DIVISOR (Cont.)

SOLUTION	INDEX IN KEYBOARD	TOUCH FUNCTION KEYS IN SEQUENCE	DISPLAY
5) $\frac{12367}{12^2} = 85.88194$		$\boxed{+}$	85.88194
6) $\frac{12367}{12^3} = 7.15683$		$\boxed{+}$	7.15683

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H. ROUND OFF AND TRUNCATE

Round Off and Truncate action is performed on the digit to the right of the digit in the lowest decimal position displayed. The answer will be rounded off or truncated depending on the position of the Round Off Switch. That is, in a Round Off calculation, the Round Off Switch must be preset to the position of R/O prior to starting the calculation. If the Round Off Switch is not preset to the position of R/O, the answer will be truncated instead.

Also, if the decimal digit numbers of the entry are greater than the Decimal Switch setting, the entry number will be rounded off or truncated by depression of the Plus Equal key. The number displayed will be defined by the Decimal Switch setting.

PROBLEMS: (Decimal Switch set at "2")

(1) Addition and Subtraction under round off condition.

$$5.372 + 17.369 - 1.234 = 21.51$$

(2) Multiplication and Division under round off and truncate condition.

$$\begin{array}{l} 45.769 \times 3.52 = 161.11 \\ 45.769 \div 3.52 = 13.00 \end{array} \left. \vphantom{\begin{array}{l} 45.769 \times 3.52 = 161.11 \\ 45.769 \div 3.52 = 13.00 \end{array}} \right\} \text{Rounding Off}$$
$$45.769 \times 3.52 = 161.10 \quad \text{Truncate}$$

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H. ROUND OFF AND TRUNCATE (Cont.)

SOLUTION	INDEX IN KEYBOARD	TOUCH FUNCTION KEYS IN SEQUENCE	DISPLAY
1) $5.372 + 17.369 - 1.234$ =21.51	5.372 17.369 1.234	 R/O ↓ C += += -=	5.37 22.74 21.51
2) $45.769 \times 3.52 = 161.11$	45.769 3.52	 R/O ↓ X +=	45.769 161.11
3) $45.769 \times 3.52 = 161.10$	45.769 3.52	R/O ↑ X +=	45.769 161.10
4) $45.769 \div 3.52 = 13.00$	45.769 3.52	$\div$ +=	13.00

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CALCULATING METHODS

I. COMBINED CALCULATIONS

Examples of combined calculations are shown in the three problems that follow.

PROBLEMS:

(1) $123 \times 45.6 \div 78.9 - 1.47 + 25.76 = 95.3774$

(2) $\frac{1000}{(160+320+102)} = 1.7182$

(3) $\frac{(1+0.05)^5 - 1}{0.05} \times 12300 = 67965.264375$

SOLUTION	INDEX IN KEYBOARD	TOUCH FUNCTION KEYS IN SEQUENCE	DISPLAY
1) $123 \times 45.6 \div 78.9 - 1.47 + 25.76 = 95.3774$	123 45.6 78.9 1.47 25.76	 R/O ↓ X ÷ += -- +=	123. 5608.80 71.09 69.62 95.38
2) $\frac{1000}{(160+320+102)} = 1.7182$	160 320 102 1000	 R/O ↓ C += += += ÷ R +=	160.00 480.00 582.00 582.00 582.00 1.72

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I. COMBINED CALCULATIONS (Cont.)

SOLUTION	INDEX IN KEYBOARD	TOUCH FUNCTION KEYS IN SEQUENCE	DISPLAY
3) $\frac{(1+0.05)^5 - 1}{0.05} \times 12300$		 R/O ↓ K ↓ C	
= 67965.264375	1		1.00000
	0.05		1.05000
			1.05000
			1.10250
			1.15763
			1.21551
			1.27629
		K ↑	1.27629
	1		0.27629
			0.27629
	0.05		5.52580
	12300		67967.34000

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LOGIC ELEMENTS

A. COMPOSITION OF FUNDAMENTAL CIRCUIT

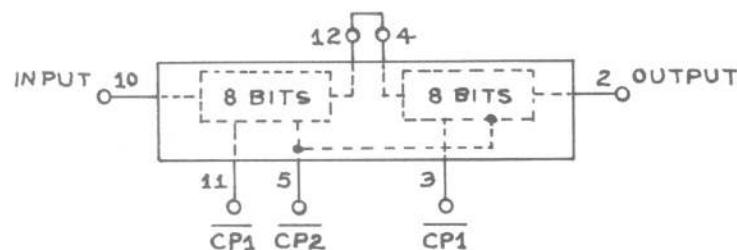
The logic circuits of this machine are composed primarily of eight types of MOS (Metal Oxide Semiconductor) IC (integrated circuit) packaged in dual-in-line circuit chips. Other circuits in the machine are composed of discrete components such as diodes, transistors, etc.

Shown in the Table below are the 8 MOS IC chips used in the machine and their circuit function. A brief explanation of each chip is also included here to familiarize the CSRep with their general function.

Type of IC	Circuit Function
HD 3101	dual 8-bit quasi-static shift register
HD 3103	five MOS FETs (Inverters)
HD 3104	dual 4 input AND gate + two inverters
HD 3106	dual 2 input & a dual 3 input AND gate
HD 3107	quadruple quasi-static D type flip-flop
HD 3109	60 + 4 + 4 bits dynamic shift register (with control gates)
HD 3112	delayed full adder
HD 3115	triple quasi-static RSS flip-flop

1. HD 3101 (Dual 8-bit Shift Register)

A dual 8-bit shift register which is connected in a series configuration to form a 16-bit shift register as shown in Figure 3-1.



HD 3101

FIGURE 3-1

1115 ELECTRONIC CALCULATOR

LOGIC ELEMENTS

2. HD 3103 (5 MOS FET's)

This IC contains 5 MOS FET's which are used as inverters (Figure 3-2) or as transfer gates (Figure 3-3).

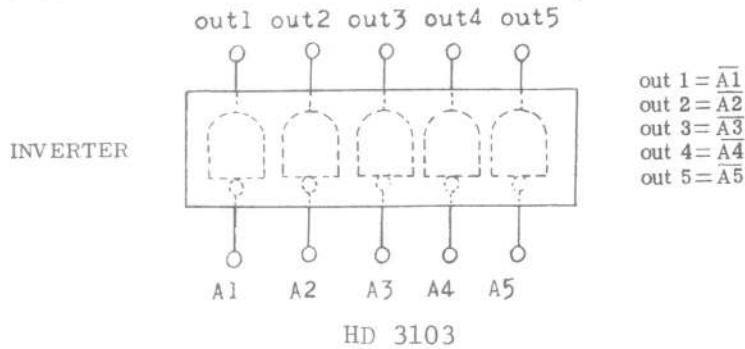


FIGURE 3-2

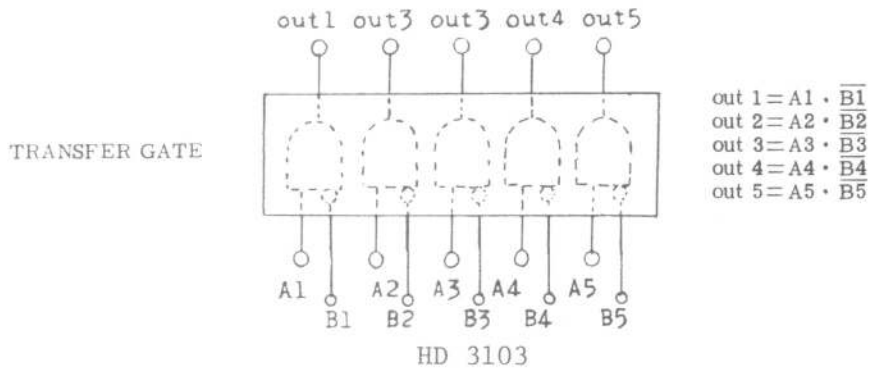
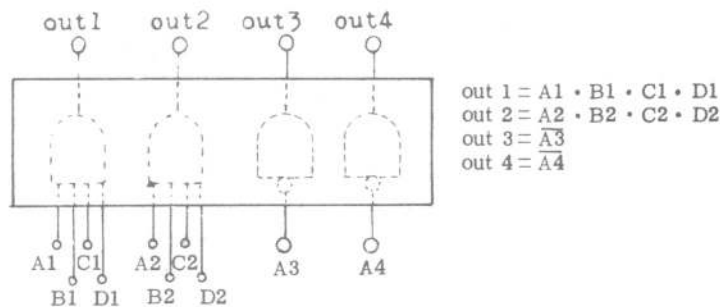


FIGURE 3-3

3. HD 3104 (Dual 4-input AND gate plus 2 Inverters)

This IC is composed of dual 4-input AND/OR gates and 2 Inverters. The gate circuits operate as AND circuits when Logic 1 corresponds to "0" volts and operate as OR gates when Logic 0 correspond to "0" volts (Figure 3-4).



HD 3104

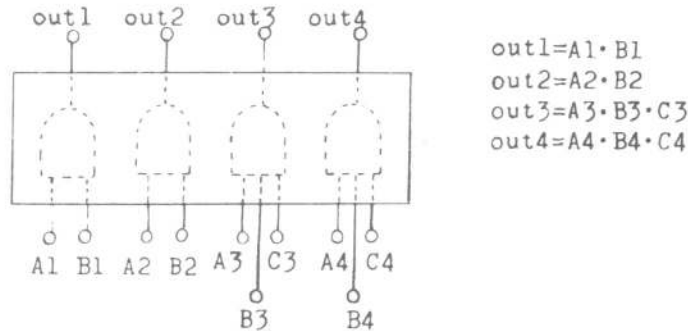
FIGURE 3-4

1115 ELECTRONIC CALCULATOR

LOGIC ELEMENTS

4. HD 3106 (Dual 3-input AND/OR gate and Dual 2-input AND/OR gate)

This IC is composed of dual 3-input AND/OR gate circuits and dual 2-input AND/OR gates which are used extensively in the various logic circuits of the machine (Figure 3-5).

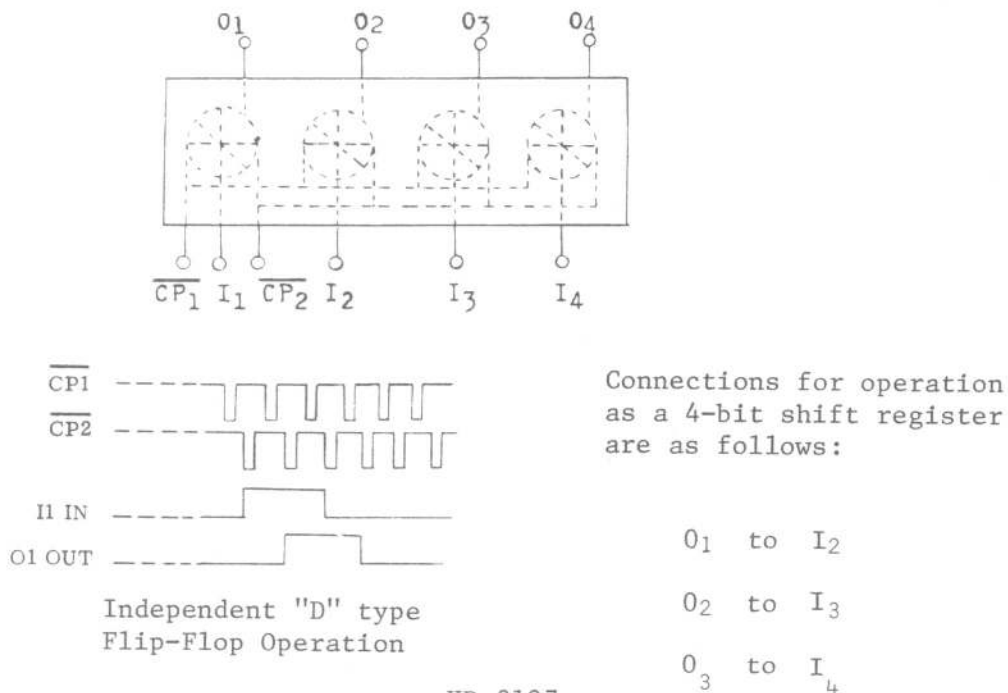


HD 3106

FIGURE 3-5

5. HD 3107 (4 "D" type Flip-Flops)

This IC is composed of 4 "D" type FFs which can be used as individual flip-flops or if connected in series, can be used as a 4-bit shift register (Figure 3-6).



HD 3107

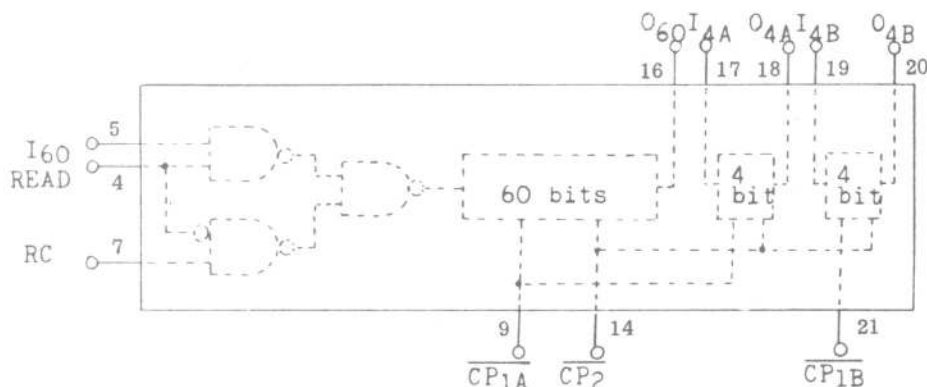
FIGURE 3-6

1115 ELECTRONIC CALCULATOR

LOGIC ELEMENTS

6. HD 3109 (60 +4 +4-Bit Dynamic Shift Register)

This IC is called a Medium Scale Integrated Circuit (MSI) and contains a 68-bit shift register (60 + 4 + 4). That is, the IC can retain 68 bits of data consisting of 17 4-bit (BCD) digits in a dynamic shift register (Figure 3-7).



HD 3109

FIGURE 3-7

ADD

X	Y	C	FA OUT	FC IN
0	0	0	0	0
1	0	0	1	0
0	1	0	1	0
1	1	0	0	1
0	0	1	1	0
1	0	1	0	1
0	1	1	0	1
1	1	1	1	1

BASIC FAS TRUTH TABLES

SUB

X	Y	C	FA OUT	FC IN
0	0	0	0	0
1	0	0	1	0
0	1	0	1	1
1	1	0	0	0
0	0	1	1	1
1	0	1	0	0
0	1	1	0	1
1	1	1	1	1

X = X input

Y = Y input

C = CONDITION OF CARRY (FC)

FA OUT = SUM ADDER OUTPUT

FC IN = CARRY ENABLE INPUT

ADD

FAS COMPENSATION TRUTH TABLES

SUB

BT4				
XC1	Ff	HC	Xo	HC ENABLE
0	0	0	0	0
1	0	0	1	0
0	1	0	1	0
1	1	0	0	1
0	0	1	1	0
1	0	1	0	1
0	1	1	0	1
1	1	1	1	1

XC1 = LSD OF DIGIT FROM 4-BIT REGISTER

Ff = OUTPUT OF COMPENSATION FLIP-FLOP.

HC = OUTPUT OF COMPENSATION CARRY FLIP-FLOP.

BT4				
XC1	Ff	HC	Xo	HC ENABLE
0	0	0	0	0
1	0	0	1	0
0	1	0	1	1
1	1	0	0	0
0	0	1	1	1
1	0	1	0	0
0	1	1	0	1
1	1	1	1	1

XO = COMPENSATION ADDER OUTPUT

HC ENABLE = CARRY ENABLE INPUT

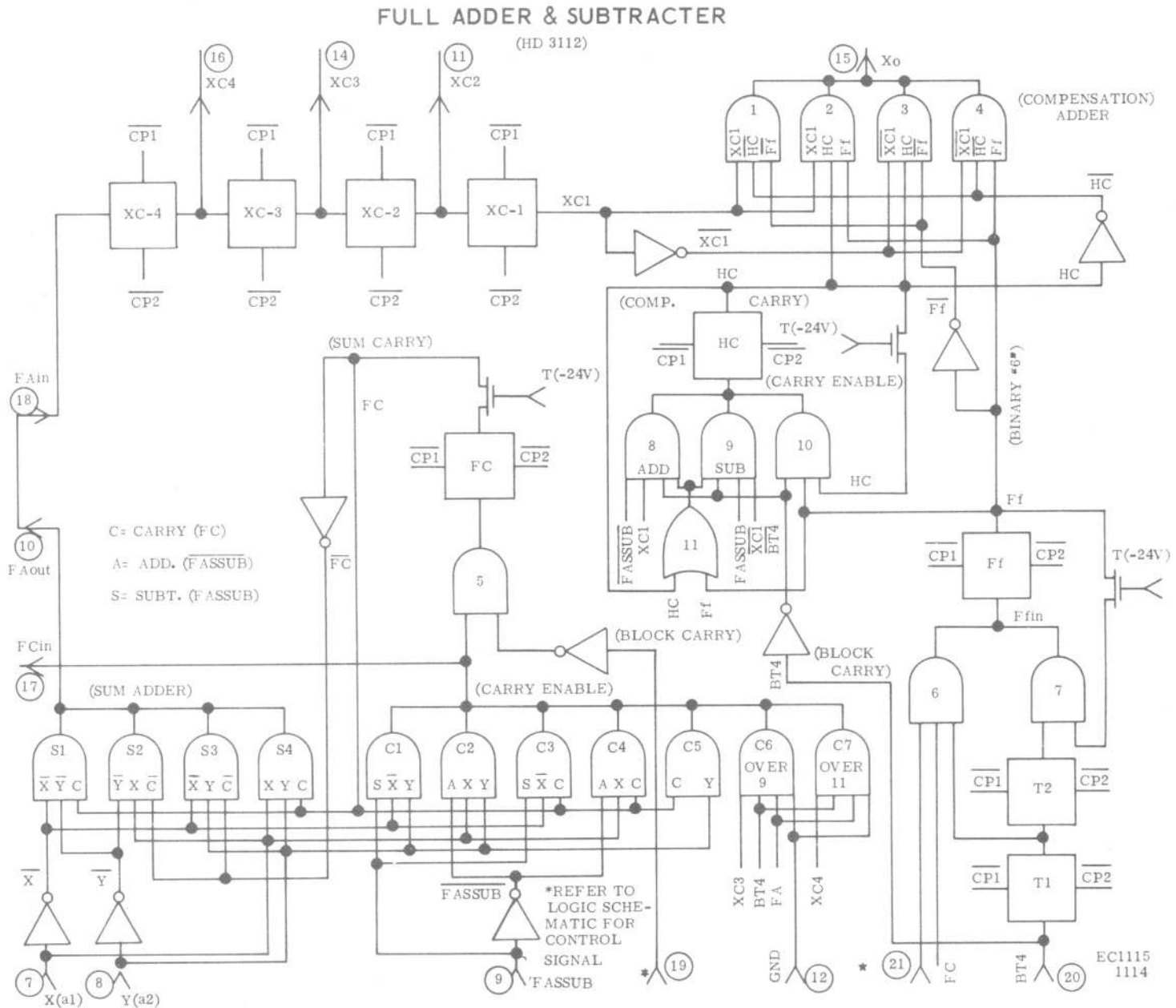
AT BT4. (NOTE: CARRY CANNOT BE ENABLED AT BT4 TIME.)

1115 ELECTRONIC CALCULATOR

LOGIC ELEMENTS

7. HD 3112 (Delayed Full Adder)

This IC is a Medium Scale Integrated Circuit (MSI) and performs as a series delayed Full Adder/Subtractor. Figure 3-8 shows the HD 3112 IC as it is used in the EC 1115 machine. (FAS Add and Subtract Truth Tables are illustrated on page 3-4.)



HD 3112

FIGURE 3-8

1115 ELECTRONIC CALCULATOR

LOGIC ELEMENTS

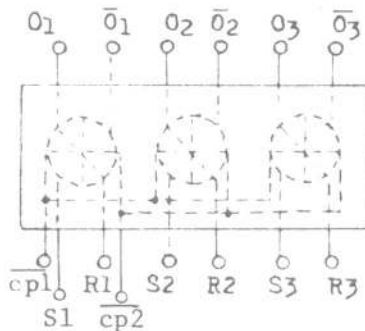
8. HD 3115 (RSS Flip-Flop)

This MOS IC contains 3 RSS type flip-flops so designated because of the set-reset control logic which acts in the following manner.

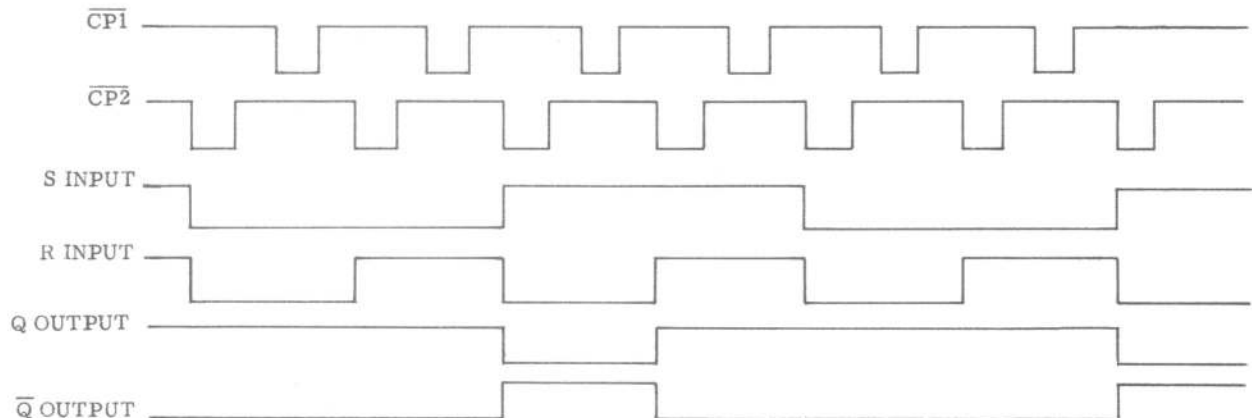
- (1) With a false input to the set and reset inputs, the output of the FF does not change when triggered.
- (2) With a false input to the set input and a true to the reset input, the FF will transition to the reset (true) condition when triggered.
- (3) With a true to the set input and a false to the reset input, the FF will transition to the set (true) condition when triggered.
- (4) With a true at both the set and reset inputs, the FF will set if it was reset, but it does not toggle under this condition.

The IC is shown in the diagram (Figure 3-9) below, along with its truth table.

logic table for R-S-S
flip-flop



INPUT		SET SIDE OUTPUT
S	R	Q
0	0	Qn (NO CHANGE)
0	1	0
1	0	1
1	1	1



HD 3115

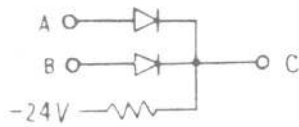
FIGURE 3-9

1115 ELECTRONIC CALCULATOR

LOGIC ELEMENTS

9. OR GATE

OR gates in this machine are composed of discrete components (diodes) arranged as shown in the illustration below (Figure 3-10). (NOTE: Diode packs (HD9001) containing 4 diodes are also used.)



OR GATE

A	B	C
0	0	0
0	1	1
1	0	1
1	1	1

"OR" TRUTH TABLE

FIGURE 3-10

1115 ELECTRONIC CALCULATOR

SECTION 4

FUNCTIONAL DESCRIPTION

SECTION CONTENTS

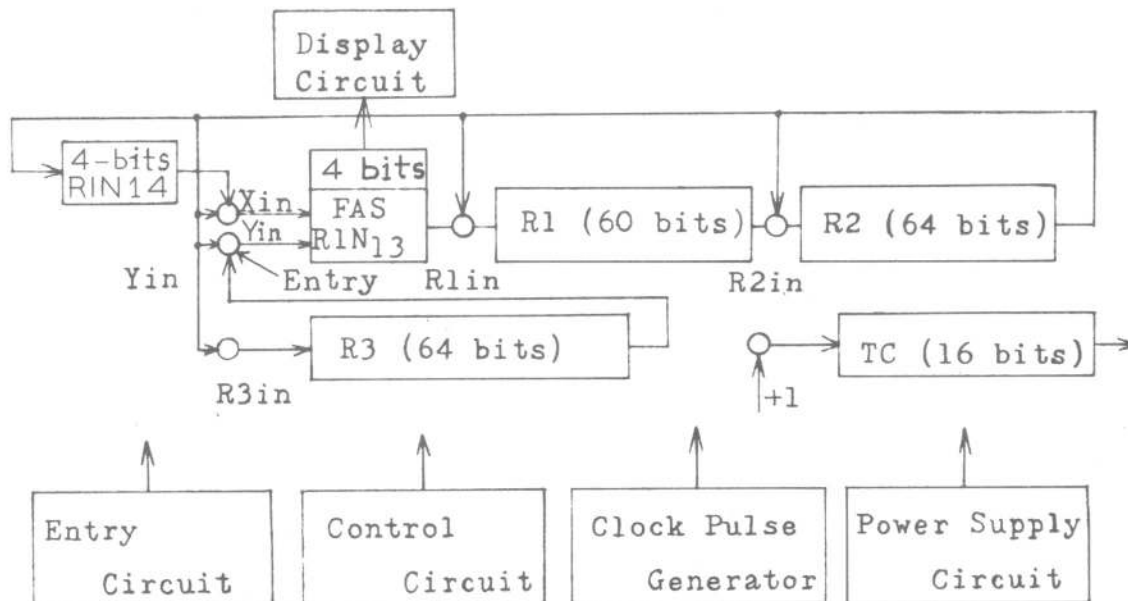
	PAGE
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B. OPERATION OF EACH REGISTER	4-1
REGISTER CONTENTS	4-2
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OPERATION OF TC COUNTER	4-4
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Add or Subtract	4-9
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Divide	4-10
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AUTO CLEAR	4-26

1115 ELECTRONIC CALCULATOR

FUNCTIONAL DESCRIPTION

A. GENERAL

In Figure 4-1 is shown a block diagram of the 1115 Electronic Calculator indicating the data flow through the registers. A brief explanation of the block diagram and associated control circuits is included here to aid in understanding the operation of the machine.



1115 BLOCK DIAGRAM

FIGURE 4-1

FAS: Full Adder/Subtractor (includes R1N13 consisting of 4-Bits).

R1N14: 4-Bits of R1 Register used only in a left shift operation.

R2: Entry input and output (answer). Also used in series with R1 for dynamic data flow and during calculation to develop the answer in conjunction with the other two registers (R1 & R3) and FAS. (64 bit dynamic shift register.)

R3: Factor Register (64 bit dynamic shift register).

TC: Counter (16 bit static shift register).

B. OPERATION OF EACH REGISTER

Each register stores data in a unidirectional shift flow. That is, data flow is dynamic and serial in the form of binary coded decimal (BCD) information. Data is organized into Word times, Digit times, and Bit times under control of the clock pulses: CP1 CP1. CP2, BT4CP1, WTCPI, and WT2CP1.

1115 ELECTRONIC CALCULATOR

FUNCTIONAL DESCRIPTION

B. OPERATION OF EACH REGISTER (Cont.)

Entry data and the result (output) is retained in R2 and the output data from R2 is gated into the input of R2 to form a loop. At the same time that R2 data is re-circulated into its own input gate, it is parallel shifted into the Full Adder and Subtractor (FAS). Then the BCD data output from FAS is gated into a decoder circuit to the Indicator Nixie Tubes for display. During the time R2 data is being displayed via the output from FAS, the data loop between FAS and register R1 is open and the contents of FAS and R1 are eliminated. However, when the machine is in a calculating operation, the output of R1 is connected to the input of R2 to form a double length register of 32 digits (128) bits. (Note: R1N14 is used only during a left shift, therefore, its output is open.)

1. REGISTER CONTENTS

In this machine, a decimal point counter and sign flip-flop are not used. Instead, the decimal point and sign information are stored within specific positions in the register. That is, each register consists of 64 bits (16 digits) and registers R2 and R3 are divided into segments having 56 bits, 3 bits, and 5 bits. The portion of the register having 56 bits is used for retaining the arithmetic data. The next portion having 3 bits is used for retaining the sign data; and the portion having 5 bits is used for retaining the decimal point data. The relative position of the 3 segments of the register is shown in Figure 4-2. Starting at the right end of the register each segment is explained as follows:

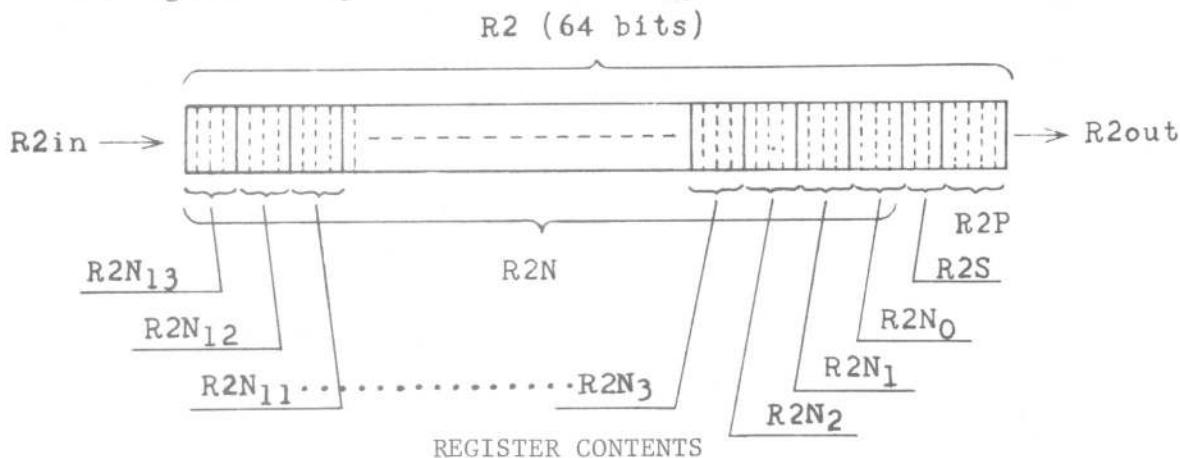


FIGURE 4-2

- R2P (5 bits): Contains information defining the decimal point position of the number to be displayed.
- R2S (3 bits): Contains the sign data which is defined as "000" for positive and "100" for negative.
- R2N (56 bits): Contains the binary coded decimal (BCD) information representing the arithmetic data.
- R2N0 (4 bits): Used when calculating a Round Off.
- R2N-1 to N-12: The contents in this position represents the 12 digits to be displayed.
- R2N-13: The 4 bits in this position are used in the dynamic data loop and also to detect an overflow condition.

1115 ELECTRONIC CALCULATOR

FUNCTIONAL DESCRIPTION

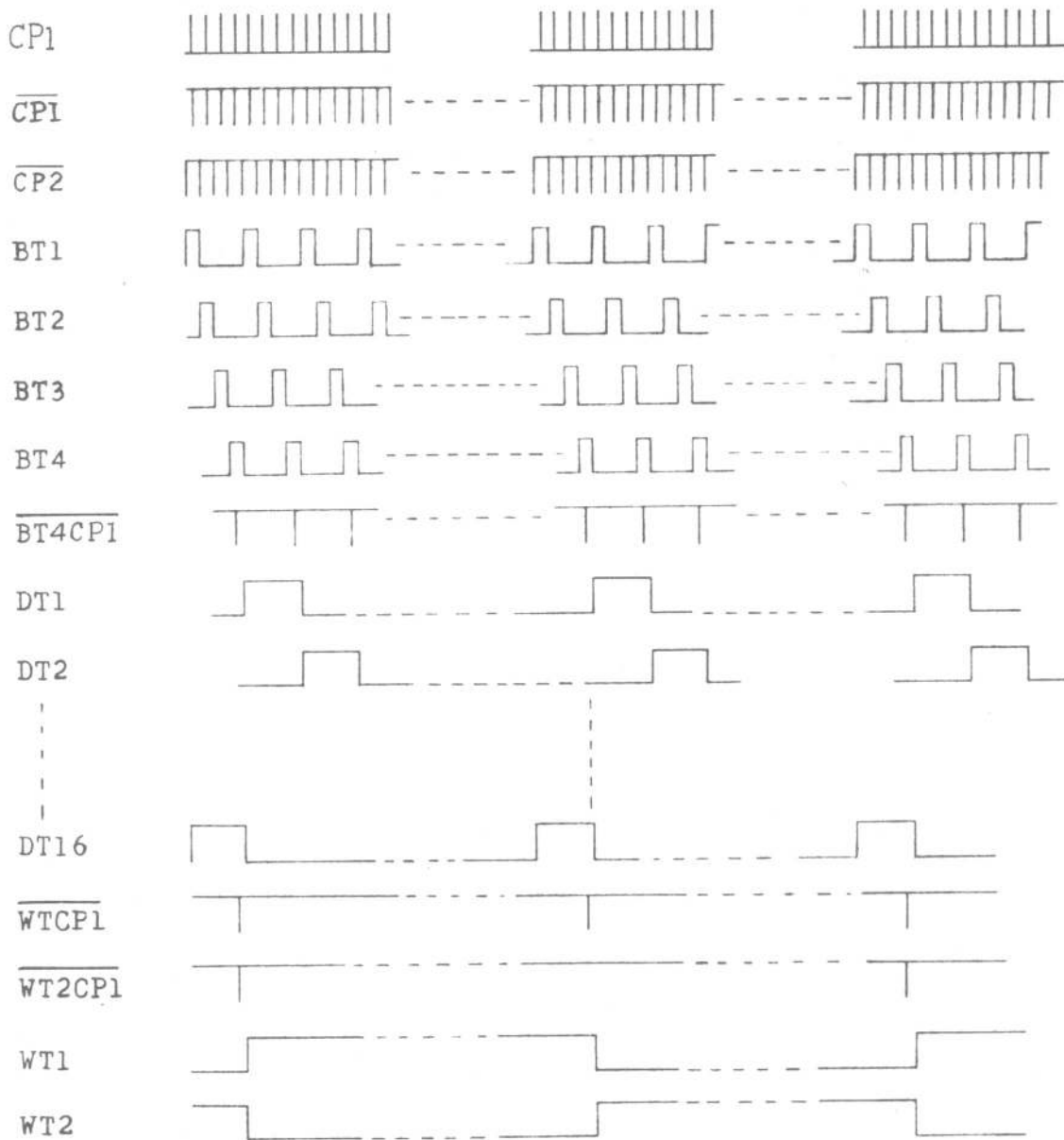
2. SHIFT PULSE AND TIMING

In this machine, the following shift pulses and timing pulses (Figure 4-3) are used.

Timing Pulse: WT1, WT2, DT1 through DT16, and BT1 through BT4.

Clock Pulses: $\overline{CP1}$, $\overline{CP2}$, $\overline{BT4CP1}$, $\overline{WTCP1}$, $\overline{WT2CP1}$, and CP1.

NOTE: WT1+WT2 is equal to one word time and there are 128 shift pulses generated during each word time. Each shift pulse corresponds to one bit time in the register.



TIMING WAVEFORMS

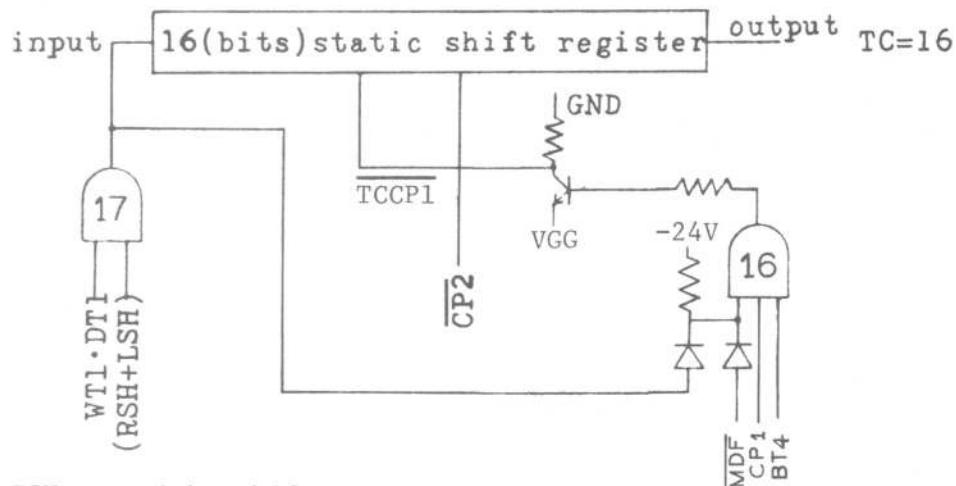
FIGURE 4-3

1115 ELECTRONIC CALCULATOR

FUNCTIONAL DESCRIPTION

3. OPERATION OF TC COUNTER

The TC Counter is a 16-bit counter (corresponding to the information in one register) used for controlling the shifting of data during a Mult or Divide operation. For example, when the MDF FF is set indicating a Mult or Divide operation the right or left shift enabling logic to Gate 17 will cause an input pulse to the TC counter each $WT1.DT1$ time. Also, each time Gate 17 is enabled, it enables Gate 16 and the TCCP1 shift pulse will increment the TC Counter. When a Mult or Divide operation is not being performed, Gate 17 is inhibited and Gate 16 is enabled via the signal MDF, therefore, the TC Counter will be cleared.



RSH : right shift

LSH : left shift

MDF : output in multiplication and division

TC COUNTER

FIGURE 4-4

C. BASIC MACHINE OPERATION

A general description of the EC 1115 operation covering the: 3-Register Calculation, Display Circuits, Input Circuits, Power Supply and Auto Clear Circuit, and Master Oscillator and Clock Pulse Generator is included in this section of the manual.

Data flow in the three registers of the 1115 is serial and dynamic in step with the four bit times, BT1, BT2, BT3, and BT4 developed in each digit time, and under control of the clock pulses, CP1, CP2, BT4CP1, WTCP1, and WT2CP1. A complete data loop via R1 and R2 consists of 32 digits (128 bit pulses) under control of the Clock Pulse Generator.

1115 ELECTRONIC CALCULATOR

FUNCTIONAL DESCRIPTION

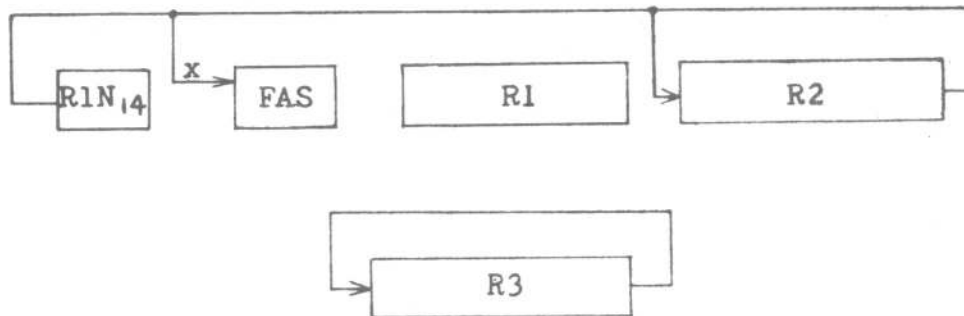
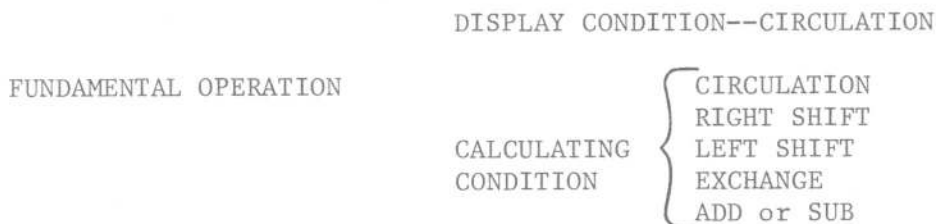
C. BASIC MACHINE OPERATION (Cont.)

The logic for the 1115 is similar to that of the 1114 but does not include the "Underflow" system, or the "Memory" storage. It does however, operate with a 3-register system, a Roundoff Feature, an Overflow system, a Fixed Decimal Point output controlled by a Decimal Switch, a Floating Point input system, and a Constant Multiplier or Divisor feature.

1. DEVELOPMENT OF THE FUNDAMENTAL OPERATION

The fundamental operation of the 1115 concerns the data flow within the registers during the time of Display and during the time the machine is calculating. Both of these conditions will be explained in the illustrations and discussion that follow.

The fundamental operation of the 1115 can be divided as follows:



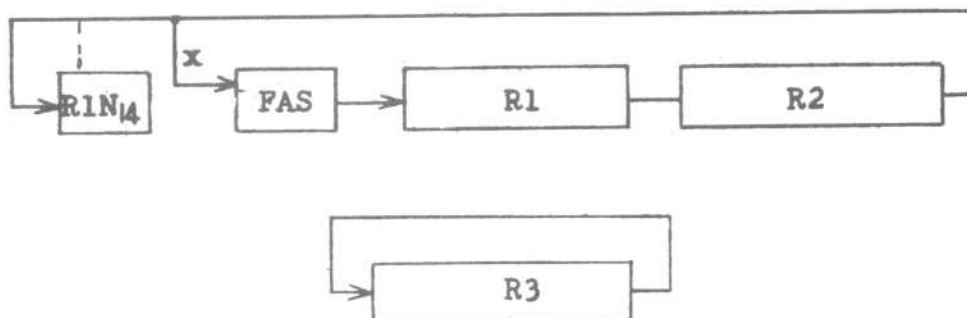
DISPLAY CONDITION--CIRCULATION

FIGURE 4-5

a. DISPLAY CONDITION--CIRCULATION. In a display condition without key operation (machine idling), the data movement throughout the 3-registers is as shown in Figure 4-5. Output data from register R2 re-enters the input to R2 and at the same time it enters the "X" input to the full adder and subtractor (FAS). The X₀ output between FAS and the R1 register is open and the FAS X₀ output data is destroyed. The display outputs from FAS (FA, XC2, XC3, and XC4), however, are used to feed the display decoder circuits and therefore, R2N data is displayed digit by digit as it enters FAS. The contents of R2 and R3 are retained in their closed loops, making two complete circulations each word time.

1115 ELECTRONIC CALCULATOR

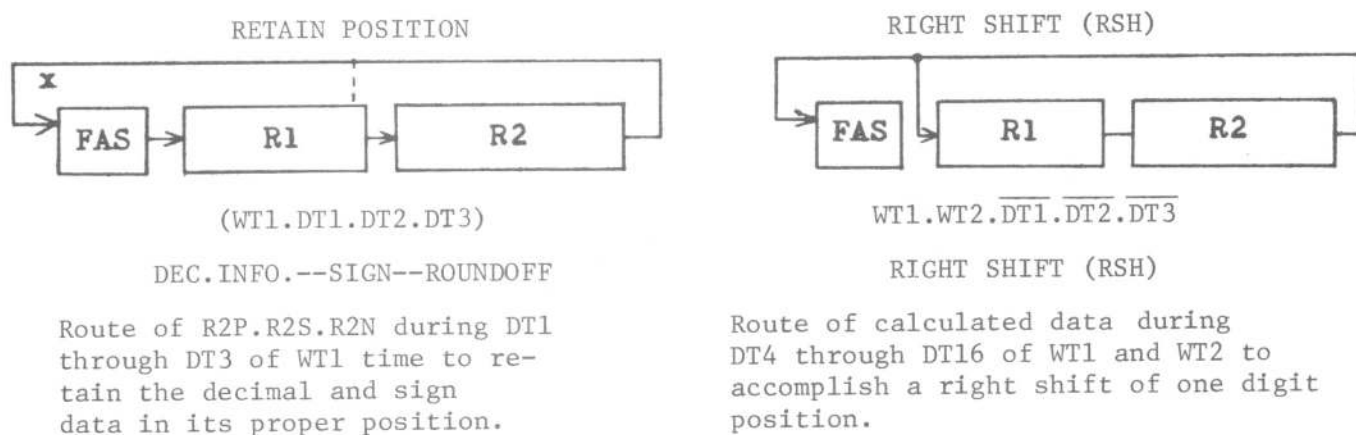
FUNCTIONAL DESCRIPTION



CALCULATING CONDITION --CIRCULATION

FIGURE 4-6

b. CALCULATING CONDITION--CIRCULATION. In a calculating condition, the circulation when not doing a right or left shift, exchange, or add or subtract function is as shown in Figure 4-6. During this circulation, the X_o output between FAS and R1 is closed, allowing data flow through R1, R2, and FAS in a circulatory loop. The contents of register R3 are retained via the closed loop and two circulations of R3 are completed during one circulation of R1-R2-FAS. During the time R1-R2-FAS is circulating, the contents are being sensed in order to determine the next step of the function being performed.



RIGHT SHIFT

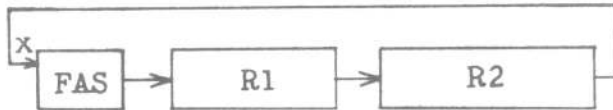
FIGURE 4-7

c. RIGHT SHIFT (RSH). As mentioned previously, register R2 is divided into data segments designated R2N, R2P, and R2S with each segment retaining calculated data, decimal point data, and sign data respectively. In a right shift operation, the calculated data is shifted one digit position to the right. Since R1 is used for retaining the entire calculated data, the contents of R1 and R2N must be shifted at the same time. On the other hand, since the contents of R2P and R2S must be retained without shifting data positions, the data in these two segments is routed in a different circulatory loop than the calculated data. The routing and timing for the two conditions is shown in Figure 4-7.

1115 ELECTRONIC CALCULATOR

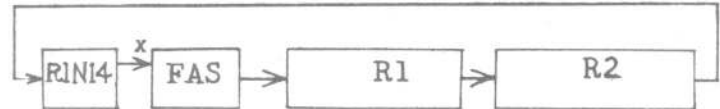
FUNCTIONAL DESCRIPTION

RETAIN POSITION



Route of R2P, R2S, R2N during DT1 through DT3 of WT1 time to retain the decimal and sign data in its proper position.

LEFT SHIFT

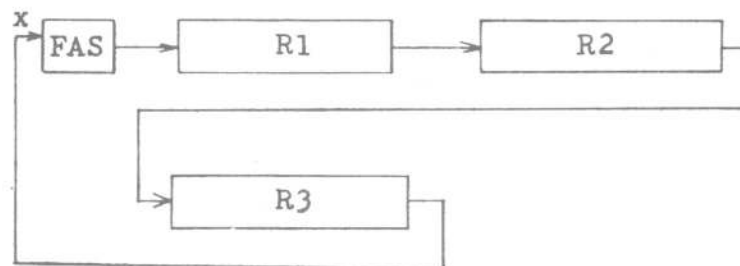


Route of calculated data during DT4 through DT16 of WT1 and WT2 to accomplish a left shift of one digit position.

LEFT SHIFT

FIGURE 4-8

d. LEFT SHIFT (LSH). In a left shift operation, the contents in R1 and R2N are shifted one digit position to the left, but the contents in R2S, R2P, and R2N-0 are retained in their respective positions. That is during DT1 through DT3 time, the contents of R2P, R2S, and R2N-0 are circulated in the data loop via the normal idle shift route. Then, during DT4 through DT16 time, of WT1 and WT2, the contents of R1 and R2N are routed into R1N-14 to cause a left shift. The routing and timing for the two conditions is shown in Figure 4-8.



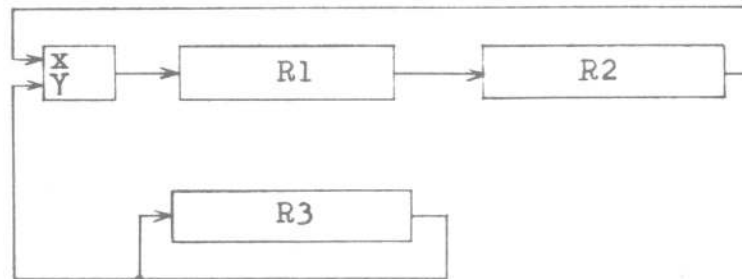
EXCHANGE

FIGURE 4-9

e. EXCHANGE (CHG). In an exchange operation, the contents of R2 (R2N, R2P, and R2S) are exchanged with the contents of R3 (R3N, R3P, and R3S) during WT1 time (1st half of the word time). The routing of the registers is shown in Figure 4-9.

1115 ELECTRONIC CALCULATOR

FUNCTIONAL DESCRIPTION

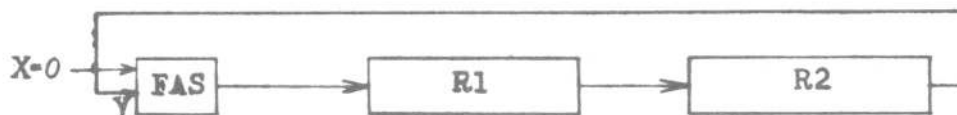


The Timing of Y-input	Operation	Calculation
DT3~DT16 of WT1	$R2N + R3N$	Addition & subtraction
DT3~DT16 of WT2	$R1 + R3N$	Multiplication & division

ADD OR SUBTRACT

FIGURE 4-10

f. ADD AND SUBTRACT (AOS). In an Add or Subtract operation, the contents of $R2N$ and $R3N$, or $R1$ and $R3N$ are gated into the full adder and subtractor FAS and the sum or difference of the two factors is developed. The composition of registers in $R1 + R3N$ and $R2N + R3N$ is the same, but the two calculations are distinguished from each other by the timing into the "Y" input of FAS. For example, as shown in the chart below Figure 4-10, the timing of the "Y" input to FAS for an Add or Subtract operation of $R2N + R3N$ occurs in DT3 through DT16 of WT1. The timing of the "Y" input for a Mult or Divide operation of $R1 + R3N$ occurs in DT3 through DT16 of WT2.



DT3 through DT16 of WT1

CHANGE TO AND FROM COMPLEMENT

FIGURE 4-11

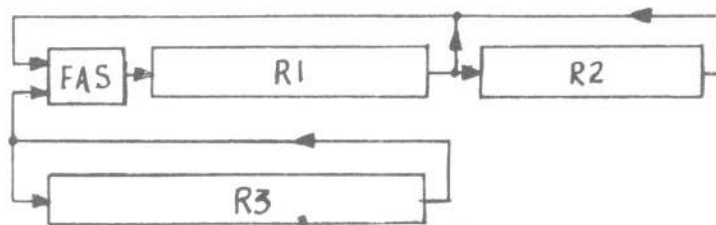
g. COMPLEMENT (CWF). In addition and subtraction, the contents of $R2N$ circulates via the "Y" input to FAS during one word time after the Add or Subtract function. Then, if the result (output) of a subtract operation is a complement, another subtract command is given to FAS and the contents in $R2N$ is subtracted from "0" changing the complement to a positive number. The routing of the CWF operation is shown in Figure 4-11.

1115 ELECTRONIC CALCULATOR

FUNCTIONAL DESCRIPTION

2. THREE REGISTER OPERATION

As shown in Figure 4-12, three registers designated: R1, R2, and R3 are used in conjunction with the Full Adder and Subtractor (FAS) to perform the arithmetic calculations. The three register system is explained briefly as follows:

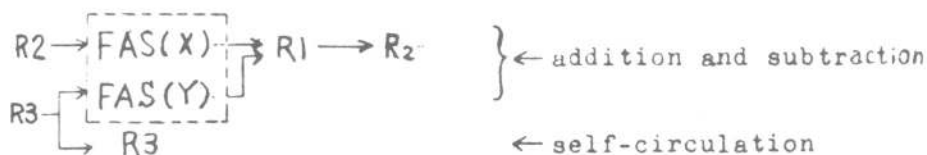


FAS: FULL ADDER AND SUBTRACTER

FIGURE 4-12

a. ENTRY DATA is gated into R2 and the previous answer or data already in R2 is shifted into R3. As data circulates through the route of R1-R2-FAS-R1, the contents of R3 make two passes through its data loop.

b. ADD OR SUBTRACT. In an Add or Subtract operation, the arithmetic calculation is performed between the contents of R2 and R3 as shown in the data flow diagram, Figure 4-13.



ADD OR SUBTRACT

FIGURE 4-13

c. MULT. In a Mult operation, R2 contains the multiplier and R3 contains the multiplicand. A series of repeat "Add" operations are carried out for each digit, and the partial product is gated into R1. As each repeat "Add" cycle is completed for each digit, a control number in R2 is decremented by "1" until it reaches "0", and then a right shift occurs to bring the next control digit into position for the next series of repeat "Add" cycles. As the product is developed (partial product) it is fed into R1 and R2 in series. At the end of the mult operation, the final product is in R2.

1115 ELECTRONIC CALCULATOR

FUNCTIONAL DESCRIPTION

d. **DIVIDE.** In a Division operation, R2 contains the dividend and R3 contains the divisor. A series of repeat subtractions ($R1 - R3$) is performed until an overdraft occurs. As each subtraction is performed, R2N1 is incremented. The overdraft is then restored, R2N1 is decremented, and the data in R1 and R2 is shifted left one digit position. This sequence of: repeat subtraction, increment R2N1, restore overdraft, decrement R2N1, shift R1 and R2 left is performed as part of the answer development. The successful subtractions are incremented in R2N1 each time until an overdraft occurs, signaling the start of the "restore overdraft", decrement R2N1, left shift cycle. This action will continue until the quotient in R2 has shifted left so that its MSD is in the R2N13 position. At this time, the final decimal alignment of the quotient begins with R2 shifting right until the number of decimal places in the quotient is equal to the setting of the decimal switch.

e. **3-REGISTER CALCULATION USING EXAMPLES.** To aid in understanding the machine operation, a brief description of an "Add" operation and a "Mult" operation is included here.

(1) Addition (Decimal Switch on "5")

Example: $1.23 + 45.6 = 46.83000$

(a) Entry of 1.23

1. Depression of the digit key "1" causes the contents of the R2 register to be shifted to R3 and a binary coded decimal 1 (0001) to be entered into the LSD position of R2 (R2N1).
2. Depression of the decimal point key causes the decimal point control flip-flop (POT) to set.
3. Depression of the digit key "2" causes the contents of register R2 to shift left one digit position while the new entry "2" is shifted into the LSD position of R2. Also, at the time the "2" is being entered, a "1" is added to the decimal point information in R2P.
4. Depression of the digit key "3" causes the same action as described for the digit key "2".

At the end of the entry of 1.23, the contents of the registers appears as shown in Figure 4-14.

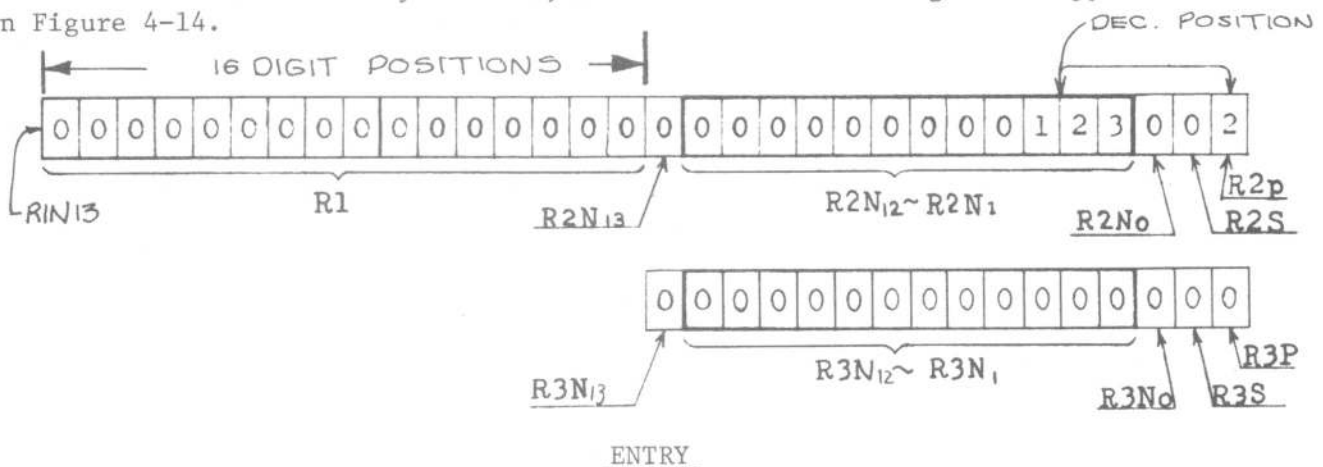


FIGURE 4-14

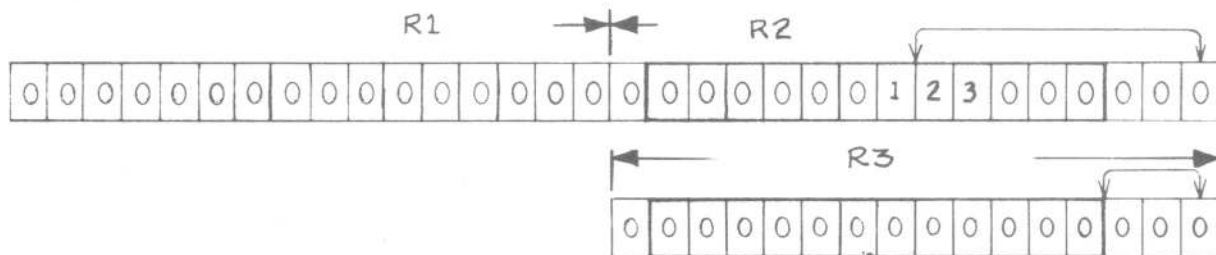
1115 ELECTRONIC CALCULATOR

FUNCTIONAL DESCRIPTION

(b) Function Key Operation (+=). Depressing the Plus Equal key causes the following actions:

1. Alignment. The number of decimal point digits of the contents "1.23" of R2 (retained in R2P) is compared with the decimal preset number "5". Since the contents of R2P are smaller than the decimal point number, the contents of R2N are shifted to the left a number of places equal to the difference between R2P and the decimal preset number and R2P is incremented by "1" for each left shift.

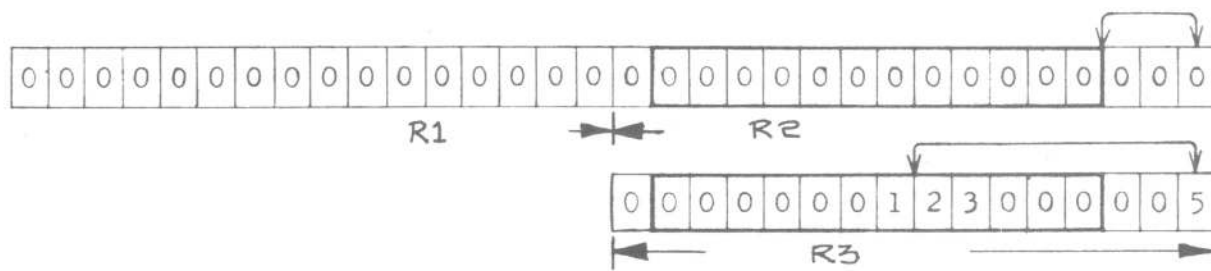
In this example, after the above alignment operation, the contents of R2N becomes: 1.23000 and the contents of R2P becomes: "5". The contents of the registers are as shown in Figure 4-15.



ALIGNMENT

FIGURE 4-15

2. Exchange. Depression of the Plus Equal key causes the R2 contents "1.23000" to be exchanged with the contents of R3 and the register appears as indicated in Figure 4-16.



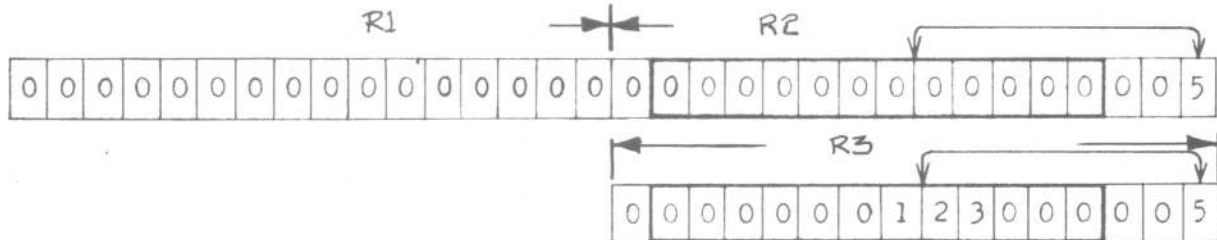
EXCHANGE

FIGURE 4-16

1115 ELECTRONIC CALCULATOR

FUNCTIONAL DESCRIPTION

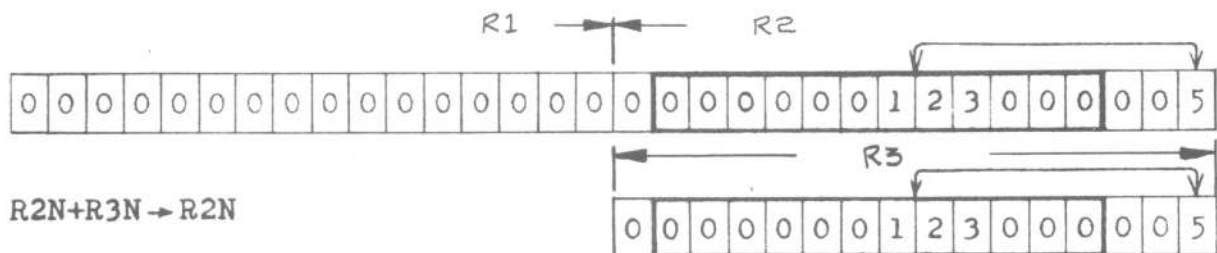
3. Alignment. After the exchange operation takes place as described in item 2, another decimal alignment takes place the same as described in item 1. Then, as shown in Figure 4-17, the contents of R2 becomes "0.00000" by shifting five digit positions to the left; and the contents of R2P becomes "5" as a result of the five left shifts.



ALIGNMENT

FIGURE 4-17

4. Addition. The contents of R2N "0.00000" and the contents of R3N "1.23000" are simultaneously gated into the Adder (FAS) and the added output is gated into R2N. The contents of R3N are retained in R3N. As a result, the number 1.23000 is retained in R2 and R3 as shown in Figure 4-18.



ADDITION

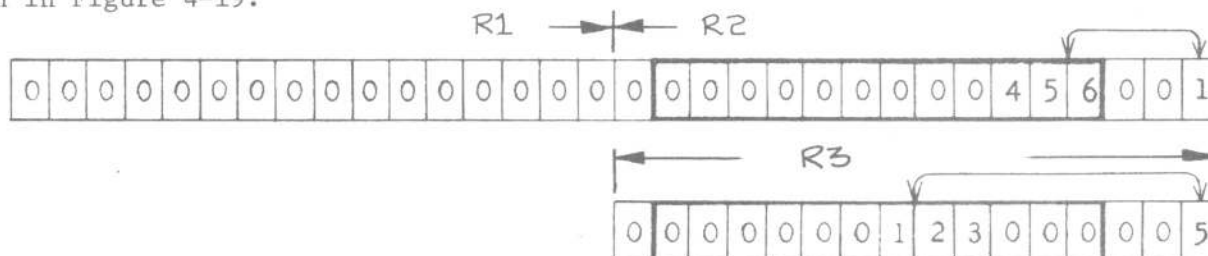
FIGURE 4-18

5. Round Off. A round off, if desired, is done during the final steps of the calculation. For example, if the R/O key is latched down and the contents of R2N-0 are larger than "4", a "1" is added to the LSD of the number displayed in R2. The R2N-0 contents are then cleared in readiness for the next calculation.

1115 ELECTRONIC CALCULATOR

FUNCTIONAL DESCRIPTION

(c) Entry of 45.6. Entry of the digits 45.6 is accomplished in the same manner as described for the entry of 1.23. The contents of the register after entry are as shown in Figure 4-19.



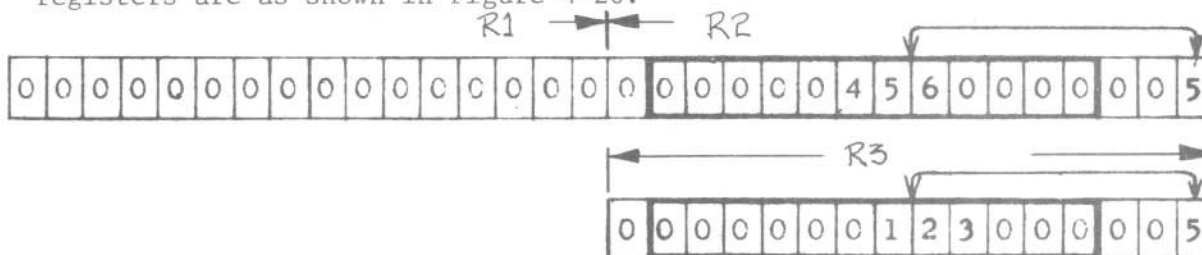
ENTRY

FIGURE 4-19

(d) Function Key Operation (+=). Depressing the Plus Equal key causes the following actions to occur.

1. Alignment. The number of decimal point digits of the contents 45.6 of R2 (contained in R2P) is compared with the decimal preset number "5". Since the contents of R2P are smaller than the decimal point number, the contents of R2N are shifted to the left a number of places equal to the difference between R2P and the decimal preset number, and R2P is incremented by "1" for each left shift.

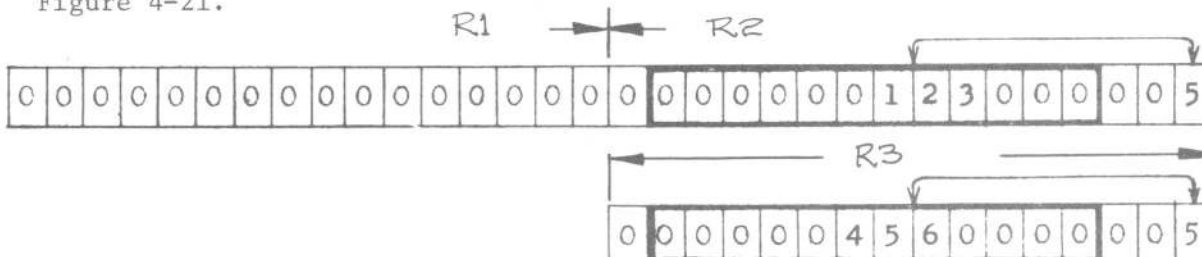
In this example, after the alignment takes place, the contents of R2N becomes: 45.60000 and the contents of R2P becomes: "5". The contents of the registers are as shown in Figure 4-20.



ALIGNMENT

FIGURE 4-20

2. Exchange. Depression of the Plus Equal key causes the R2 contents 45.60000 to be exchanged with the contents of R3 and the registers now appear as shown in Figure 4-21.



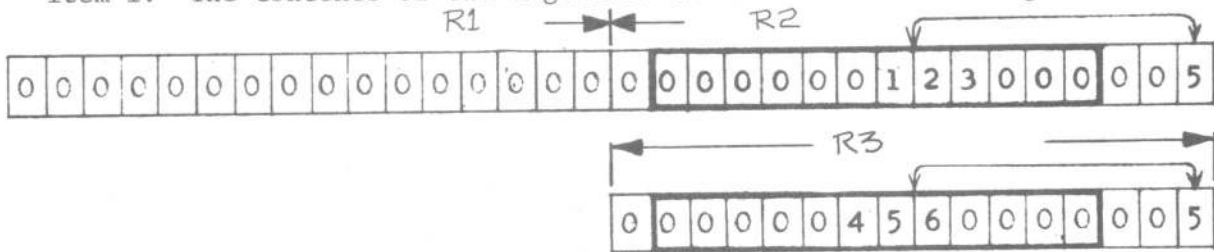
EXCHANGE

FIGURE 4-21

1115 ELECTRONIC CALCULATOR

FUNCTIONAL DESCRIPTION

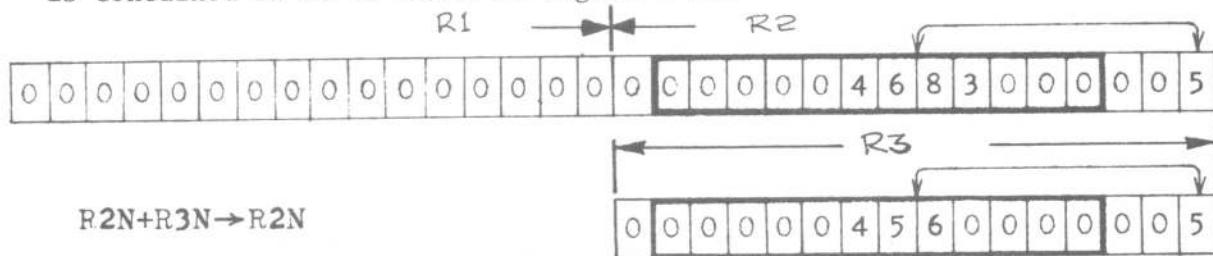
3. Alignment. After the exchange takes place as described in item 2, if a decimal point alignment is necessary it occurs in the same manner as described in item 1. The contents of the registers are now as shown in Figure 4-22.



ALIGNMENT

FIGURE 4-22

4. Addition. The contents of R2N "1.23000" and the contents of R3N "45.60000" are simultaneously gated into the Adder (FAS) and the added output is gated into R2N while the contents of R3N are retained in R3N. As a result of the addition, the number "46.83000" is contained in R2 and the number "45.60000" is contained in R3 as shown in Figure 4-23.



R2N+R3N→R2N

ADDITION

FIGURE 4-23

5. Round Off. A round off if desired, is done during the final steps of the calculation. For example, if the R/O key is latched down and the contents of R2N-0 are greater than "4", a "1" is added to the LSD of the number displayed in R2. The R2N-0 contents are then cleared in readiness for the next calculation.

(2) Multiplication (Decimal Switch on "2")

Example: $1.23 \times 4.56 = 5.60$

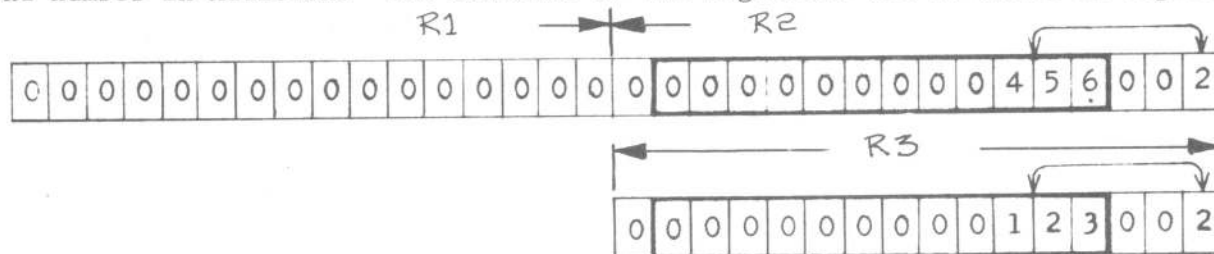
- (a) Entry of 1.23. Same as described for the Addition operation.

- (b) Function Key Operation (Mult key). The control flip-flop MLT1 is set for the purpose of retaining the Mult instruction during the mult operation.

1115 ELECTRONIC CALCULATOR

FUNCTIONAL DESCRIPTION

(c) Entry of 4.56. Entry of the second number "4.56" is the same as described for the second number in Addition. The contents of the registers are as shown in Figure 4-24.

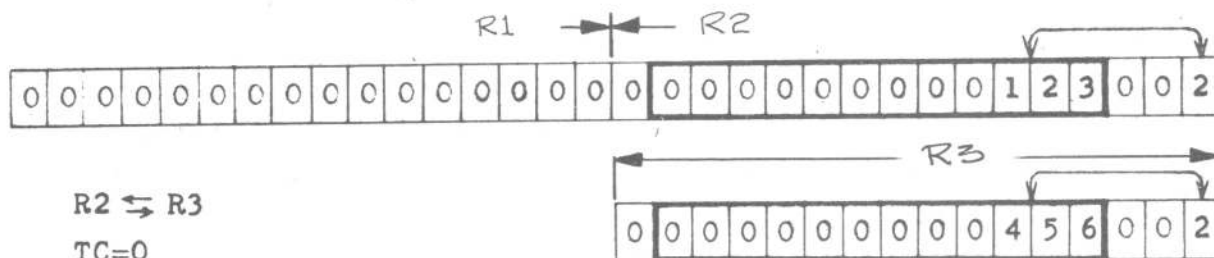


ENTRY

FIGURE 4-24

(d) Function Key Operation (+=). Depressing the Plus-Equal key causes the following actions to occur.

1. Exchange. The contents of R2 "4.56" are exchanged with the contents of R3 "1.23". The contents of the registers after the exchange are as shown in Figure 4-25.



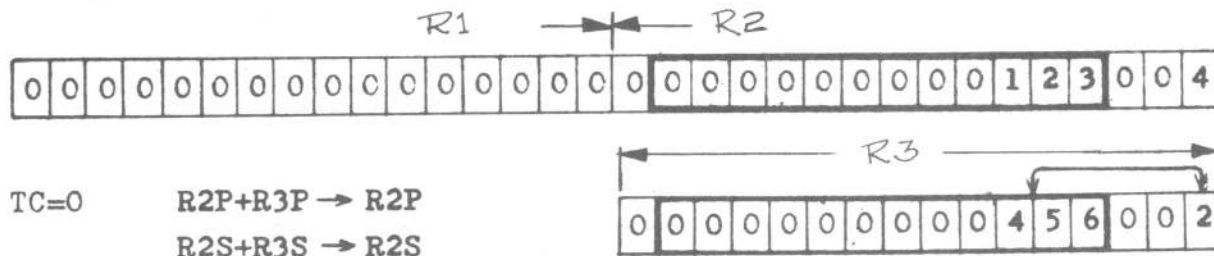
$R2 \leftrightarrow R3$

TC=0

EXCHANGE

FIGURE 4-25

2. Calculating the Decimal Digits and Sign of the Product. The contents of R2P (digit 2) and the contents of R3P (digit 2) are simultaneously gated into the Adder (FAS) and the added output is gated through R1 and into R2P while the contents of R3P are retained in R3P. The contents of R2P now contains a "4" which is the intermediate decimal position of the product. Also, the contents of R3S and R2S are added via FAS and their added output is gated through R1 and into R2S as the proper sign of the product. If the number in R2S is "000" after the addition, the sign is positive. If the number in R2S is "100" the sign is negative. The contents of the registers are as shown in Figure 4-26.



TC=0

$R2P + R3P \rightarrow R2P$

$R2S + R3S \rightarrow R2S$

DECIMAL & SIGN

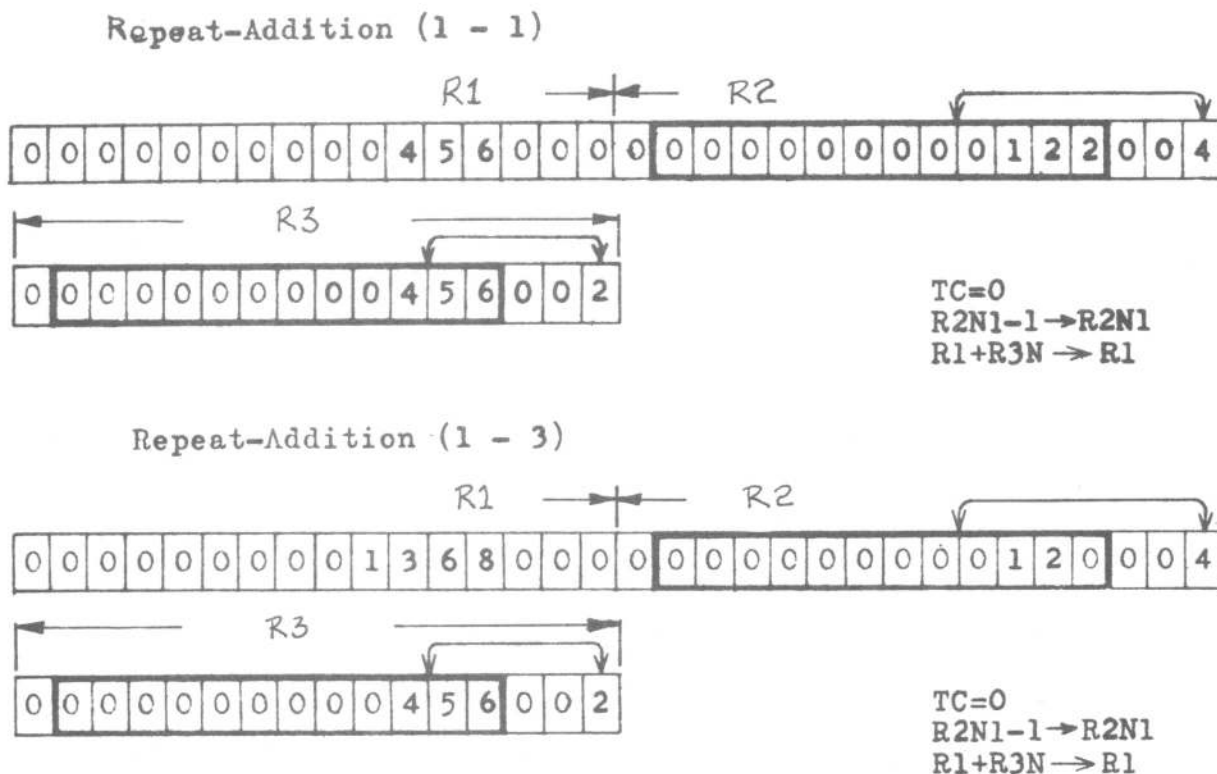
FIGURE 4-26

1115 ELECTRONIC CALCULATOR

FUNCTIONAL DESCRIPTION

- Repeat Addition (Mult). If the LSD of the Multiplier in R2N1 is not zero, then each subsequent data pass will add the Multiplicand in R3N to the contents of R1N, and subtract "1" from the LSD of R2N1 until it reaches zero. When the LSD in R2N1 reaches zero, the contents of R1N and R2N will be shifted right one digit position, and the TC counter will be incremented by "1" to keep count of the right shifts. This action continues for each LSD of the Multiplier until all the digits in the Multiplier have been counted to zero. When the TC counter equals 16 (TC=16) the answer will have been developed and shifted from R1N to R2N.

As a result of the Repeat Addition (Mult), the product "5.6088" is retained in register R2 and the multiplicand "4.56" is retained in R3. The series of Repeat Add cycles and right shifts are illustrated in the register diagrams, Figure 4-22.

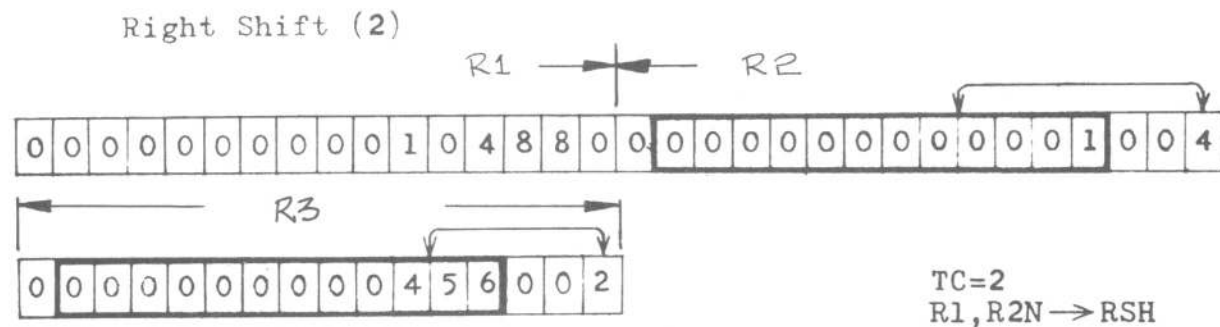
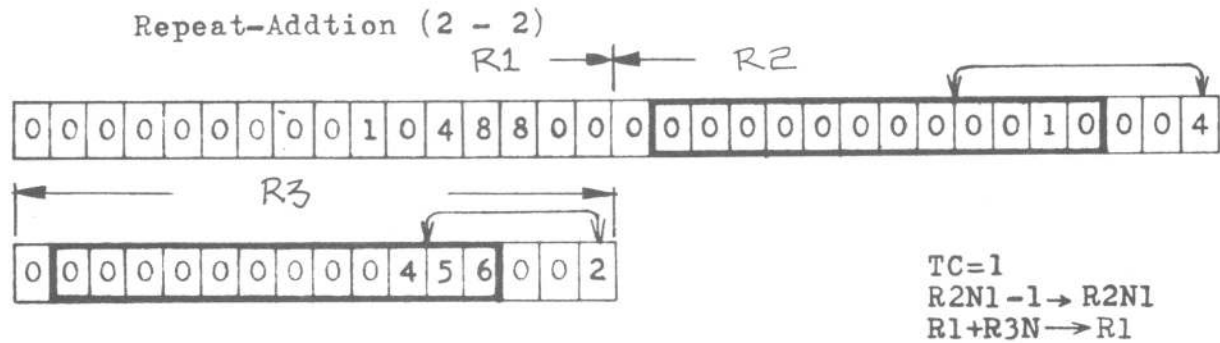
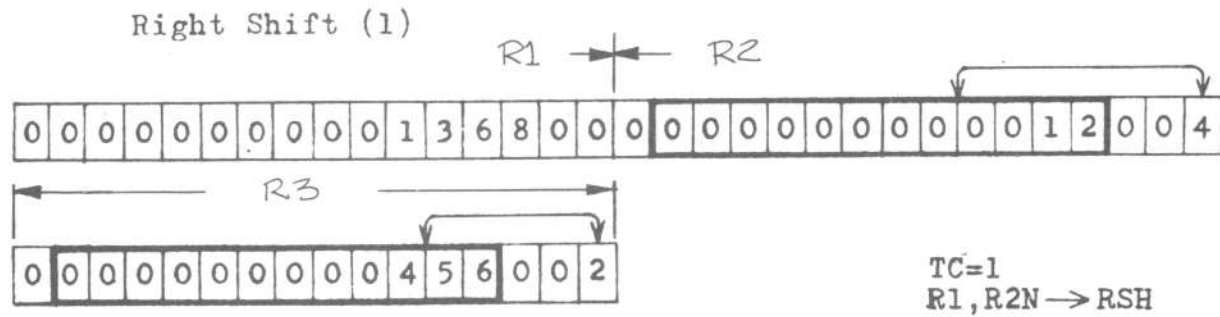


REPEAT ADD & RIGHT SHIFT
(Cont. on next page)

FIGURE 4-27

1115 ELECTRONIC CALCULATOR

FUNCTIONAL DESCRIPTION



REPEAT ADD & RIGHT SHIFT
(Cont. on next page)

FIGURE 4-27

1115 ELECTRONIC CALCULATOR

FUNCTIONAL DESCRIPTION

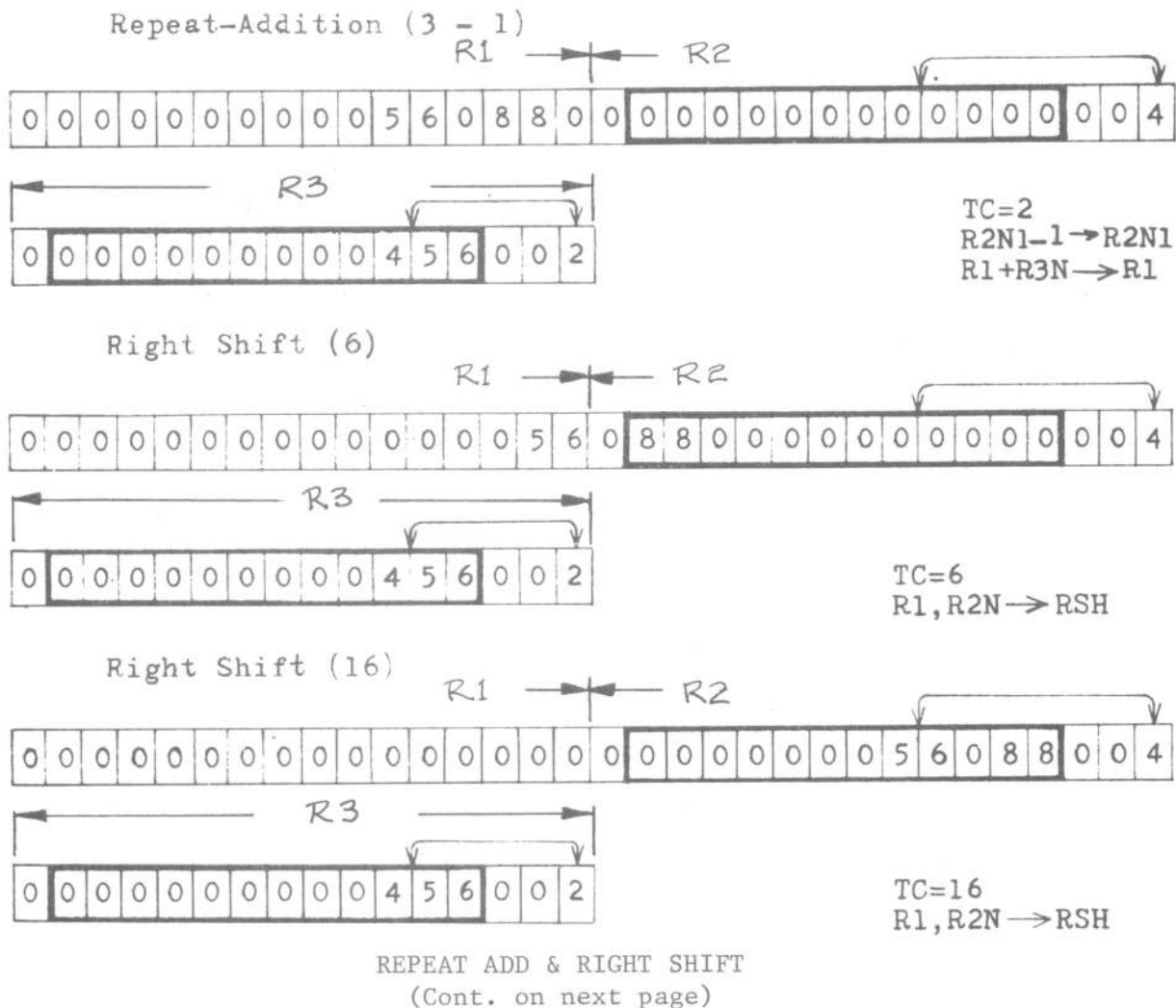


FIGURE 4-27

4. Alignment. The number of decimal digits of the product in R2P ("4" in this example) is compared with the decimal preset number "2" and if the number of decimals of the product is larger than the decimal preset number, the contents of R2N are shifted right a number of places equal to the difference. As each right shift occurs, a "1" is subtracted from R2P. The result of aligning the product to the position designated by the setting of the Decimal Switch is as shown in the register, Figure 4-28.

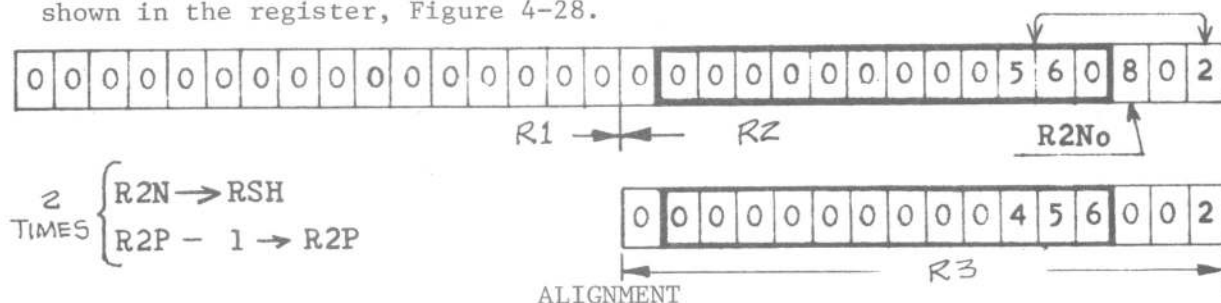
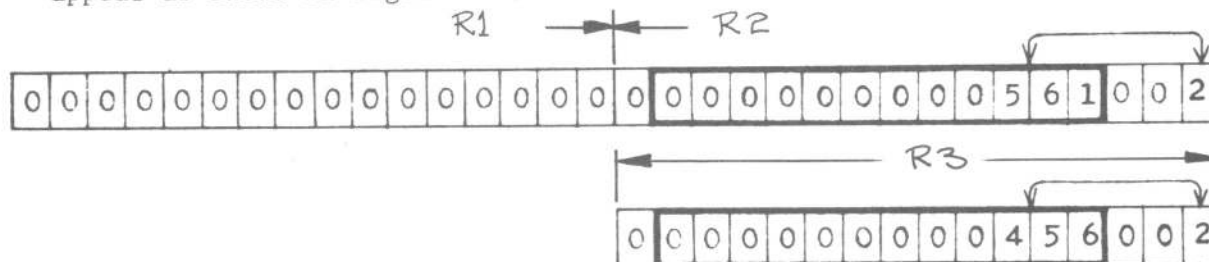


FIGURE 4-28

1115 ELECTRONIC CALCULATOR

FUNCTIONAL DESCRIPTION

5. Round Off. If the Round Off switch is latched down and the digit in R2N-0 is larger than "4", a "1" is added to the LSD in R2N. After the operation, the contents of R2N-0 are cleared. The contents of the registers after Round Off appear as shown in Figure 4-29



ROUND OFF

FIGURE 4-29

3. DISPLAY

The Indicator Circuit corresponding to the output device of a calculator consists of Indication Flip-Flops, a Logic Decoder, and Numeric and Decimal Point Indicator Drive circuits for the Anodes and Cathodes of the Indicator (Nixie) Tubes.

The Cathodes in each Indicator (Nixie) tube corresponds to the "0" through "9" digits, and the Decimal Point. Also, each tube has one Anode which is common to the Numeric and Decimal Point Cathodes. In order to fire a tube and display a particular digit (or decimal point), the Cathode associated with the digit or decimal point must be at the proper bias voltage with respect to the Anode voltage.

Decimal and numeric data is fed via the FAS outputs (FA, XC4, XC3, and XC2) to the Indicator flip-flops at the end of the digit times and is decoded via a diode decoder network. The 12 Indicator Tubes are fired sequentially in step with the digit times, starting with the #1 tube and Digit Time DT2. However, because of the arrangement of data in the R2 register: Sign, Decimal Point, Round Off, Numeric; with respect to the Digit Times (DT1 through DT16), the sequential timing occurs as indicated in the Display Timing Chart, Figure 4-30.

Displayed Contents	Timing	Figure to be Displayed
R2P	DT2	Decimal Point
R2N1	DT5	The 1st Figure (LSD)
R2N2	DT6	The 2nd Figure
thru		
R2N12	DT16	The 12th Figure (MSD)

DISPLAY TIMING

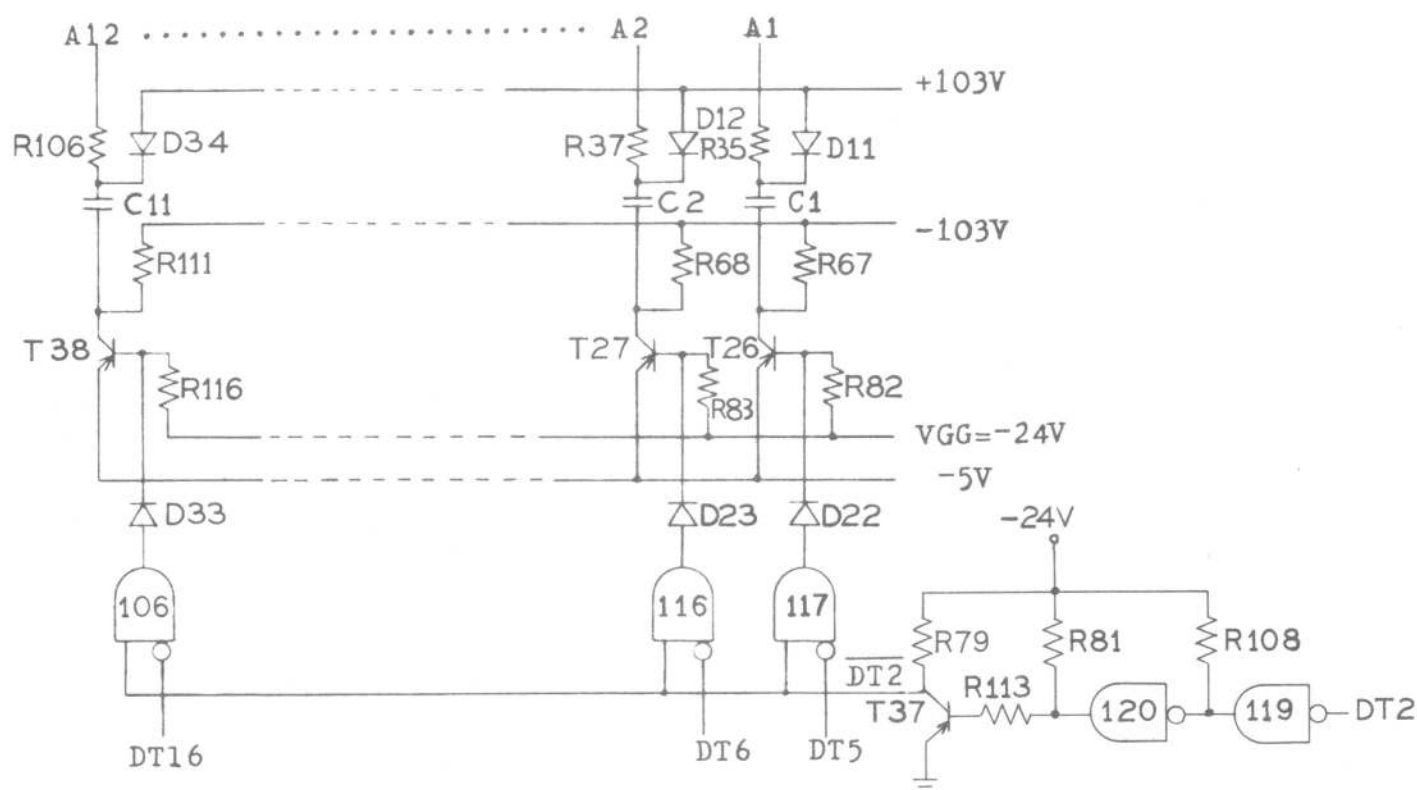
FIGURE 4-30

1115 ELECTRONIC CALCULATOR

FUNCTIONAL DESCRIPTION

a. ANODE CONTROL CIRCUIT

A positive potential of approximately 200 volts is supplied to the Anodes of the individual Indicator Tubes in step with the associated digit time signals via their respective control circuits. This high voltage potential is developed by charging the capacitors (C1 through C11) to approximately 206 volts. Then, when an anode control transistor (T26, T27, etc.) is turned on, its collector goes to approximately -5V and the capacitor connected to its collector feels a change of 98V ($-103V - 5V$) in the positive direction. This +98V change on the capacitor plate is added to the +103V charge on the other plate for a total output voltage of approximately 200V to the anode of the indicator tube being fired. The simplified schematic in Figure 4-31 illustrates the charging circuit described above.



ANODE CONTROL CIRCUIT

FIGURE 4-31

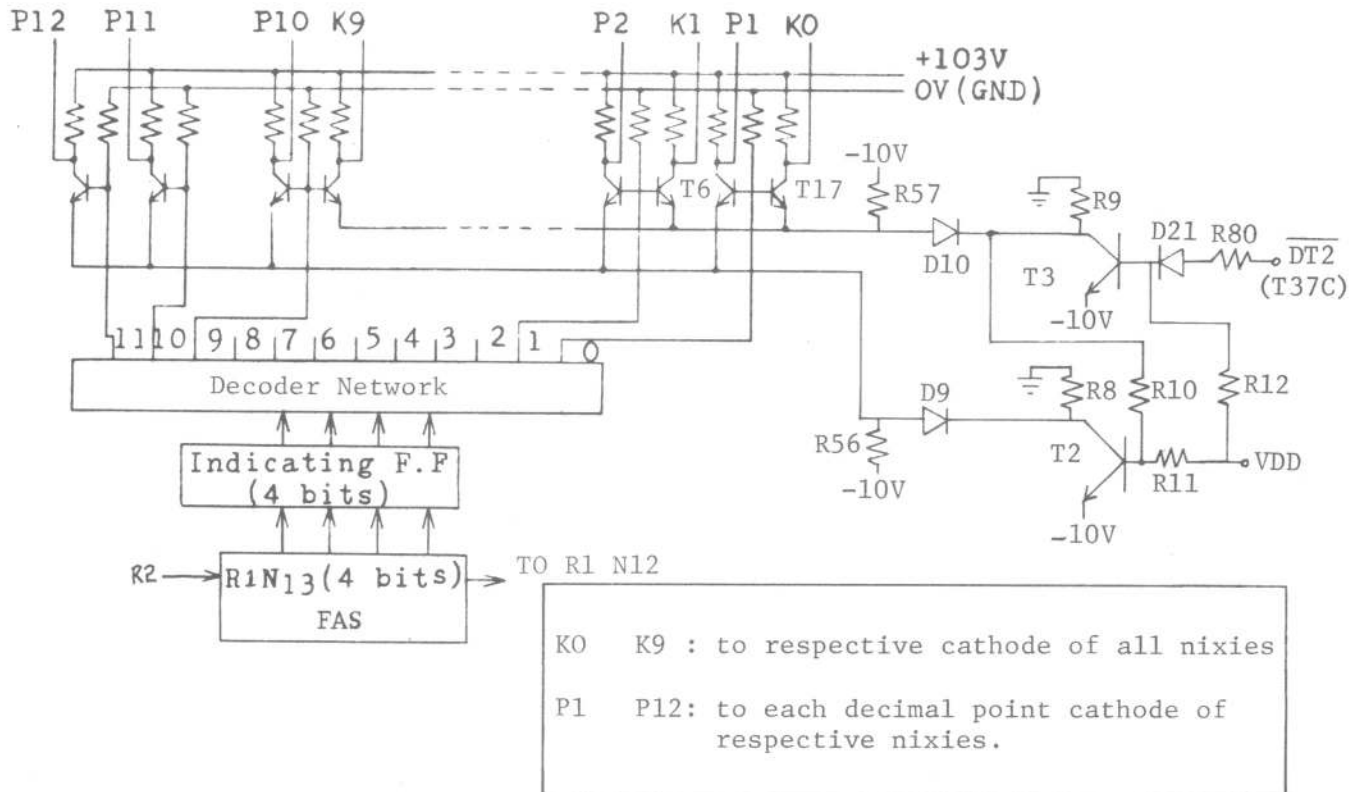
In timing the firing of the Indicator Tubes, the arrangement of the data (Decimal Point, Sign, and Numeric) in the register must be considered. For example, during DT1 time, the decimal data is shifted into FAS, but during this time, the anode circuits are blocked because transistor T37 is on, clamping its collector at ground and preventing the Anode Transistors from turning on. At the end of DT1 time, the decimal point data at the FAS output terminals: FA, XC4, XC3, and XC2 is parallel shifted into the Cathode Decoder flip-flops. When DT2 goes True at the input to Gate 119, the Control Transistor T37 will turn off. With transistor T37 off, its collector output will be at logic 0 (False) and the output of all the Anode Control Gates (106 through 117) will be False, causing the Anode Driver Transistors (T26, T27, etc.) to turn on.

1115 ELECTRONIC CALCULATOR

FUNCTIONAL DESCRIPTION

The Anode Driver Transistors turning on will discharge the capacitor circuits allowing approximately 200 volts to be felt at the Anodes of all 12 Indicator Tubes.

In the meantime, the transistor corresponding to the decoded Decimal Point Cathode (P1, P2, etc.) has been turned on and its collector will be clamped to approximately -10V causing the Decimal Point Cathode to glow. After DT2 time, the Anode Control Gates (106 through 117) are under control of their respective Digit Times DT5 through DT16 which corresponds to the R2-1 (LSD) through R2-12 (MSD) register positions.



CATHODE CONTROL CIRCUIT

b. CATHODE CONTROL CIRCUIT

FIGURE 4-32

Shown in Figure 4-32 are the control circuits for driving the Cathodes of the Indicator Tubes. Since there are 12 decimal point positions (P1 through P12) and 10 digits (K0 through K9), a total of 22 Driver Transistors are required. The base inputs for the digit transistors are shared with the base inputs of their respective decimal point transistors, leaving the two base inputs to the transistors for P11 and P12 independent. The emitters of the digit Driver Transistors are bused together and the emitters of the decimal point Driver Transistors are bused together; therefore, the voltage level applied to the two emitter buses will determine whether a Digit Transistor, or a Decimal Point Transistor will turn on. For example, if the data in R2P is zero, the decoder output on the "0" line establishes a turn on voltage on the bases of Transistors T17 and T6 (associated with K0 and P1 in Figure 4-32). At this same time, the control circuitry feeding the emitter buses will allow only the emitter bus connected with the decimal point transistors to forward bias the emitter for Transistor T6, causing T6 to turn on.

1115 ELECTRONIC CALCULATOR

FUNCTIONAL DESCRIPTION

the emitter buses will allow only the emitter bus connected with the decimal point transistors to forward bias the emitter for Transistor T6, causing T6 to turn on.

4. INPUT CIRCUITS

The input circuits for the 1115 machine are similar to those described for the 1114 machine in that the signal Key Common is used as the Entry Control signal and provides a time delay to ensure synchronization of all Control flip-flops to the clock pulses. The input circuits are shown in Figure 4-33.

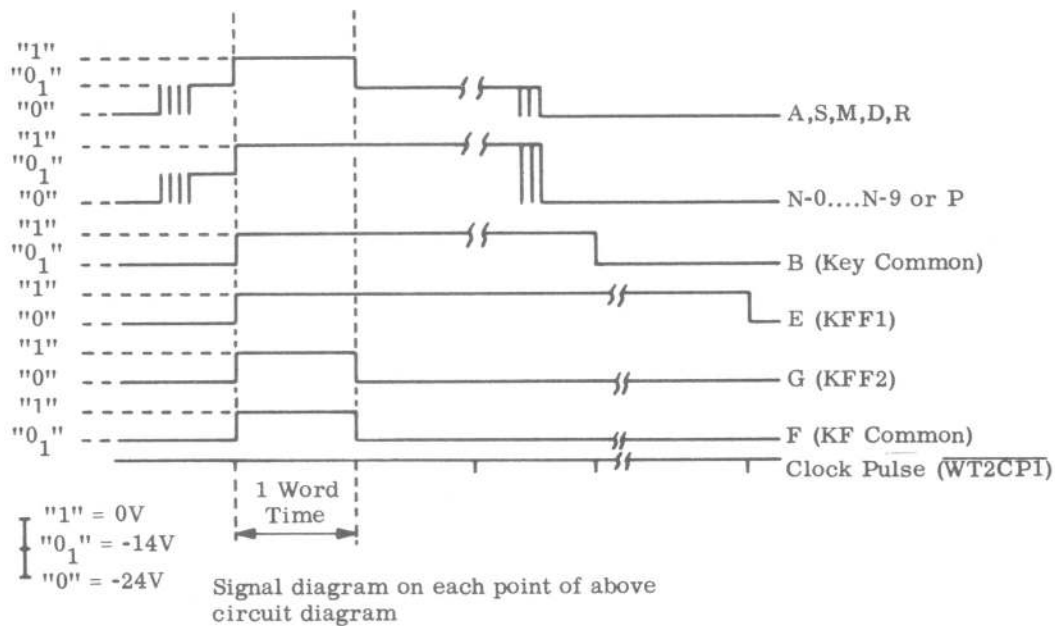
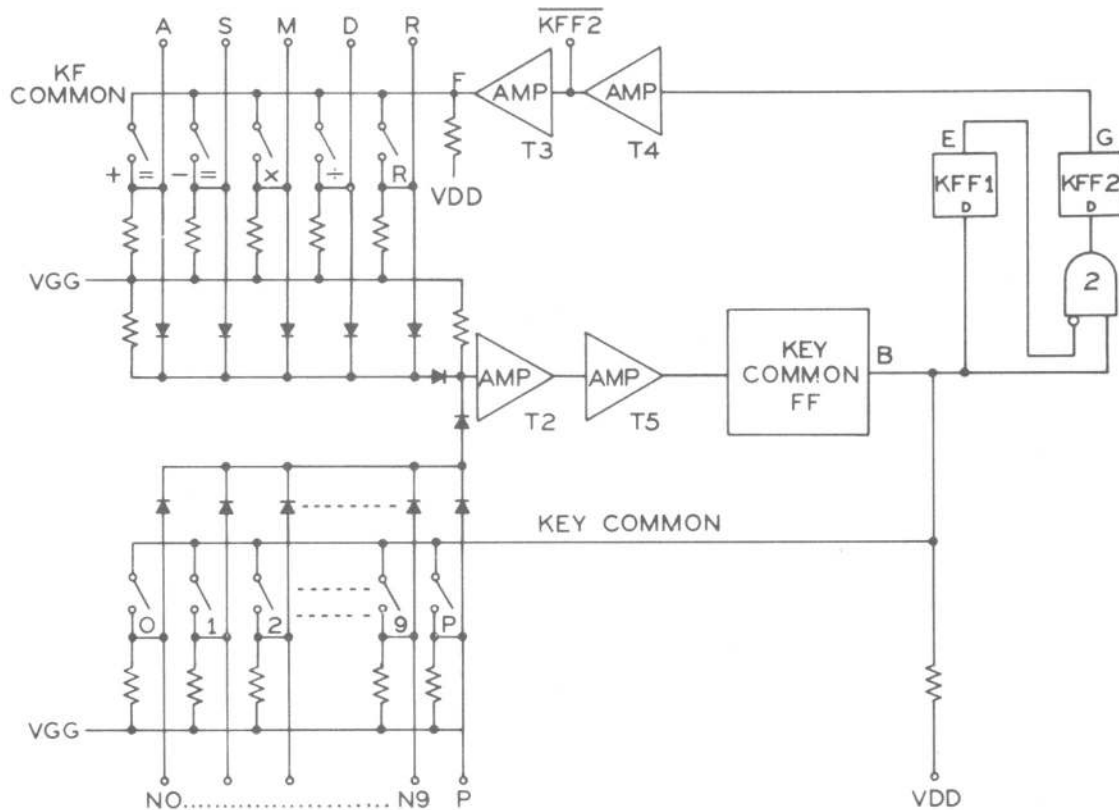
The logic circuits controlling the 1115 machine are under control of, and synchronized with the clock pulse generator. However, Entry data developed when a digit or a function key is depressed occurs at random and must be synchronized with the machine logic. A signal designated "Key Common" is used for synchronizing the Entry data, and a signal designated "KF Common" is used for synchronizing the Function key data. Development of Key Common and KF common is described as follows:

The Key Common line and the KF Common line are initially clamped to -14 volts (logic 0) via resistor R126 at the Set input terminal of the Key Common FF, and resistor R129 at the collector of transistor T3. When a Numeral, a Decimal Point key, or a Function key is depressed, its corresponding switch is closed and the appropriate diodes in the diode decoder network are forward biased allowing transistor T2 to turn on. As transistor T2 turns on, its collector is connected to a delay circuit (RC circuit) which provides the turn on potential to transistor T5 after a period of approximately 5 milliseconds. When transistor T5 is fully on, its collector being True enables the setting of the Key Common FF and when the clock pulse WTCPl occurs, the Key Common FF is permitted to set.

As the signal "Key Common" goes True in synchronization with the clock pulse WTCPl, KFF1 and KFF2 are enabled to be set. (KFF2 set input is also qualified by the False output from KFF1.) Then, as the clock pulse WT2CPl occurs, KFF1 and KFF2 are set simultaneously. Prior to KFF2 being set, its output is False into the base of transistor T4 and T4 is off. The collector of T4 "KFF2" is therefore at 0 volts (True) into the base of transistor T3 and T3 is also off. With transistor T3 off, the KF Common line to the Function key switches is clamped to -14 volts via the T3 collector resistor. Only after Key Common goes True enabling the set of KFF2 can transistor T4 turn on. Transistor T4 turning on causes its collector output to be clamped to the emitter voltage VGG and transistor T3 is turned on. With transistor T3 turned on, its collector output is clamped to 0 volts (True) and the signal KF Common will be True. A simplified diagram of the input circuit is shown in Figure 4-33.

1115 ELECTRONIC CALCULATOR

FUNCTIONAL DESCRIPTION



INPUT CIRCUITS

FIGURE 4-33

1115 ELECTRONIC CALCULATOR

FUNCTIONAL DESCRIPTION

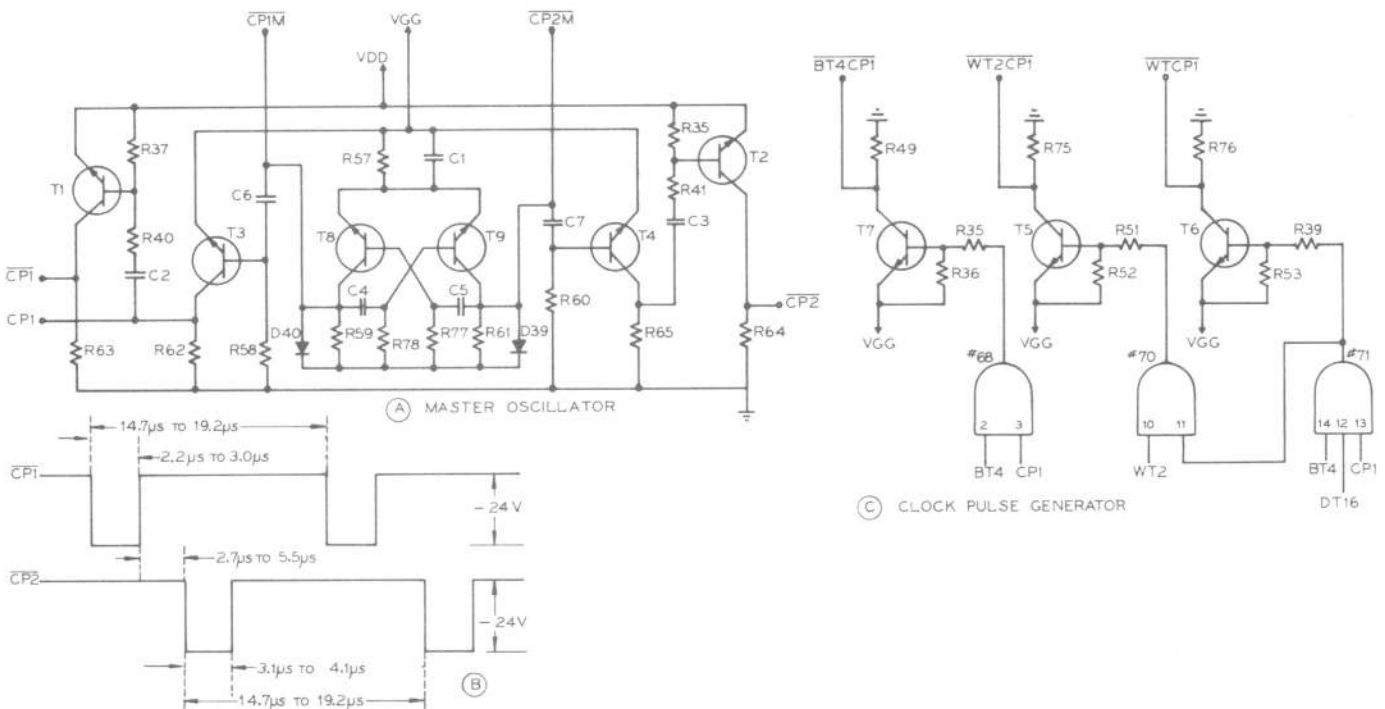
5. MASTER OSCILLATOR AND CLOCK PULSE GENERATOR

The Master Oscillator (Figure 4-34) is composed of an unsymmetrical astable multi-vibrator operating at a frequency of 60KHz (+8 KHz). A complete operational description of this type of circuit may be found in Lesson 19 of the "Friden Electronics Correspondence Course".

The output waveforms produced at the collectors of transistors T8 and T9 are further shaped by transistors T3 and T4. These outputs are then inverted by transistors T1 and T2 to produce the CP1 and CP2 clock pulses as shown in Figure 4-34.

Transistors, T5, T6, and T9 are inverter amplifiers used in conjunction with gates 70, 71, and 68 to develop clock pulses WT2CP1, WTCPI, and BT4CP1.

The collector output of transistor T3 is designated CP1 and is used to develop special clock pulses via gates 68, 70, and 71. (Note: The outputs designated CP1M and CP2M are provided for factory production testing only.)



MASTER OSCILLATOR AND CLOCK PULSE GENERATOR

FIGURE 4-34

1115 ELECTRONIC CALCULATOR

FUNCTIONAL DESCRIPTION

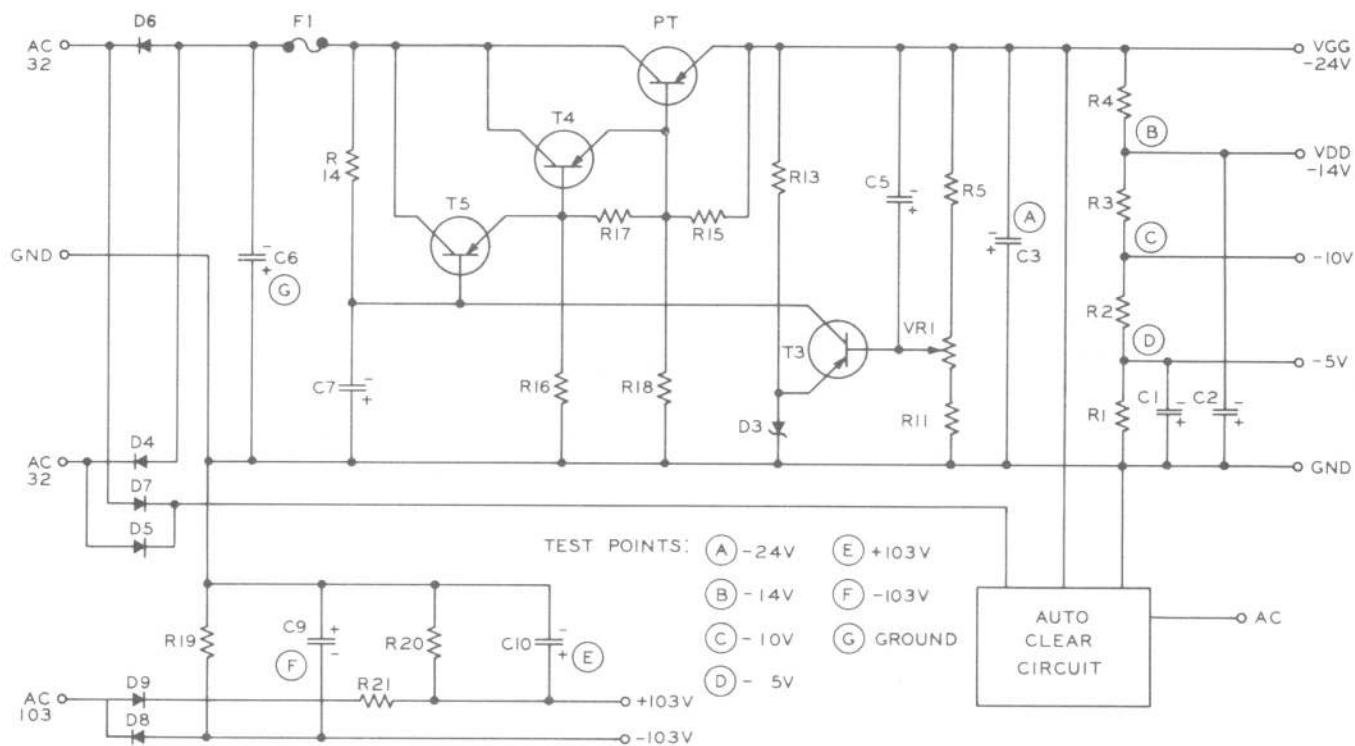
6. POWER SUPPLY

The Power Supply (Figure 4-35) develops a -24V regulated output. The 117 VAC input to the primary of the step down transformer (not shown) is via an 0.05A fuse (F2). The center tapped secondary feeds a full wave rectifier which provides a -32 volt output. Power transistor PT is part of the regulator circuit and approximately 10 volts is dropped across the PT transistor to provide a -24 volt output. A voltage divider tapped off the -24 volt supply provides regulated outputs of -14V, -10V, and -5V.

The voltage regulator circuit utilizes transistors T3, T4, T5, D3 and associated circuitry. Diode D3 provides a 14.5 volt reference for transistor T3. Potentiometer VR1 is used to adjust the -24V regulation by controlling the bias voltage for the regulation sensing transistor T3.

Assuming the -24V output decreases to -23V, the voltage at the base of T3 will go more positive, causing the collector voltage of T3 (Base of T5) to go more negative. T5 being an emitter follower will reflect the negative change at its emitter (Base T4). T4 is also an emitter follower and it reflects the negative change of voltage at the base of the Power Transistor PT causing it to conduct harder and thereby drop less voltage. Therefore, more of the 32 volt rectifier output is available at the output of the power supply and the -24 volt output remains relatively constant. The reverse action will occur if the -24 volt supply attempts to increase toward -25V.

In addition to the -24V regulated supply, a non-regulated -103V and +103V supply is provided via a dual half-wave rectifier circuit. This 103 volt supply is used for operating the Indicator (Nixie) Tubes.



POWER SUPPLY SCHEMATIC

FIGURE 4-35

1115 ELECTRONIC CALCULATOR

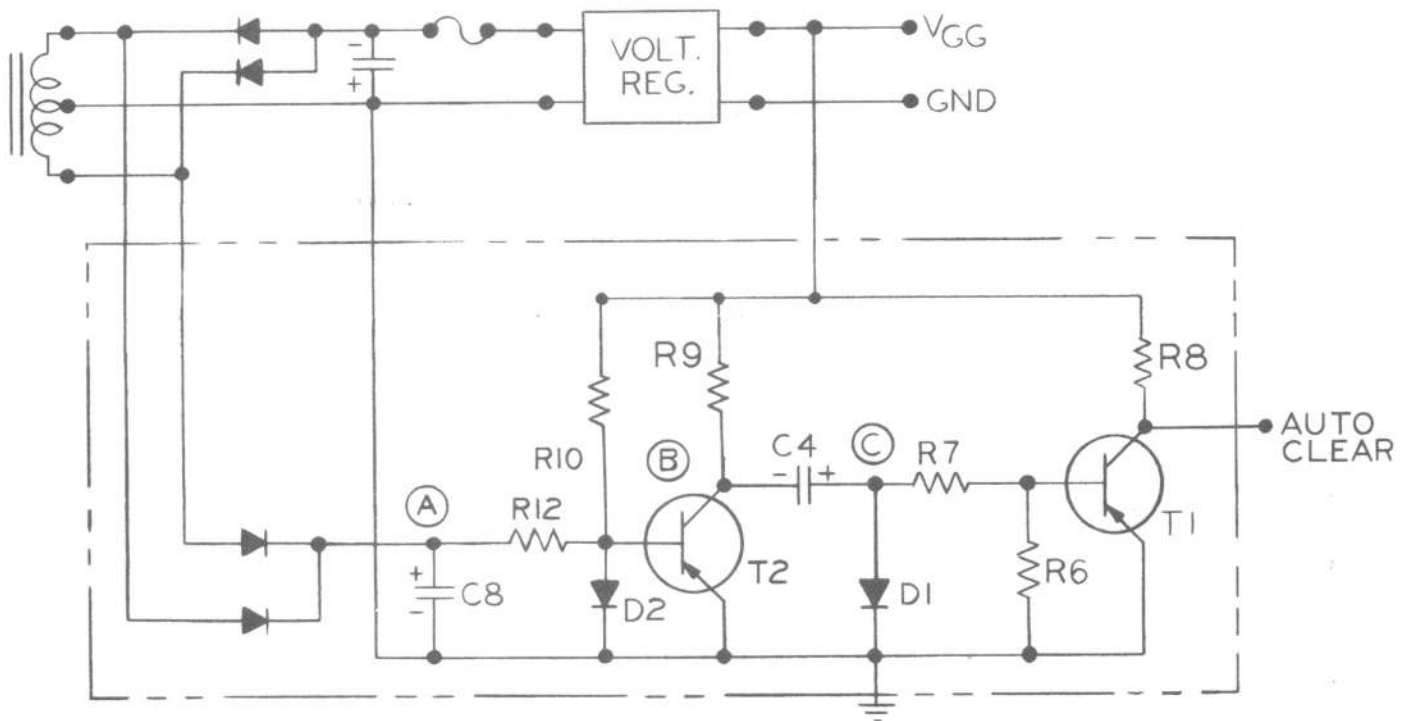
FUNCTIONAL DESCRIPTION

7. AUTO CLEAR

All registers in the 1115 are cleared automatically via the "Auto Clear" circuit (Figure 4-36) at the time the Power Switch is first turned on.

When the machine is first turned on, Transistor T2 will turn on ensuring that capacitor C4 is discharged to zero volts. Then as capacitor C8 charges, the voltage at point A goes positive, causing T2 to cutoff. With T2 cutoff, capacitor C4 will begin to charge to -24V and its charge current will cause a negative voltage to be felt on the base of T1 allowing T1 to turn on, and its output signal "Auto Clear" to become True (0 volts).

Then, when capacitor C4 becomes fully charged to 24 volts, the voltage at the base of T1 will be approximately zero, causing T1 to turn off and the "Auto Clear" signal to go False for as long as the machine remains on.



AUTO CLEAR

FIGURE 4-36

1115 ELECTRONIC CALCULATOR

SECTION 5

MAINTENANCE

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1115 ELECTRONIC CALCULATOR

MAINTENANCE

A. GLOSSARY OF SIGNAL NAMES AND LOGIC EQUATIONS

1. ENTRY SIGNALS

- (1) A (Addition): $\boxed{+}$ key signal
- (2) S (Subtraction): $\boxed{-}$ key signal
- (3) M (Multiplication): $\boxed{\times}$ key signal
- (4) D (Division): $\boxed{\div}$ key signal
- (5) R (Reverse): $\boxed{R}$ key signal
- (6) N (Number): Number key signal
- (7) P (Point): $\boxed{.}$ key signal
- (8) BD: Entry data signal of a binary coded decimal number (8-4-2-1 code).
- (9) K. (MLT2 + DIV2): $\boxed{K}$ key signal
- (10) R/O.F.K R/O: $\boxed{R/O}$ key signal
- (11) C + AC: $\boxed{C}$ key signal
- (12) C + AC + CE: $\boxed{CE}$ key signal

2. CONTROL SIGNALS

- (1) KFF1 (Key FF 1). This "D" type flip-flop is permitted to be set when the signal Key Common goes true (Logic 1) on depression of a digit or function key. The transition of the flip-flop to the set condition occurs when the clock pulse WT2CP1 occurs.
- (2) KFF2 (Key FF 2): This "D" type flip-flop is permitted to be set via logic gate #2 by: Key Common.KFF1. With KFF2 set, the signal KF Common becomes True.
- (3) POT (Decimal Point F/F). This flip-flop is set and its output signal POT goes true when the decimal point key is depressed. At the end of the Entry operation, the POT FF is reset by depression of a Function key, or by depression of the Clear or Clear Entry keys.
- (4) MLT 1 (Mult 1 F/F). This flip-flop is set and its output signal MLT 1 becomes true when the MULT key is depressed.
- (5) DIV 1 (DIV 1 F/F). This flip-flop is set and its output signal DIV 1 becomes true when the DIVIDE key is depressed.
- (6) MLT 2 (MULT 2 F/F). This flip-flop is set via the signal MLT1.SOSF and is used as the command signal for a Mult operation.

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2. CONTROL SIGNALS (Cont.)

- (7) DIV 2 (DIV 2 F/F). This flip-flop is set via the signal DIV1.SOSF and is used as the command signal for a Divide operation.
- (8) ENT (ENTRY F/F). This flip-flop is set at the end of a calculation to indicate that the machine is ready to accept another entry. When a Number key, Decimal point, or Reverse key is depressed, the ENT FF is reset.
- (9) OSF (Operation Start F/F). This flip-flop is set via the signal SOSF (Set Operation Start FF) which is developed at the output of gates 19 and 21. The Operation Start Signal is used for the Operation Start command.
- (10) CDP (Decimal Point Alignment F/F). This flip-flop is set under the various conditions requiring decimal alignment of the contents in the registers with the setting of the Decimal switch.
- (11) CHG 1 (Change 1 FF). The output of this flip-flop is used as a command signal to exchange the contents of R2 and R3 for new Entries, Reverse operations, and during Add or Subtract.
- (12) AOS (Add or Subtract F/F). When this flip-flop is set, its output signal (AOS) causes the Full Adder and Subtractor (FAS) to perform a calculation of $R2 + R3N$ in an Add or Subtract operation; or $R1 + R3N$ in a Mult or Divide operation.
- (13) CWF (Complement Word F/F). The output of this flip-flop is used to control changing a number to a complement or from a complement. For example, in an Add or Subtract operation, the contents of R2N is fed by way of the "Y" input into FAS for one word time after the answer has been developed. If the result of the subtraction is a complement number in R2N, the contents of R2N are subtracted from "0" which results in changing the complement number to a positive number.
- (14) OVFl (Overflow 1 F/F). This flip-flop is used for detecting a complement number during a subtract operation.
- (15) R/OF (Round Off F/F). This flip-flop is set during the last step of each calculation and the signal is used to perform a round off function on the LSD of the digit in R2N-1.
- (16) FAS Sub (OR Gate). During the time this signal is True at pin #18 on the FAS IC chip, FAS will act as a subtracter.
- (17) FAS Sub1 (FAS Subtraction F/F). This flip-flop sets to indicate a machine subtract is to be accomplished.
- (18) RIGHT SHIFT (RSH F/F). The output signal from this flip-flop enables a right shift of the contents of R1 and R2N.
- (19) LEFT SHIFT (LSH F/F). The output signal from this flip-flop enables a left shift of the contents of R1 and R2N.

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2. CONTROL SIGNALS (Cont.)

- (20) MULT AND DIVIDE (MDF F/F). The output signal from this flip-flop enables the repeat operations necessary in mult or divide. The MDF FF is always set simultaneously with the OSF FF via the signal SOSF.
- (21) INDICATOR REGISTER SIGN (IRS F/F). The contents of R2S are shifted out of R2 during DT2 time and if the sign of the number being displayed is negative, the signal R2.DT2 at gate #43 will be True. Then, at BT4CP1 time, the IRS FF is permitted to set and its output going True enables the Transistor T36 to turn on and the "Minus" Indicator light will turn on.
- (22) FF1 (F/F #1). When the contents of R2P are different from the setting of the Decimal Switch, the FF1 FF is set and its output signal FF1 being True enables an alignment operation.
- (23) FF2 (F/F #2). This flip-flop is used in conjunction with FF1 to enable a shift operation (alignment). The signal FF2 enables a right shift. The signal FF2 enables a left shift.
- (24) R2F (R2 F/F). This flip-flop is used as a control for various operations of Mult and Divide functions.
- (25) OVERFLOW 2 (OVF2 F/F). When the machine is in an Overflow condition, the OVF2 FF is set and the drive circuit (Transistor T1) is enabled, causing the Overflow Light to turn on.

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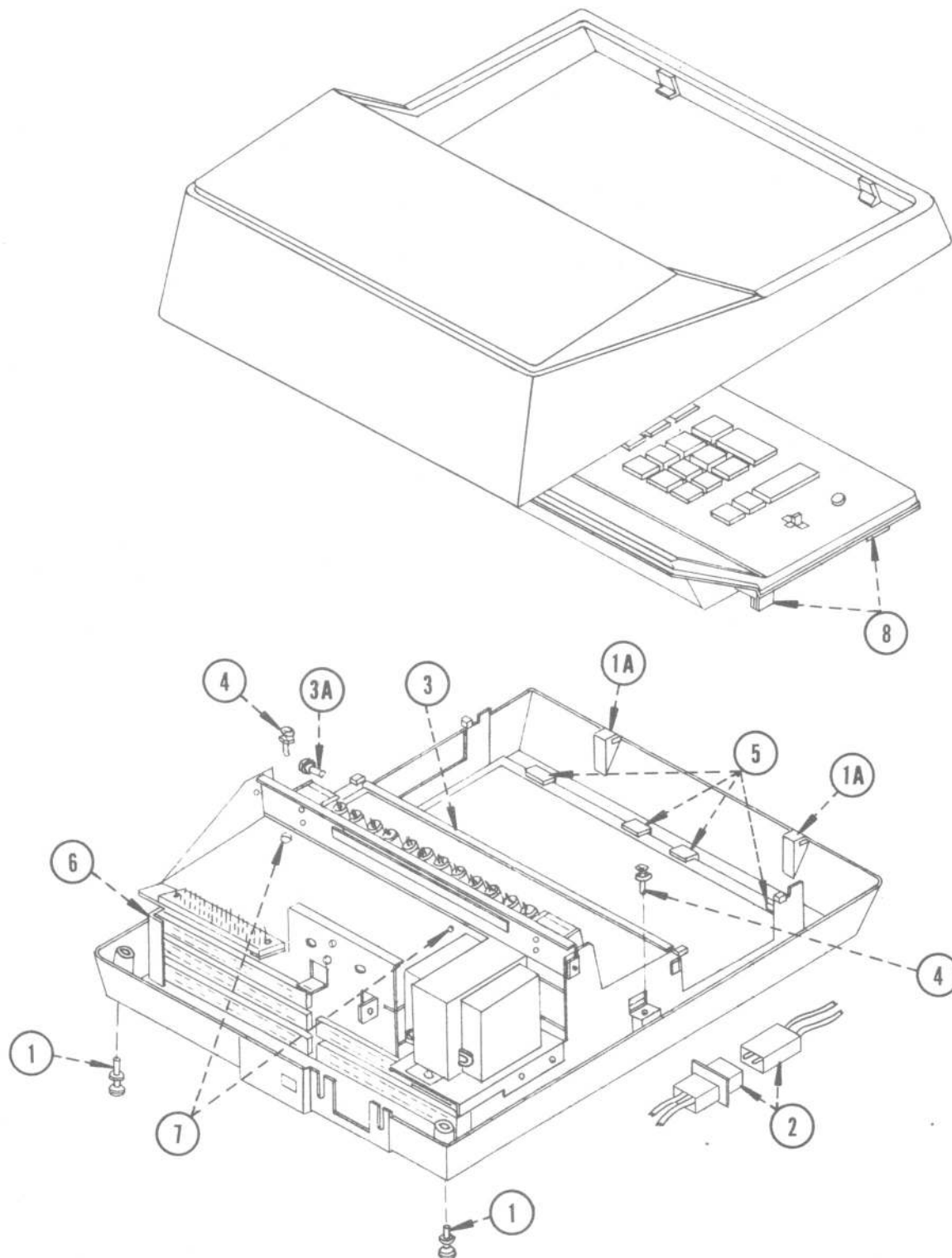


FIGURE 5-1

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B. DISASSEMBLY AND ASSEMBLY

Instructions for disassembly and assembly of the component parts of the 1115 are listed below. Each instruction is keyed to Figure 5-1.

- (1) To remove the top cover, remove 2 screws (item 1) from the bottom of the machine (rear) and lift the cover from the rear so it disengages the locking tabs from the slots in the front panel (1A).
- (2) To remove the keyboard from the chassis, disconnect the plug (item 2) and lift the keyboard off the chassis side frames. To remove the keyboard from the machine, disconnect the keyboard ground wire, and uncouple the connector plug at the right rear of the PC card holder.
- (3) To remove the PC cards:
 - (a) Remove card holder plate (item 3) by removing screw 3A.
 - (b) Remove two screws (item 4) securing the PC card holder frame to the base.
 - (c) Lift the rear of the chassis and move it rearward to disengage the chassis retainer tabs and the #31 PC card from the retainer slots (item 5).
 - (d) PC cards #31, #32, and #33 can now be removed by prying them forward with a screwdriver inserted in the appropriate holes in the side frame (6).
 - (e) PC card #34 is removed by removing the two screws (7) and lifting the card up.
- (4) To reassemble the components, reverse the order of disassembly listed above. Also the following precautions should be observed.
 - (a) When the chassis containing the PC cards is being reinstalled, be sure that the retainer tabs on the front edge of the chassis, and the #1 PC card are engaged in their respective retainer slots (5).
 - (b) When reinstalling the keyboard assembly:
 - (1) Be sure that the slotted tabs and locator grooves in the keyboard assembly (item 8) are engaged with their corresponding points on the chassis side frames.
 - (2) Check to see that the keyboard grounding strap is making good contact with the Card Holder Plate.
 - (c) Before installing the top cover, make sure that the wires and cables are out of the way so they don't get pinched when the cover is secured.

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C. INSPECTION PROCEDURE

- (1) Perform a complete operational check using the test problems starting on page 5-6. NOTE: Check to see that all numbers in the indicating tubes are operating properly.
- (2) Visually inspect the machine for worn or loose parts such as keystems, keytops, On/Off switch, Decimal Switch, etc. (Replace parts if necessary.)
- (3) Check the -24V output of Test Point "A" (negative side of capacitor C3) on PC card #34 to see that it is within the tolerance of -22.8V to -25.2V. (See Adjustment #2, Power Supply, page, 5-4 for location and adjustment procedure.)
NOTE: Connect a ground wire from the positive side of capacitor C6 (Test Point G) to the card holder side frame before making the voltage measurement.
- (4) Clean and Lubricate keyboard unit as necessary.
 - (a) Blow out all dust and foreign material.
 - (b) Lightly lubricate the top and bottom of the keystems using a small amount of grease (Shell non-stain 71212/Friden MS-136) applied with the tip of a long long bladed screwdriver. Use care to prevent grease from getting on the #31 PC card because grease will damage the protective coating on the card.
- (5) Check the adjustment of all reed switches on the keyboard.
 - (a) Each reed switch should close when its keystem has been depressed approximately half way down. See Reed Switch adjustments, page 5-10, for adjustment procedure.
- (6) Clean the exterior of the machine with soap and water. Avoid any commercial cleaner that is not recommended for use with plastic.

D. OPERATIONAL CHECK

The procedures for accomplishing a complete operational check of the 1115 are listed below. The entire sequence should be followed after replacing a PC board or after completion of a repair.

1. Check of decimal set switch, round off, and truncate operation. FP = preset position of decimal switch. R/O $\uparrow$ = Round off switch up. R/O $\downarrow$ = Round off switch latched down.

		(Operation)		(Indication)
(a)	FP=5	R/O $\uparrow$ 1.23456789	$\overline{=}$	 1.23456 C
(b)	FP=5	R/O $\downarrow$ 123	$\overline{+}$	 123.00000 C
(c)	FP=2	R/O $\downarrow$ 1.23567890	$\overline{+}$	 1.24 C
(d)	FP=0	R/O $\downarrow$ 1.56789000	$\overline{+}$	 2. C
(e)	FP=0	R/O $\uparrow$ 1.56789000	$\overline{+}$	 1. C

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D. OPERATIONAL CHECK (Cont.)

2. Check of addition and subtraction

FP=5 and $\boxed{R/O} \downarrow$

- (a) 123.123 $\boxed{+}$ 0.123123 $\boxed{+}$ 1231231.23 $\boxed{+}$
 1231231.23123 $\boxed{+}$ 2462585.70735
- (b) C 0.00123 $\boxed{-}$ 1.23 $\boxed{-}$ 1230 $\boxed{-}$
 1231.23123 $\boxed{-}$ 2462.46246 $\boxed{-}$ 1.23 $\boxed{+}$
 1.23 $\boxed{+}$ 1.23 $\boxed{+}$ 1.23 $\boxed{+}$ 4920.00492- (NEG)

3. Check of multiplication and division

At FP=5 and $\boxed{R/O} \downarrow$

- (a) 1234.5679 $\boxed{\times}$ 7.2 $\boxed{+}$ 8888.88888
- (b) 12345679 $\boxed{\times}$ 0.36 $\boxed{+}$ 4444444.44000
- (c) 1.23000000000 $\boxed{\times}$ 1.23000000000 $\boxed{+}$ 1.51290
- (d) 1111.11 $\boxed{\times}$ $\boxed{+}$ 1234565.43210
- (e) 15129 $\boxed{\div}$ 12300000 $\boxed{+}$ 0.00123
- (f) 45600 $\boxed{\div}$ 0.01 $\boxed{-}$ 4560000.00000-
- (g) 123 $\boxed{\times}$ $\boxed{+}$ $\boxed{\times}$ 12.3 $\boxed{\times}$ 1.23 $\boxed{\times}$ 1.23 $\boxed{\div}$ 123 $\boxed{\div}$
 1.23 $\boxed{\div}$ 1.23 $\boxed{+}$ 1512.90000

4. Check of constant calculation

FP-5, $\boxed{R/O} \downarrow$ $\boxed{K} \downarrow$

- (a) 123 $\boxed{\times}$ $\boxed{+}$ 15129.00000
 $\boxed{+}$ 1860867.00000

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2	$\div$	246.00000
3	$\div$	369.00000
	$\div$	45387.00000
	$\div$	5582601.00000
$\div$ 123	$\div$	45387.00000
	$\div$	369.00000
	$\div$	3.00000
2	$\div$	0.01626
3	$\div$	0.02439

FP=5 R/0 ↓

123 - = 456 R + = X R + = ÷ R + = ...333.00000

Confirm the overflow light after each of the following calculations.

FP=2 R/O ↓

(a) 1234567890123 overflow light comes on

(b)	9999999999	$+=$	1	$+=$	.	.	"	"	"
(c)	9999999999	$-=$	1	$-=$	.	.	"	"	"
(d)	9999999999.99	$+=$	0.006	$+=$			"	"	"
(e)	999999	X	$+=$	.	.	.	"	"	"
(f)	1000000000	$\div$	0.1	$+=$			"	"	"

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E. TROUBLESHOOTING

Prior to attempting to repair or service the 1115 Electronic Calculator, be sufficiently well informed concerning the operating conditions in the customer's office such as: Excessive high or low temperature (operating temperature 32° F. to 104°F.); proper line voltage (115 volts $\pm 10\%$, 50/60 Hz.); excessively high humidity; and that correct operating procedures are being observed.

Locate and repair obvious problems such as: blown fuses, sticking keys, etc. Any complicated condition which requires a relatively long service time should be accomplished by exchanging subassemblies such as logic cards and keyboard. These can then be returned to the branch office for repair, or sent to the Service Center in your area for repair.

1. PC BOARD REPLACEMENT

If the PC boards are suspected of causing trouble, special precautions must be observed while replacing or troubleshooting the boards due to the extreme sensitivity of the MOS IC circuits. Replace only one board at a time while observing the following precautions.

- (1) Turn the Power Switch "OFF" before replacing a PC board. If a board is removed or installed with the power on, possible damage to the components such as IC's, transistors and diodes may occur.
- (2) Avoid indiscriminate touching of the IC's with your bare fingers. Due to their electrical characteristics, the MOS IC's used in the 1115 have an extremely high input impedance and are very sensitive to static charges (especially when the PC boards are removed from the machine). Handle the boards only by the metal side frames.
- (3) When the PC boards are not in use or while transporting or shipping individual boards, be sure to short circuit the terminals with a protective connector. (Two each, Part #KCA 22035 with all pins soldered together.) Protective connectors with short circuited pins are used to maintain all PC board contacts at an equal potential so that no potential difference exists between the IC leads. However, not all the IC leads are connected to the PC contacts and care must be taken to prevent touching the IC leads with the fingers.
- (4) Avoid damaging the components mounted on the PC boards. Damage to the components can occur or their insulation may be lowered if the PC boards are allowed to contact each other, or are stacked one on top of the other.
- (5) Avoid external force or shock to the PC boards.
- (6) Do not insert a PC board into a connector for another board. Also, since the connecting terminals of the PC boards are arranged symmetrically, it is possible to insert a board upside down. Therefore, check to see that the component side of the board is facing up, prior to inserting it. The proper arrangement of the PC boards in the machine is #31 through #34 with the #31 board at the bottom.
- (7) Before connecting any test leads, or using a soldering iron, the logic ground must be connected to the chassis ground. This can be done by connecting a test clip lead wire between the positive (+) side of C6 (470 mfd electrolytic capacitor on card #34 Test point G) and chassis ground or "Scope" ground.

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- (8) Perform the operational check after each replacement of a PC board.

The basic card functions are listed to help diagnose troubles.

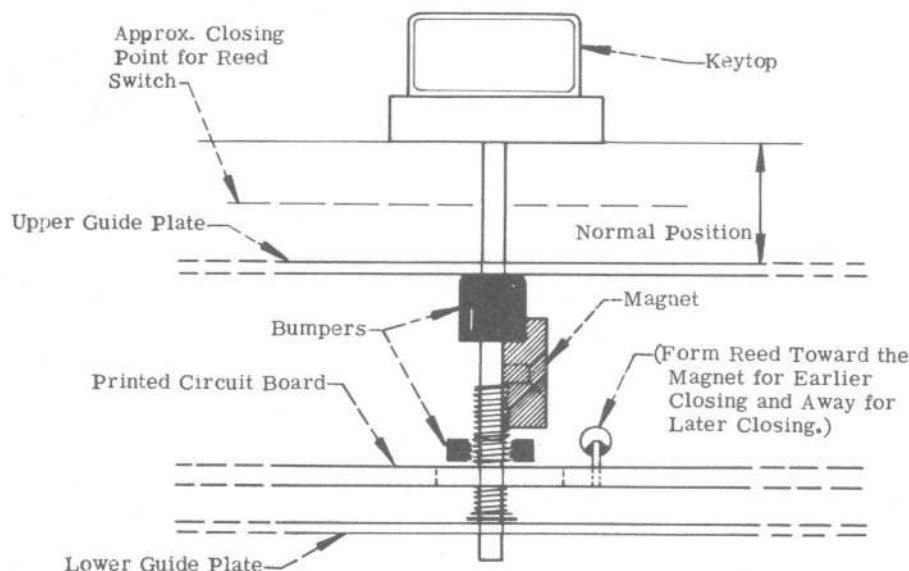
Card #31	Entry and Control Functions (Master & Conditional Control)
Card #32	Master Oscillator and Shift Registers
Card #33	Display Decoding, Number Indicating Tubes, and Digit Counter
Card #34	Power Supply

NOTE: Card extender, tool #18770, designed for use on the 1150 Printing Calculator can be modified for use on the 1115 Calculator by removing the card extractor on each side of the card. When using the modified extender on an 1115 PC card, be sure to insulate the exposed terminals with electrical tape or equivalent insulating material.

2. REPLACEMENT OF COMPONENTS ON PC BOARDS

- (1) When replacing broken or burned resistors, it may be necessary to use insulating tubing on the leads of the stand up type resistors to prevent shorting with adjacent resistors.
- (2) When replacing IC's, be sure to align the locator on the IC with the locator on the PC card as shown in Figure 5-5.

F. ADJUSTMENTS



KEY DEPRESSION

Closing Range

Normal Position
.079"
(Approx. Closing Range of Reed Switch)
.158"
Full Depression (.225")

Opening Range

Normal Position
.020"
(Approx. Opening Range of Reed Switch)
.158"
Full Depression (.225")

FIGURE 5-2

1. KEYBOARD

The keyboard reed switches must close when their respective keystems have been depressed approximately half way down. To adjust, move the individual reed switches closer or farther away from their respective magnets as shown in Figure 5-2.

(NOTE: Moving the switches closer to the magnets causes them to close sooner. Moving them farther away from the magnets causes them to close later.)

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F. ADJUSTMENTS (Cont.)

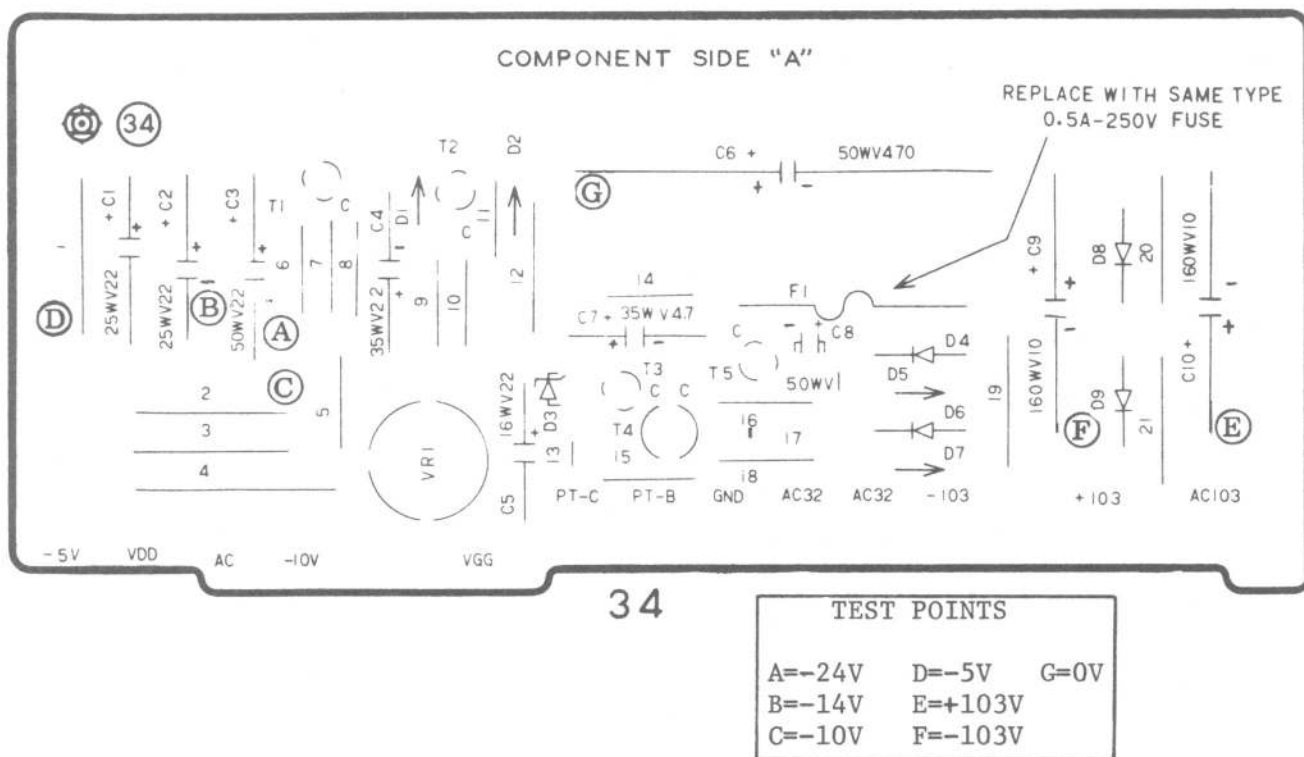


FIGURE 5-3

2. POWER SUPPLY

The -24V output at Test Point "A" (negative side of C3) on PC card #34 should read -24V or within the tolerance of -22.8V to -25.2V. The adjustment is made by turning the shaft on potentiometer VR1 as required. After making the adjustment, the shaft should be secured with Locktite, or other suitable cement.

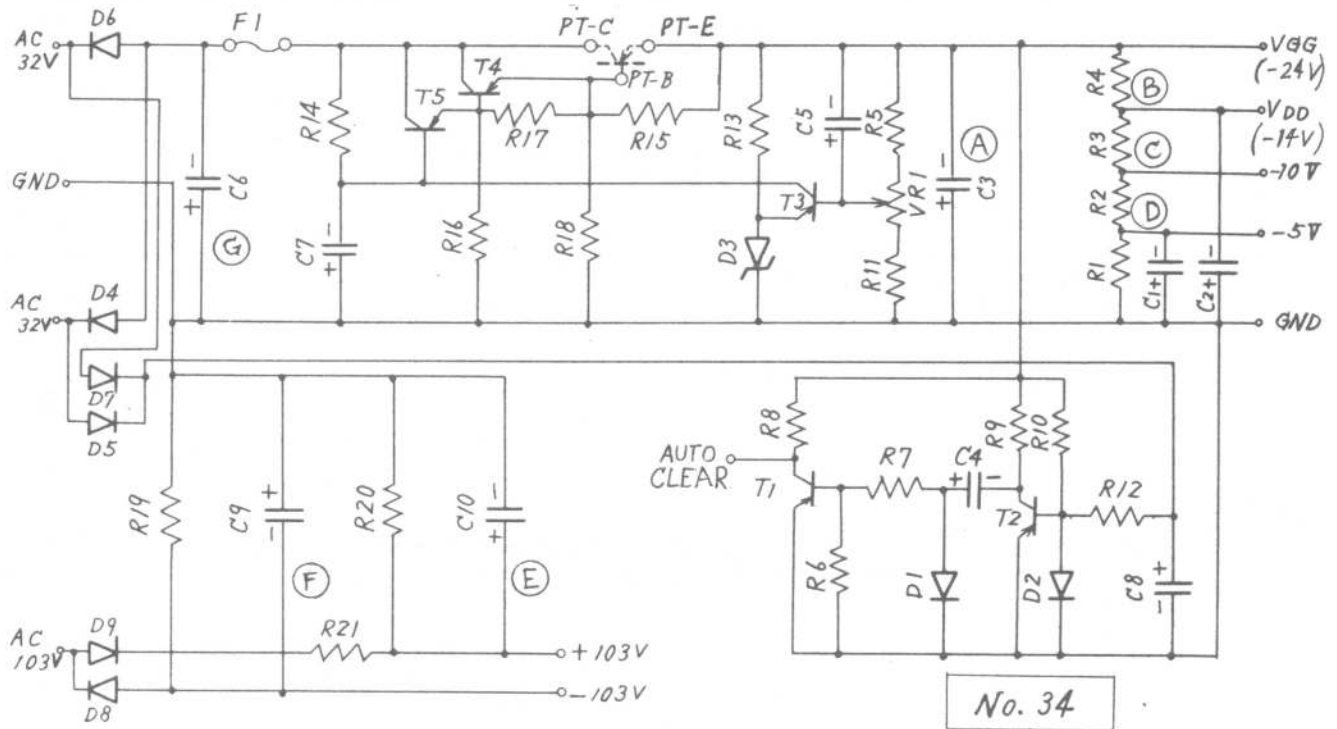
(NOTE: Prior to checking any voltages, connect a ground wire from the positive side of capacitor C6 (Test Point G) to the card holder side frame.)

Test Points B, C, D, E, and F should also be checked and their outputs should be within the specified tolerance range: Point B, -14V (-13.5V to -15.3V); Point C, -10V (-8.5V to -11.5V); Point D, -5V (-3V to -6.3V); Point E, +103V (+75V to +100V); Point F, =103V (-90V to -115V); Point G, 0V.

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2. POWER SUPPLY (Cont.)



POWER SUPPLY SCHEMATIC

FIGURE 5-4

a. SCHEMATIC. For convenience of the CSRep, a schematic of the Power Supply is shown in Figure 5-4 with the voltage test points indicated.

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LOCATOR NOTCH

(A)

TYPE 3106 SEQ. NO. 23

(B)

VDD

TYPE 3101 SEQ. NO. 50

(C)

TYPE 3112 SEQ. NO. 9-1

VGG

23AL

23

23AR

1. PRINTED CIRCUIT BOARD

Resistors: Indicated on PC board as 1, 2, 3, etc. and numbered from left to right.

Diodes: Indicated on PC board as D1, D2, D3, etc. and numbered from left to right.

Capacitors: Indicated on PC board as C1, C2, C3, etc. and numbered from left to right.

IC Chips: Indicated symbolically by a centerline drawn between the two ends and with the notched end at the top. The two numbers at the end of the chip are interpreted as follows: The 1st number indicates the last digit of the IC type. For example, IC 3106 would be indicated by a "6". The 2nd number indicates the successive use of that particular type of chip on the PC board. For example, 6-1 indicates a type 3106 IC chip, and "1" indicates its sequence number. The system is illustrated in "A", "B", and "C" of Figure 5-5. Also shown in Figure 5-5 is the pin numbering arrangement used on the 3 sizes of IC chips used in the 1115.

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2. NUMBER INDICATING TUBES

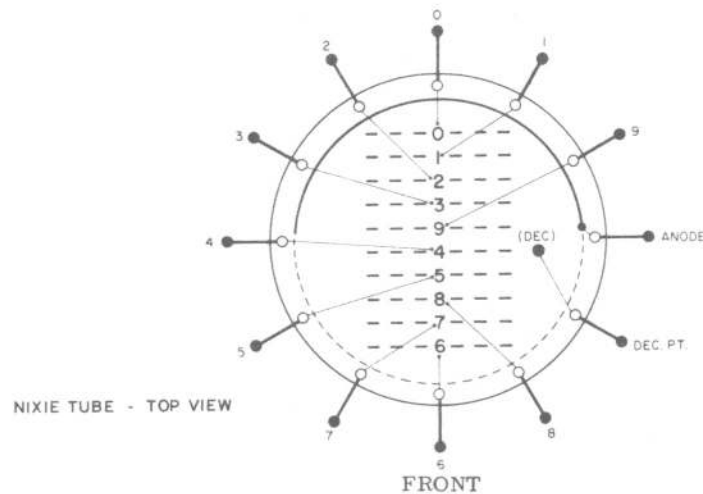


FIGURE 5-6

Shown in Figure 5-6 is a top view of a number indicating tube which illustrates the relative position of the number cathodes, the decimal point, and the anode inside the tube. Also shown are the internal and external connections to the cathodes and the anode.

3. TRANSISTORS

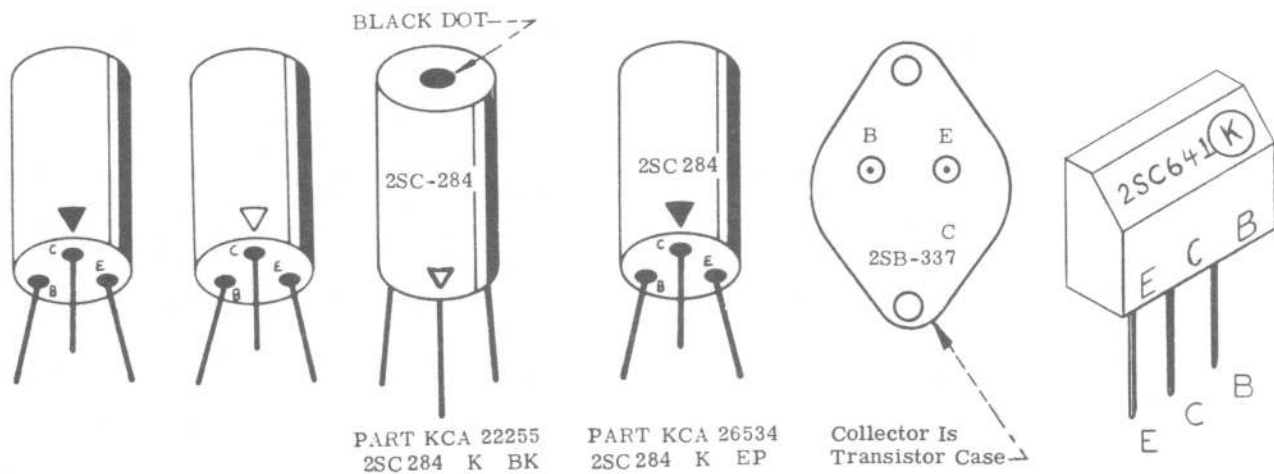


FIGURE 5-7

In Figure 5-7, are shown the various transistors used in the 1115 machine and their Collector, Emitter, and Base lead identification. To distinguish the difference between the two transistors having the same type number 2SC284, one has a black dot on its top. The Part Numbers and type identification for these two transistors are as indicated in the illustration.

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4. DIODES

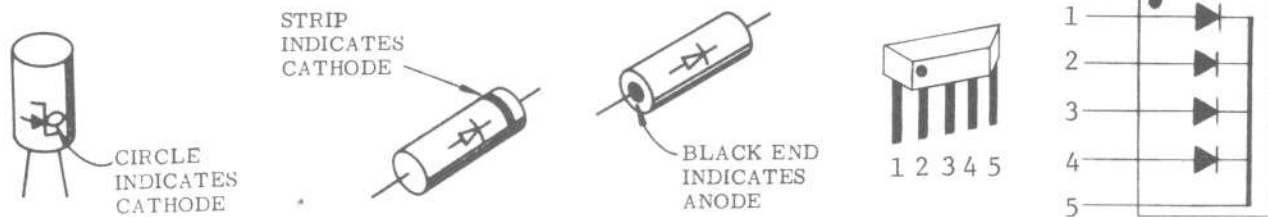


FIGURE 5-8

As shown in Figure 5-8, a small circle is used to indicate the cathode lead on the zener diode, a stripe is used to indicate the cathode on the diodes, or a black dot on the end of a diode indicates its anode lead. The diode array is a module containing four diodes with a common cathode. The terminals are identified as indicated in the drawing. NOTE: Dot on module indicates #1 lead.

5. PC BOARD CONNECTOR ASSEMBLY

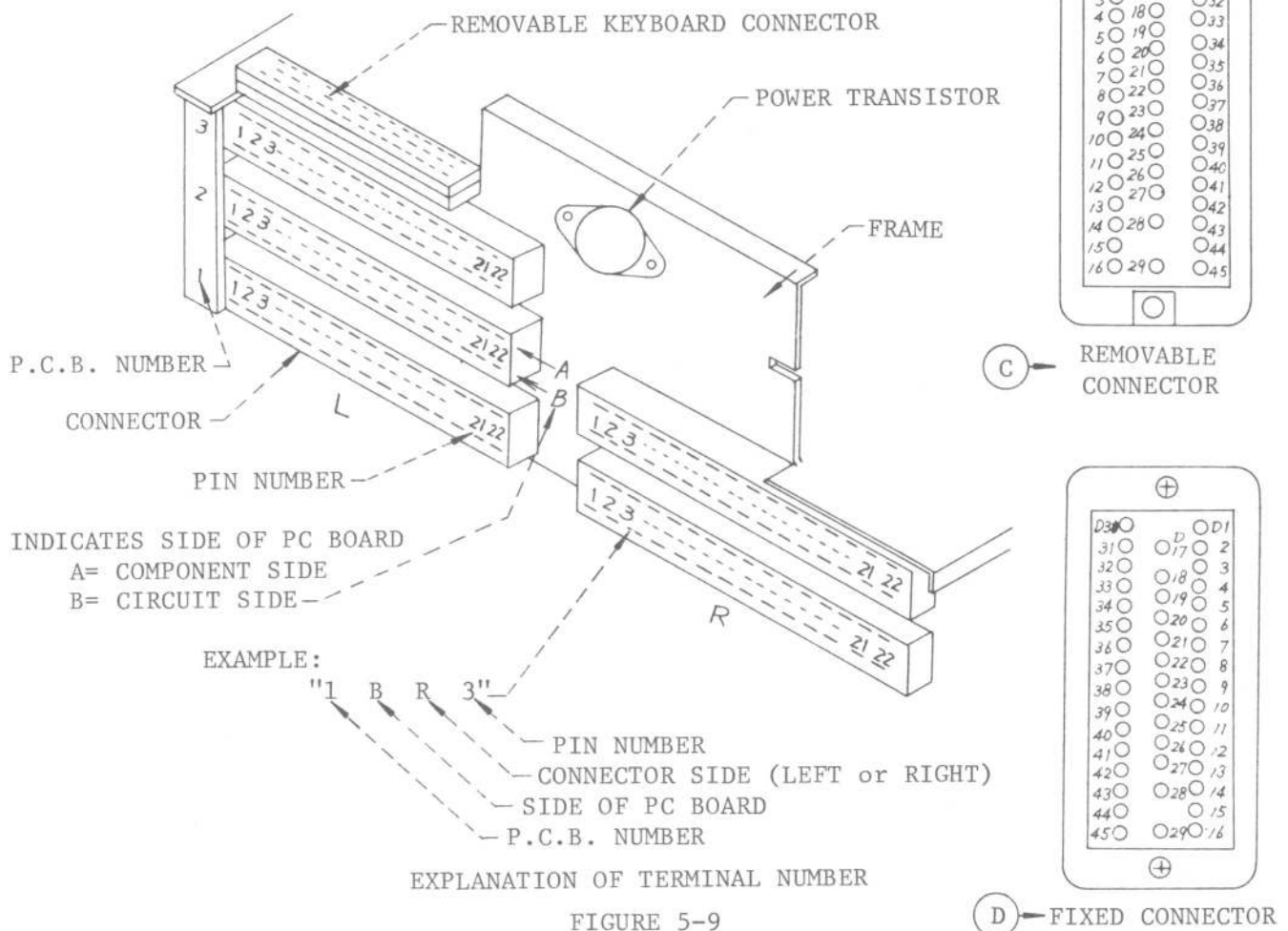


FIGURE 5-9

In Figure 5-9 is the PC Board Connector Assembly. The various identification points associated with the PC boards that are inserted in the plug connectors are as shown.

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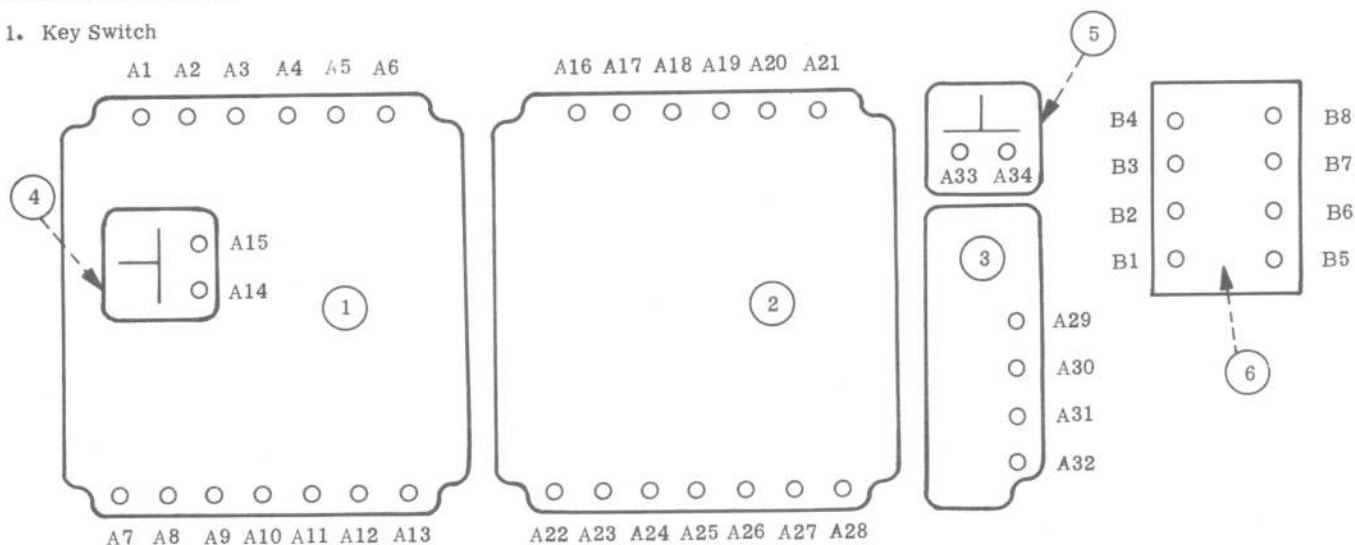
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6. EXTERNAL TERMINAL NUMBER IDENTIFICATION

In Figure 5-10 are shown the connector terminals for the Keyboard, Decimal Set Switch, Power Transistor, Transformer, and Indicating Lights.

TERMINAL NUMBER

1. Key Switch



1. Function Key Set

2. Number Key Set

3. Clear Key Set

4. ☐ R/O Key (Latch Down Type)

5. ☐ K Key (Latch Down Type)

6. Decimal Set Sw.

3. Power Transistor (Type : 2SB337)

4. Transformer

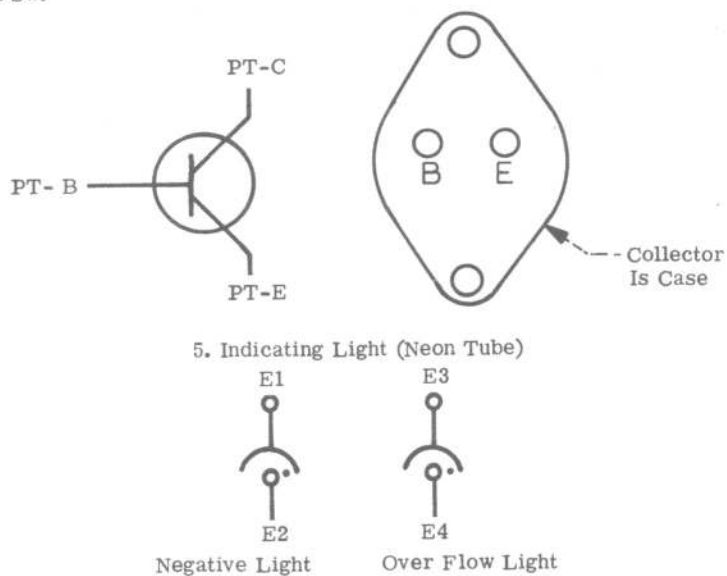
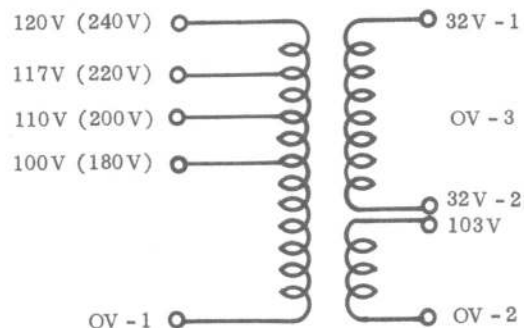
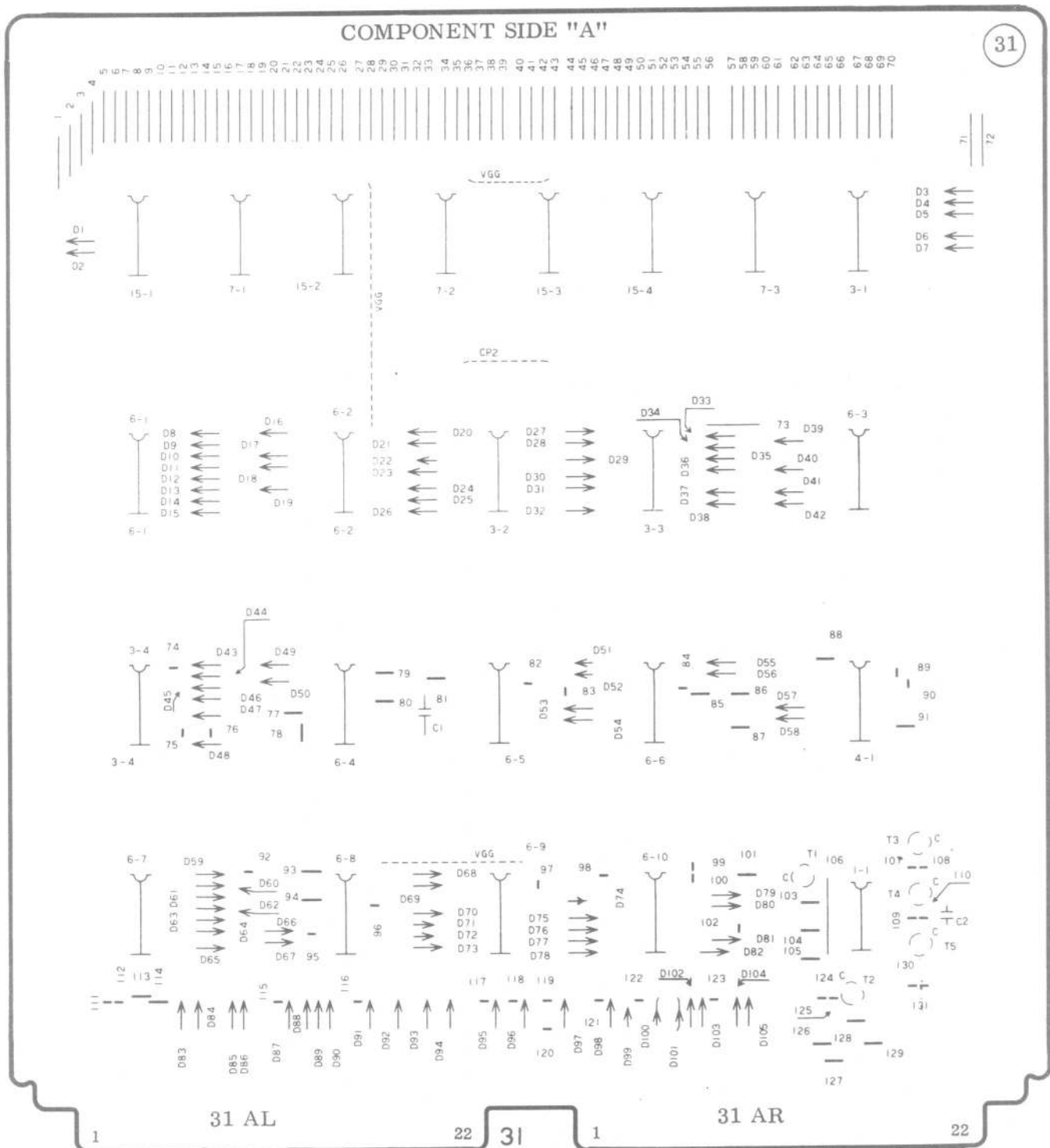


FIGURE 5-10

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H. PRINTED CIRCUIT CARDS AND COMPONENT LISTS



LOGIC CARD #31 (Entry and Control Function Logic)

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COMPONENT LIST FOR PC CARD #31

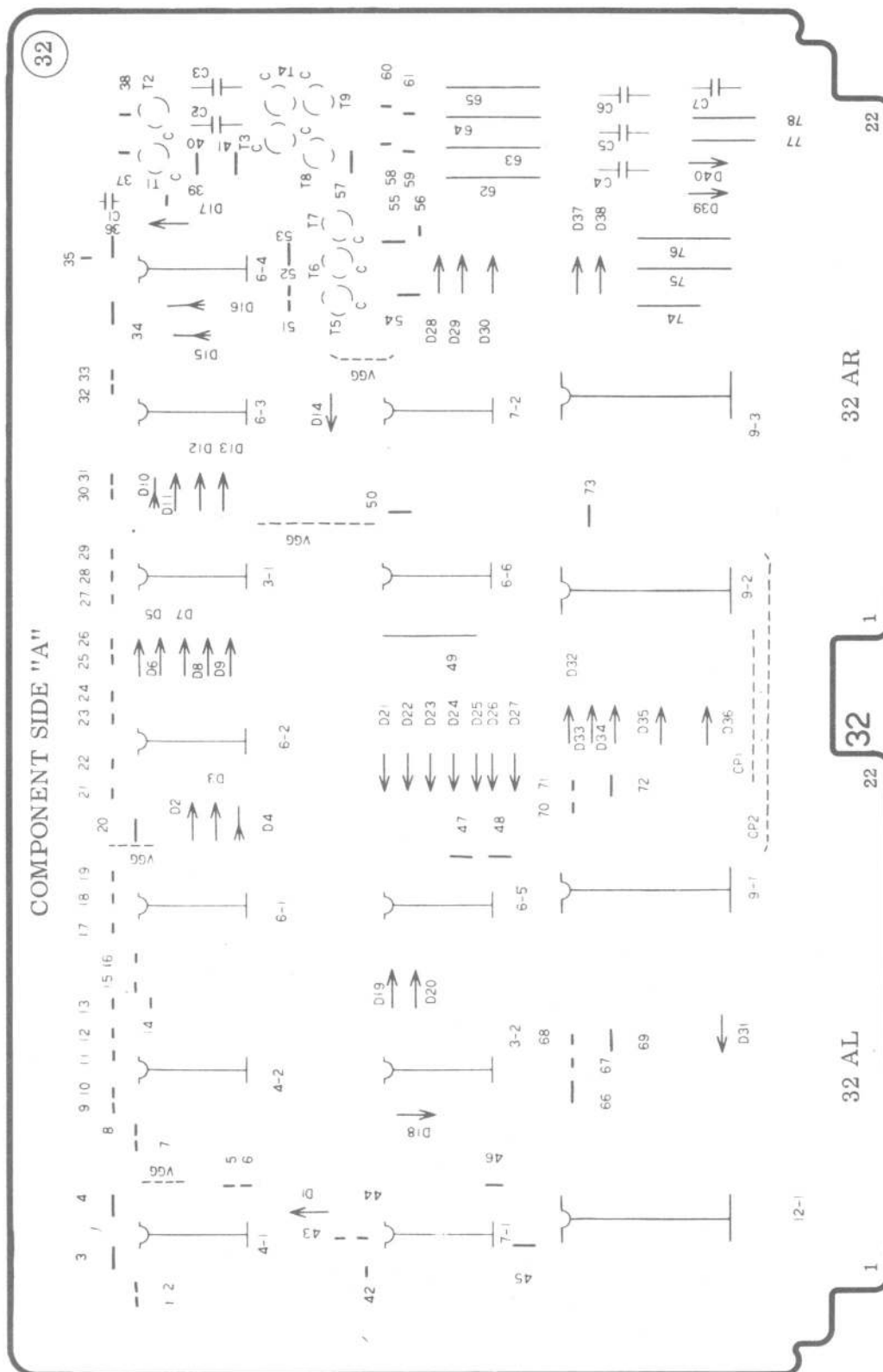
P. C. B. No. 31

[illegible]

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LOGIC CARD #32 (Master Oscillator and Shift Registers)



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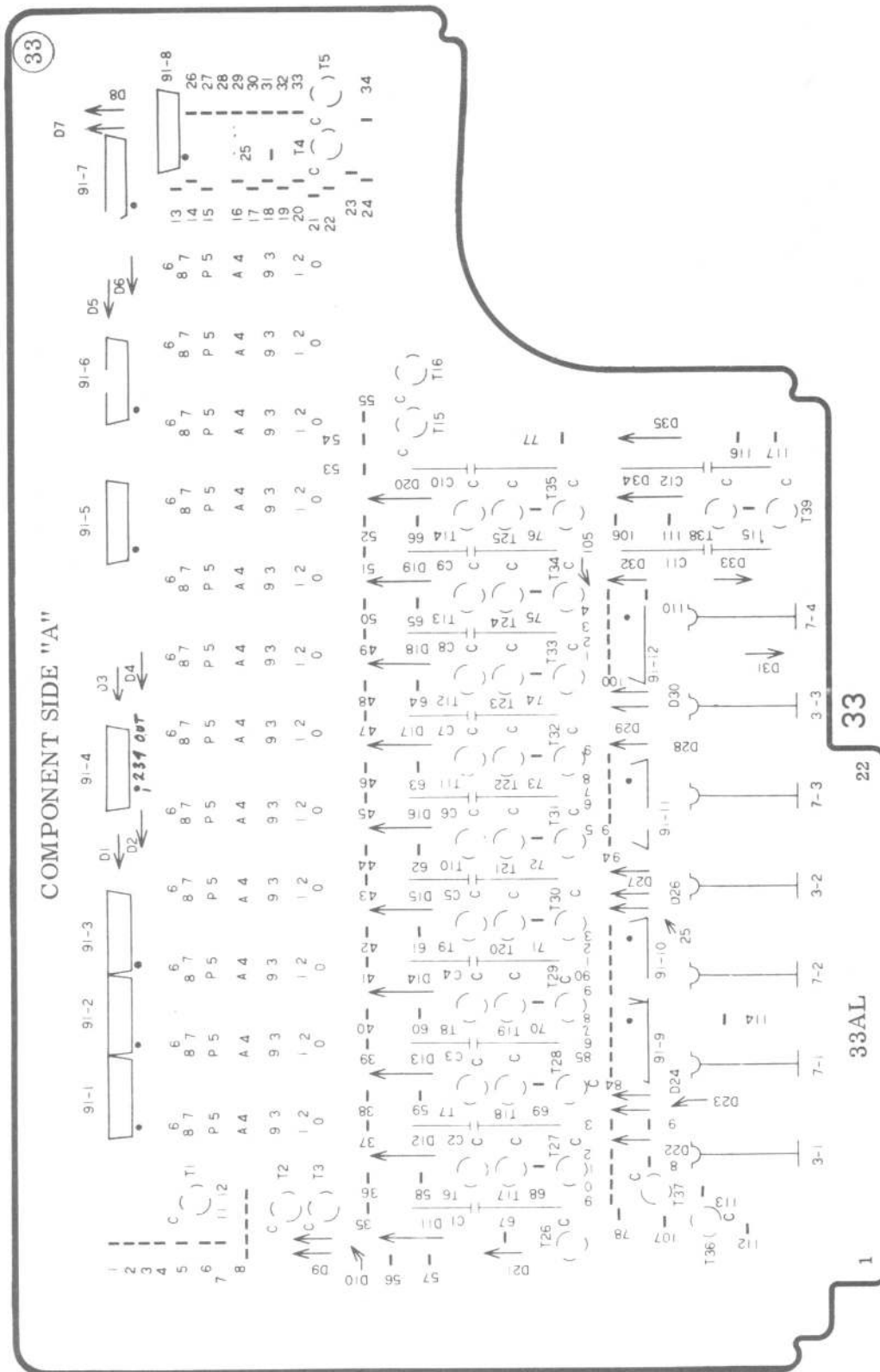
COMPONENT LIST FOR PC CARD #32

PC B NO. 32											
MOS IC	13	14	15	16	17	18	19	20	21	22	23
3-1 HD3103	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2
2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2
4-1 HD3104	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2
2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2
6-1 HD3106	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2
2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2
3	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2
4	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2
5	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2
6	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2
7-1 HD3107	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2
2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2
9-1 HD3109	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2
2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2
3	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2
12-1 HD3112	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2
30	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2
31	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2
32	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2
33	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2
R RESISTOR	34	35	36	37	38	39	40	41	42	43	44
1	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2
2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2
3	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2
4	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2
5	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2
6	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2
7	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2
8	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2
9	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2
10	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2
11	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2
12	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2
C CAPACITOR	13	14	15	16	17	18	19	20	21	22	23
1	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2
2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2
3	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2
4	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2
5	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2
6	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2
7	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2
8	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2
9	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2
10	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2
11	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2
12	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2
T TRANSISTOR	24	25	26	27	28	29	30	31	32	33	34
1	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2
2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2
3	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2
4	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2
5	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2
6	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2
7	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2
8	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2
9	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2
10	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2
11	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2
12	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2

1115 ELECTRONIC CALCULATOR

MAINTENANCE

LOGIC CARD #33 (Display Decoding, Number Indicating Tubes & Digit Counter)



1115 ELECTRONIC CALCULATOR

MAINTENANCE

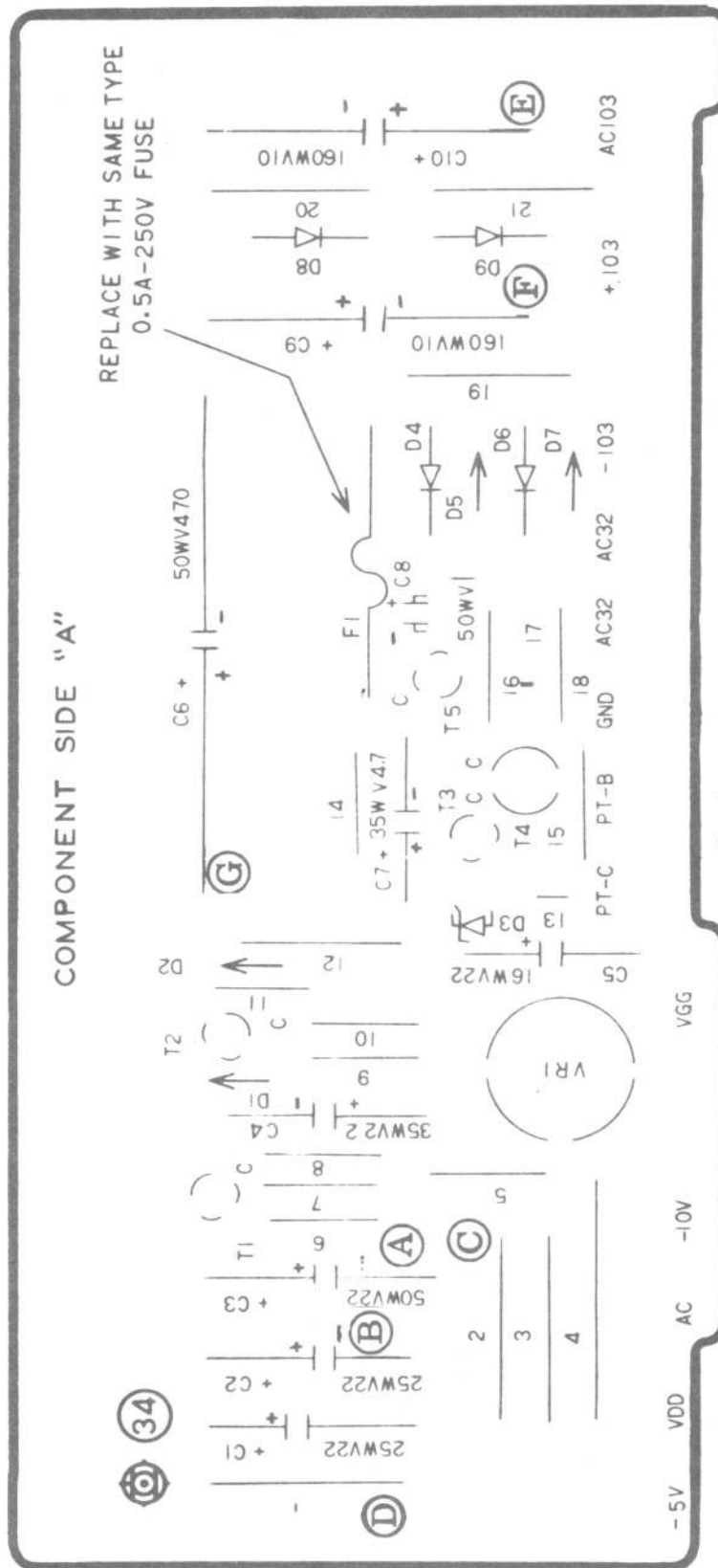
COMPONENT LIST FOR PC CARD #33

P.C.B. NO. 33									
QDS IC	22	23	24	25	26	27	28	29	30
3-1 HD3103	22	23	24	25	26	27	28	29	30
2	24	25	26	27	28	29	30	31	32
3	25	26	27	28	29	30	31	32	33
7-1 HD3107	26	27	28	29	30	31	32	33	34
2	27	28	29	30	31	32	33	34	35
3	28	29	30	31	32	33	34	35	36
4	29	30	31	32	33	34	35	36	37
	30	31	32	33	34	35	36	37	38
	31	32	33	34	35	36	37	38	39
	32	33	34	35	36	37	38	39	40
	33	34	35	36	37	38	39	40	41
R RESISTOR	34	35	36	37	38	39	40	41	42
1	35	36	37	38	39	40	41	42	43
2	36	37	38	39	40	41	42	43	44
3	37	38	39	40	41	42	43	44	45
4	38	39	40	41	42	43	44	45	46
5	39	40	41	42	43	44	45	46	47
6	40	41	42	43	44	45	46	47	48
7	41	42	43	44	45	46	47	48	49
8	42	43	44	45	46	47	48	49	50
9	43	44	45	46	47	48	49	50	51
10	44	45	46	47	48	49	50	51	52
11	45	46	47	48	49	50	51	52	53
12	46	47	48	49	50	51	52	53	54
13	47	48	49	50	51	52	53	54	55
14	48	49	50	51	52	53	54	55	56
15	49	50	51	52	53	54	55	56	57
16	50	51	52	53	54	55	56	57	58
17	51	52	53	54	55	56	57	58	59
18	52	53	54	55	56	57	58	59	60
19	53	54	55	56	57	58	59	60	61
20	54	55	56	57	58	59	60	61	62
21	55	56	57	58	59	60	61	62	63
	56	57	58	59	60	61	62	63	64
	57	58	59	60	61	62	63	64	65
	58	59	60	61	62	63	64	65	66
	59	60	61	62	63	64	65	66	67
	60	61	62	63	64	65	66	67	68
	61	62	63	64	65	66	67	68	69
	62	63	64	65	66	67	68	69	70
	63	64	65	66	67	68	69	70	71
	64	65	66	67	68	69	70	71	72
	65	66	67	68	69	70	71	72	73
	66	67	68	69	70	71	72	73	74
	67	68	69	70	71	72	73	74	75
	68	69	70	71	72	73	74	75	76
	69	70	71	72	73	74	75	76	77
	70	71	72	73	74	75	76	77	78
	71	72	73	74	75	76	77	78	79
	72	73	74	75	76	77	78	79	80
	73	74	75	76	77	78	79	80	81
	74	75	76	77	78	79	80	81	82
	75	76	77	78	79	80	81	82	83
	76	77	78	79	80	81	82	83	84
	77	78	79	80	81	82	83	84	85
	78	79	80	81	82	83	84	85	86
	79	80	81	82	83	84	85	86	87
	80	81	82	83	84	85	86	87	88
	81	82	83	84	85	86	87	88	89
	82	83	84	85	86	87	88	89	90
	83	84	85	86	87	88	89	90	91
	84	85	86	87	88	89	90	91	92
	85	86	87	88	89	90	91	92	93
	86	87	88	89	90	91	92	93	94
	87	88	89	90	91	92	93	94	95
	88	89	90	91	92	93	94	95	96
	89	90	91	92	93	94	95	96	97
	90	91	92	93	94	95	96	97	98
	91	92	93	94	95	96	97	98	99
	92	93	94	95	96	97	98	99	100
	93	94	95	96	97	98	99	100	101
	94	95	96	97	98	99	100	101	102
	95	96	97	98	99	100	101	102	103
	96	97	98	99	100	101	102	103	104
	97	98	99	100	101	102	103	104	105
	98	99	100	101	102	103	104	105	106
	99	100	101	102	103	104	105	106	107
	100	101	102	103	104	105	106	107	108
	101	102	103	104	105	106	107	108	109
	102	103	104	105	106	107	108	109	110
	103	104	105	106	107	108	109	110	111
	104	105	106	107	108	109	110	111	112
	105	106	107	108	109	110	111	112	113
	106	107	108	109	110	111	112	113	114
	107	108	109	110	111	112	113	114	115
	108	109	110	111	112	113	114	115	116
	109	110	111	112	113	114	115	116	117
	110	111	112	113	114	115	116	117	118
	111	112	113	114	115	116	117	118	119
	112	113	114	115	116	117	118	119	120
	113	114	115	116	117	118	119	120	121
	114	115	116	117	118	119	120	121	122
	115	116	117	118	119	120	121	122	123
	116	117	118	119	120	121	122	123	124
	117	118	119	120	121	122	123	124	125
	118	119	120	121	122	123	124	125	126
	119	120	121	122	123	124	125	126	127
	120	121	122	123	124	125	126	127	128
	121	122	123	124	125	126	127	128	129
	122	123	124	125	126	127	128	129	130
	123	124	125	126	127	128	129	130	131
	124	125	126	127	128	129	130	131	132
	125	126	127	128	129	130	131	132	133
	126	127	128	129	130	131	132	133	134
	127	128	129	130	131	132	133	134	135
	128	129	130	131	132	133	134	135	136
	129	130	131	132	133	134	135	136	137
	130	131	132	133	134	135	136	137	138
	131	132	133	134	135	136	137	138	139
	132	133	134	135	136	137	138	139	140
	133	134	135	136	137	138	139	140	141
	134	135	136	137	138	139	140	141	142
	135	136	137	138	139	140	141	142	143
	136	137	138	139	140	141	142	143	144
	137	138	139	140	141	142	143	144	145
	138	139	140	141	142	143	144	145	146
	139	140	141	142	143	144	145	146	147
	140	141	142	143	144	145	146	147	148
	141	142	143	144	145	146	147	148	149
	142	143	144	145	146	147	148	149	150
	143	144	145	146	147	148	149	150	151
	144	145	146	147	148	149	150	151	152
	145	146	147	148	149	150	151	152	153
	146	147	148	149	150	151	152	153	154
	147	148	149	150	151	152	153	154	155
	148	149	150	151	152	153	154	155	156
	149	150	151	152	153	154	155	156	157
	150	151	152	153	154	155	156	157	158
	151	152	153	154	155	156	157	158	159
	152	153	154	155	156	157	158	159	160
	153	154	155	156	157	158	159	160	161
	154	155	156	157	158	159	160	161	162
	155	156	157	158	159	160	161	162	163
	156	157	158	159	160	161	162	163	164
	157	158	159	160	161	162	163	164	165
	158	159	160	161	162	163	164	165	166
	159	160	161	162	163	164	165	166	167
	160	161	162	163	164	165	166	167	168
	161	162	163	164	165	166	167	168	169
	162	163	164	165	166	167	168	169	170
	163	164	165	166	167	168	169	170	171
	164	165	166	167	168	169	170	171	172
	165	166	167	168	169	170	171	172	173
	166	167	168	169	170	171	172	173	174
	167	168	169	170	171	172	173	174	175
	168	169	170	171	172	173	174	175	176
	169	170	171	172	173	174	175	176	177
	170	171	172	173	174	175	176	177	178
	171	172	173	174	175	176	177	178	179
	172	173	174	175	176	177	178	179	180
	173	174	175	176	177	178	179	180	181
	174	175	176	177	178	179	180	181	182
	175	176	177	178	179	180	181	182	183
	176	177	178	179	180	181	182	183	184

1115 ELECTRONIC CALCULATOR

MAINTENANCE

LOGIC CARD #34 (Power Supply)



34

TEST POINTS

A=-24V	D=-5V	G=0V
B=-14V	E=+103V	
C=-10V	F=-103V	

1115 ELECTRONIC CALCULATOR

MAINTENANCE

COMPONENT LIST FOR PC CARD #34

P. C. B. NO. 34									
R RESISTOR	D	D IODE	T	TRANSISTOR					
1	1W 68Ω	1	1S2075	12SA617	⊗				
2	• 220Ω	2	•	22SB77	⊗				
3	• 100Ω	3	1S760	3	"				
4	2W100Ω	4	V06C	4	2SB89				
5	1/8 15KΩ	5	1S84	5	2SB77	⊗			
6	• 82KΩ	6	V06C						
7	• 22KΩ	7	1S84						
8	• 82KΩ	8	V06C						
9	• 22KΩ	9	"						
10	• 15KΩ								
11	• 22KΩ								
12	1/4 33KΩ								
13	⊗ 1/4 22KΩ								
14	1/8 10KΩ								
15	• "								
16	• 18KΩ	C	CHAPACITOR						
17	⊗ 1/8 10KΩ	1	25WV22μF						
18	1/8 18KΩ	2	"						
19	1/4 100KΩ	3	50WV •	F FUSE					
20	• "	4	35WV 47μF	1	0.5A 250V				
21	• 470Ω	5	16WV 22μF						
		6	50WV 470μF						
		7	35WV 47μF						
		8	50WV 1μF						
		9	16WV 10μF						
		10	"						

MAINTENANCE

The diagram illustrates the power supply circuit for a radio receiver. Key components and connections include:

- Power Input:** A power cord is connected to a power switch and a power connector, which leads to the transformer.
- Transformer:** The transformer has multiple secondary windings: 32-0-32V, 0-3V, 0-2V, 100V, 10V, 117V, 120V, and 0-1V.
- Filtering and Protection:** The 32-0-32V winding is connected to a noise filter and a solderless terminal block. A fuse is connected to the 100V winding.
- Power Distribution:**
 - The 103V winding is connected to a power transistor (2SB337B) and a 103V supply line.
 - The 10V winding is connected to a 10V supply line.
 - The 5V winding is connected to a 5V supply line.
- Lighting and Control:**
 - Neon tubes for negative and over flow light are connected to the 103V and 10V supply lines.
 - The P.C. board (No. 34) is connected to the 10V supply line.
- Terminal Plate Assembly:** The terminal plate assembly (left and right) is connected to the 5V supply line.
- Back Wiring:** The back wiring of the terminal plate assembly is shown, with connections for 3BL 1, 3BL 2, 3BL 3, 3BL 4, 3BL 5, 3BL 6, 3BL 7, 3BL 8, 3BL 9, 3BL 10, 3BL 11, 3BL 12, 3BL 13, 3BL 14, 3BL 15, and 3BL 16.

1115 ELECTRONIC CALCULATOR

MAINTENANCE

J. WIRING LISTS & SIGNAL NAME CROSS REFERENCE

SIGNAL OF TERMINAL (IN P.C. BOARD CONNECTOR)

PCB No.		PCB No.		PCB No.		PCB No.	
PIN No.	PIN No.	PIN No.	PIN No.	PIN No.	PIN No.	PIN No.	PIN No.
31		32		33		34	
A	B	A	B	A	B	A	B
1	WT2CPI	1	GND	1	GND	1	GND
2	D	2	R2P=12	2	GND	2	OVF2
3	M	3	VGG	3	VGG	3	VGG
4	MDF	4	VDD	4	VGG	4	OVFL
5	SOVF2	5	AOS	5	VDD	5	IRSL
6	FAS SUB	6	X0	6	BT4	6	-10V
7	XC4	7	OSF	7	FA	7	(DT1)
8	R2N6 > 4	8	RSH	8	1	8	VDD
9	MLT2+DIV2	9	DIV2	9	XC3	9	DT1
10	FA	10	K7	10	R2N6 > 4	10	DT1
11	BT2	11	XC3	11	FCIN	11	DT1
12	CDP	12	N1	12	C+AC	12	DT1
13	K3	13	CWF	13	(X0)	13	DT1
14	N	14	BD	14	DT1+DT2	14	DT1
15	DT2	15	DT2+BT1	15	DIV2	15	DT1
16	BT1	16	WT1	16	N+P	16	DT1
17	K6	17	N2	17	CHG	17	DT1
18	R2	18	C+AC+CE	18	ENT	18	DT1
19	SIRS	19	BT3	19	BT3	19	DT1
20	R3	20	K5	20	MDF	20	DT1
21	DT1	21	DT16	21	LSH	21	DT1
22	LSH+RSH	22	N3	22	%F	22	DT1
1	BT4	1	K9	1	BT4CPI	1	WT1
2	BT4CPI	2	C+AC	2	RSH	2	SOFA
3	N4	3	FP2	3	KFF2	3	S
4	LSH	4	%F	4	(BT1)	4	X0
5	FP5	5	DT1+DT2	5	DT2+BT4	5	OVFI
6	SOVF	6	R	6	R1	6	TC=16
7	A	7	CPI	7	SOVF2	7	OP
8	S	8	CHG	8	R2P=12	8	N
9	OVFI	9	KEY COMMON	9	BT1	9	POT
10	P	10	XC2	10	C+AC+CE	10	OVF2
11	N+P	11	CP2	11	CP2	11	OSF
12	DT3	12	KFF2	12	CP2	12	(R2)
13	%F-K%	13	OVF2	13	DT1+DT2	13	DT2+BT1
14	TC=16	14	KEY COMMON	14	CPI	14	DT3
15	DT1+DT2	15	K(MLT2+DIV2)	15	DT2	15	BT2
16	(WT2)	16	CPI	16	WT2CPI	16	BT3
17	DT4	17	WT2	17	DT16	17	WTCP1
18	R1	18	ENT	18	(CPI M)	18	MLT2+DIV2
19	DT2+BT4	19	FP COMMON	19	WT2	19	CPI
20	FCIN	20	K(MLT2+DIV2)(MLT2+DIV2)	20	(CP2 M)	20	(CP2 M)
21	OP	21	WTCP1	21	CP1 M	21	CP1 M
22	POT	22	(KFF2)	22	WT2	22	CP2 M

1115 ELECTRONIC CALCULATOR

MAINTENANCE

BACK WIRING

BACK WIRING

SIGNAL	TERMINAL NUMBER		SIGNAL	TERMINAL NUMBER		SIGNAL	TERMINAL NUMBER		SIGNAL	TERMINAL NUMBER	
CP1	IBR16	2AR14	FA SUB	IAL6	2AL5	B/D	IBL14	2AL19		IBL14	2AL19
CP2	IBR17	2AR12	FA	IAL10	2BL7	K 3	IAL13			IAL13	
CP1	IBR7	2BR13	FC IN	IAL20	2BL11	K 5	IAL20			IAL20	
CP1M	2BR21		$R2M > 4$	IAL8	2BL10	K 6	IAL17			IAL17	
CP2M	2BR22		$R2P = 12$	IBL2	2AR8	K 7	IBL10			IBL10	
(CP2M)	2BR20		TC = 16	IAL4	2BR6	K 9	IBR1			IBR1	
WTCP1	IBR21		MDF	IAL5	2AL20						
WT2CP1	IAL1	2BR17	SOVF2	IAL5	2AR7						
ET4CP1	IAL2	2AR1	OVF2	IBR13	2BR10	A	IAL7			IAL7	
			SIRS	IAL19	3AL10	S	IAL8			IAL8	
			SOSE	IAL6	2BR2	M	IAL3			IAL3	
WT1	IBL16	2BR1				D	IAL2			IAL2	
WT2	IBR17	2AR22				R	IBR6			IBR6	
(WT2)	IAL16					C+AC	IBR2			IBR2	
						C+AC+CE	IBL18			IBL18	
							2AL6			2AL6	
DT1	IAL21	2BL14	CWF	IBL13	2BL21		2BL8			2BL8	
DT2	IAL15	2AR15	RSH	IBL8	2AR2		2AL7			2AL7	
DT3	IAL12	3AL11	LSH	IAL4	2AL21		3AL8			3AL8	
DT4	IAL17	2BL22	CHG	IBR8	2AL17		2BL13			2BL13	
DT16	IBL21	2AR17	LSH+RSH	IAL22	2BL19		2AL2			2AL2	
(DT1)	3BL7	3AL22	AOS	IBL5	2BL20		3AL5			3AL5	
DT1+DT2	IBR5	2AR3	OSF	IBL7	2BR11		2AL8			2AL8	
DT1+DT2	IBL15	2AL13	POT	IAL22	2BR9		2AL1			2AL1	
DT2-BT1	IBL15	2BR13	ENT	IAL12	2BL18		2AL3			2AL3	
DT2-BT4	IAL19	2AR5	DIV2	IBL9	2AL15						
			MLT2+DIV2	IAL9	2BR18						
BT1	IAL16	2AR9	K (MLT2+DIV2)/MLT	IBR20	2BL16						
BT2	IAL11	2BR15	+DIV2								
BT3	IBL19	2BR16	%F	IBR4	2AL22						
BT4	IAL1	2BL6	%F.K%	IAL13	2AL9						
(BT1)	2AR4		KFF2	IBR12	2AR3						
FP2	IBR19		(KFF2)	IBR22							
FP3	IBR3		KCOMMON	IBR14							
FP5	IAL5		KEY COMMON	IBR9							
			N+P	IAL11	2AL16						
			N	IAL14	2BR8						
R1	IAL18	2AR6	P	IAL10							
R2	IAL18	2BL15	N1	IBL12							
R3	IAL20	2AL11	N2	IBL17							
OP	IAL21	2BR7	N3	IBL22							
X0	IBL16	2AL12	N4	IAL3							
XC2	IBR10	2AL4									
XC3	IBL11	2BL9	K (MLT+DIV2)	IBR15							
XC4	IAL17	2AL10									

1115 ELECTRONIC CALCULATOR

MAINTENANCE

INTERCONNECTION BETWEEN REMOVABLE SUB CONNECTOR AND KEYBOARD

SIGNAL	TERMINAL NUMBER	
	SUB CONNECTOR	KEY BOARD
N1	C1	A 28
D	C2	A 4
C+AC	C3	A 32
K3	C4	A 23
N3	C5	A 25
N	C6	A 27
C+AC+CE	C7	A 29
A	C8	A 13
K6	C9	A 17
K7	C10	A 20
R/O F	C11	A 14
FP2	C12	B 2
FP5	C13	B 4
K9	C14	A 16
KF COMMON	C15	A 3
K·(MLT2+DIV2)	C16	A 34
GND	C17	A 30
KEY COMMON	C19	A 24
N2	C20	A 26
S	C21	A 10
R	C22	A 11
P	C23	A 22
M	C24	A 12
R/O F·K R/O	C25	A 15
N4	C26	A 21
K5	C27	A 19
FP COMMON	C28	B 3
MLT2+DIV2	C29	A 33
DT1	C30 (C31)	
R2	C32	
OVF2	C33	
CP1M	C36 (C37)	
CP2M	C38 (C39)	
WT2	C40 (C41)	
BT1	C42 (C43)	
KFF2	C44 (C45)	

1115 ELECTRONIC CALCULATOR

SECTION 6

FLOW CHARTS

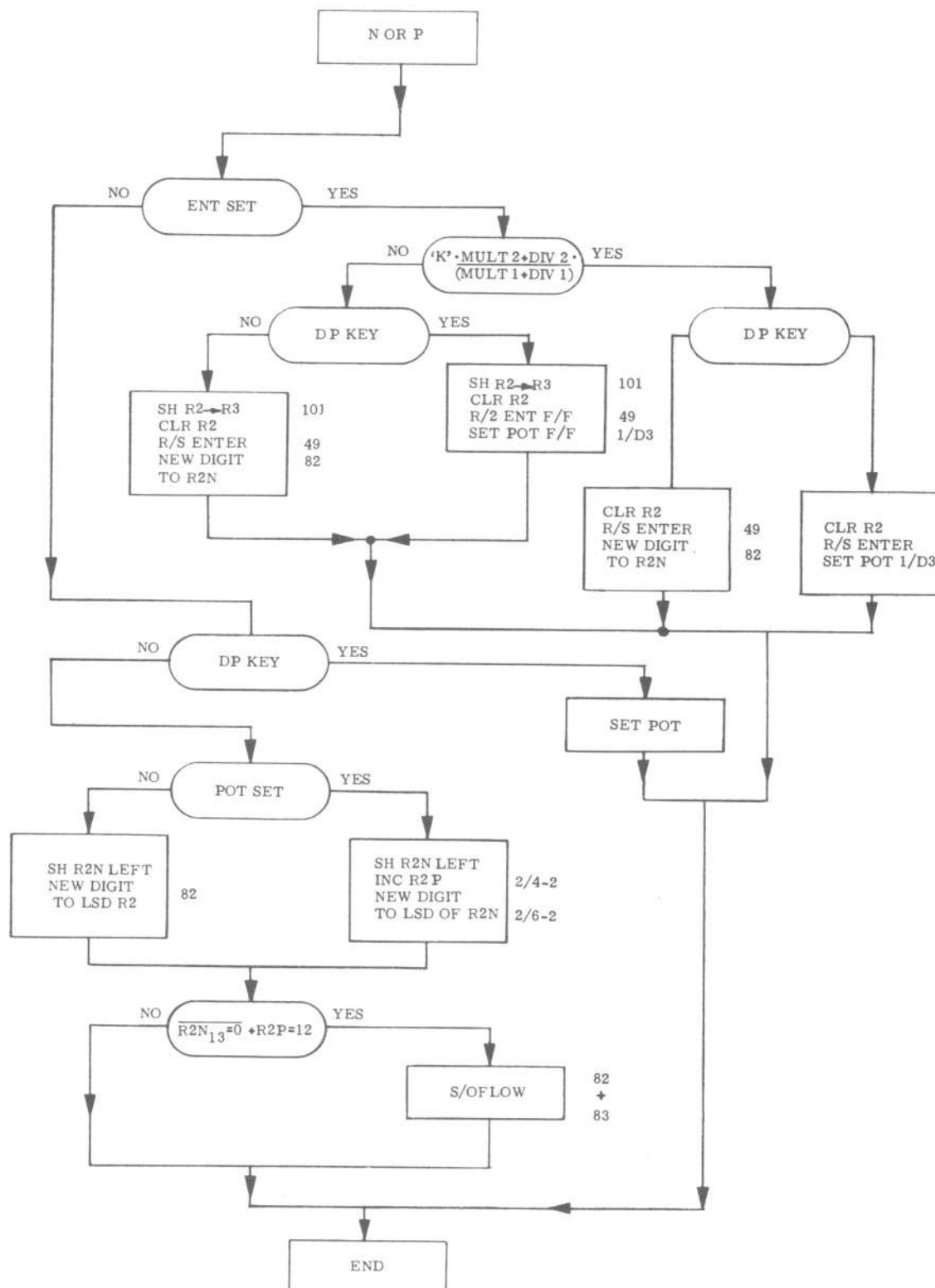
SECTION CONTENTS

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D. DIVIDE	6-6
E. M, D, +=, -=	6-9

1115 ELECTRONIC CALCULATOR

FLOW CHARTS

A. ENTRY



EC 1115

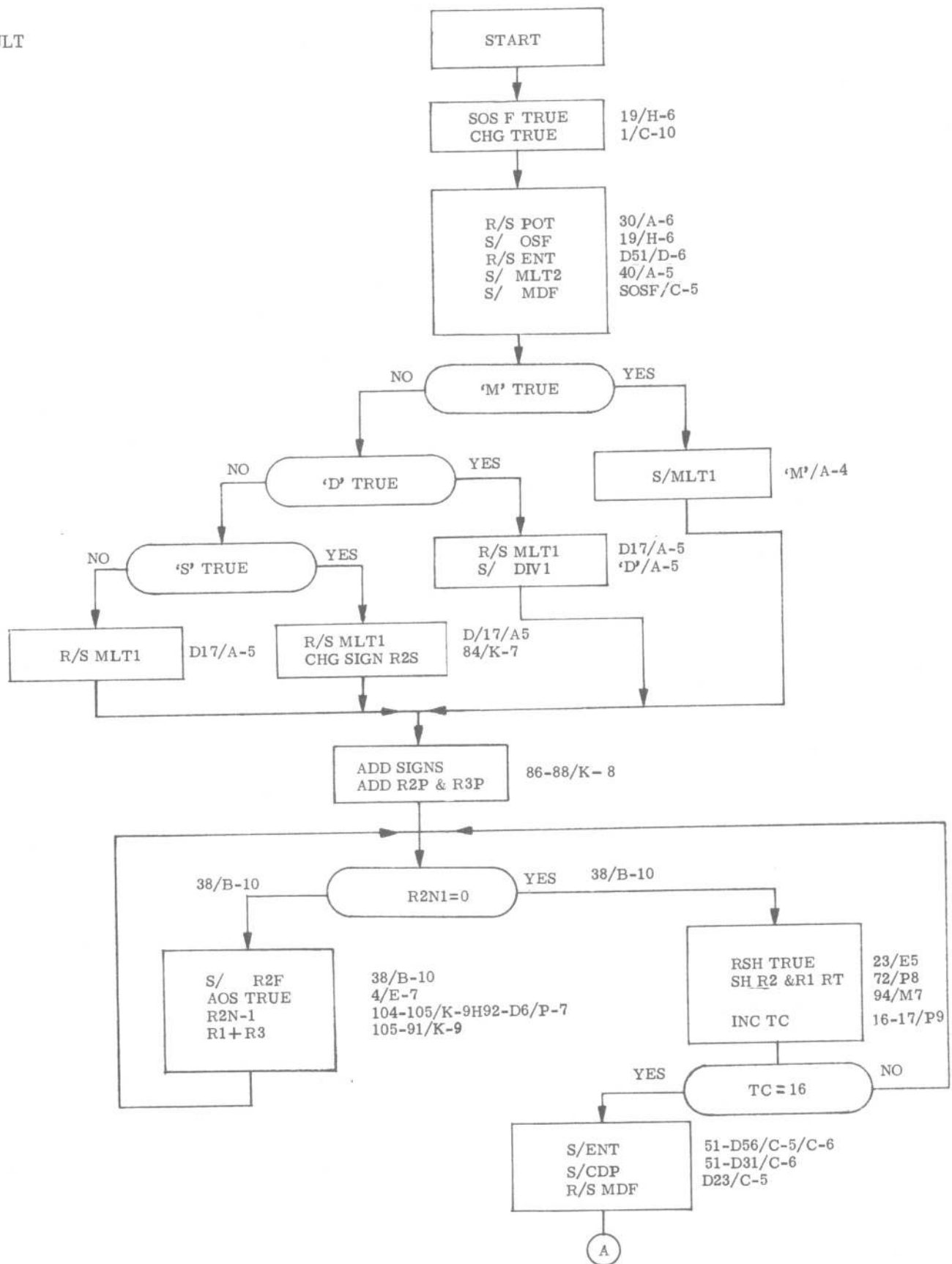
FLOW CHARTS

[illegible]

1115 ELECTRONIC CALCULATOR

FLOW CHARTS

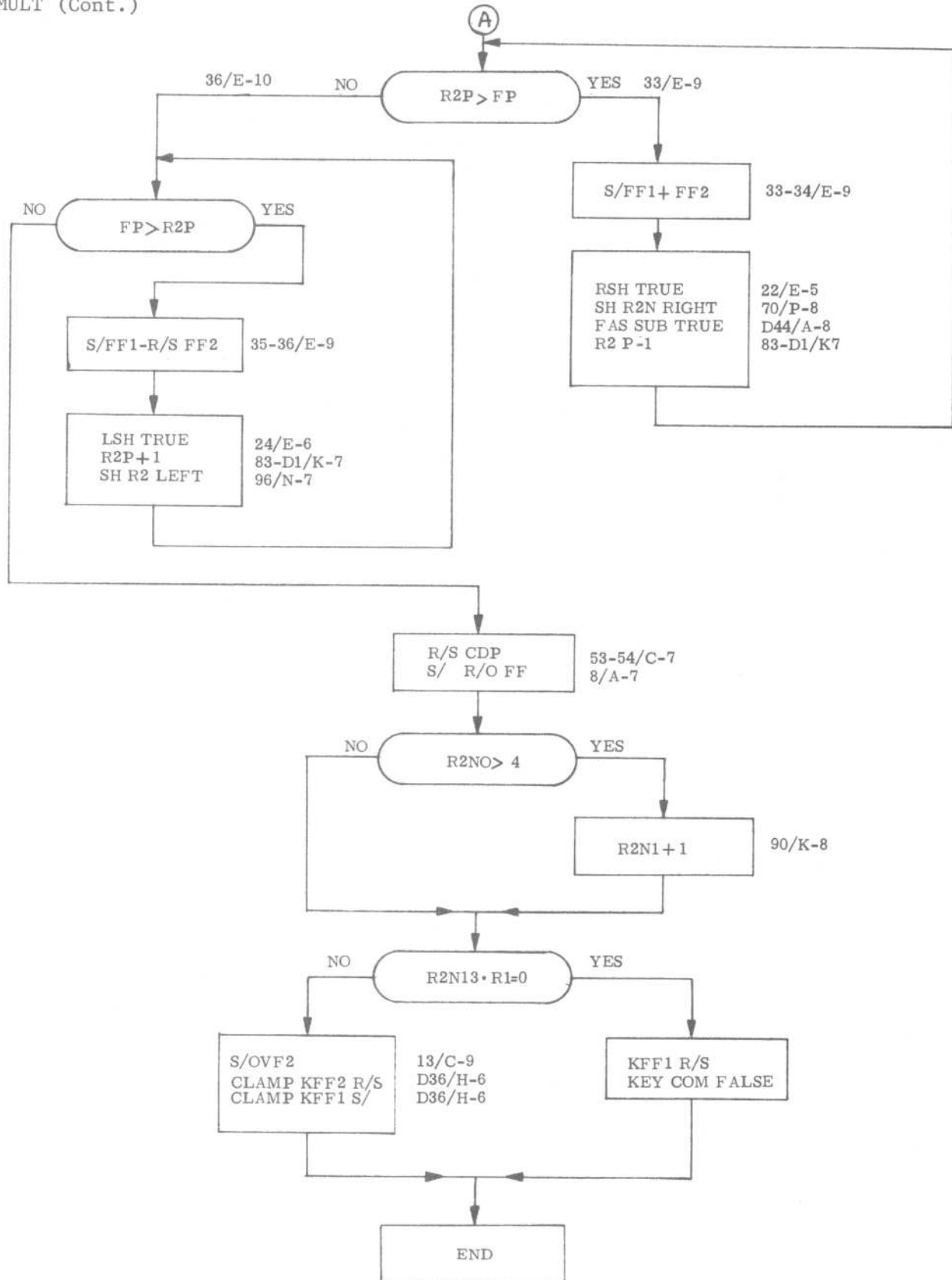
C. MULT



1115 ELECTRONIC CALCULATOR

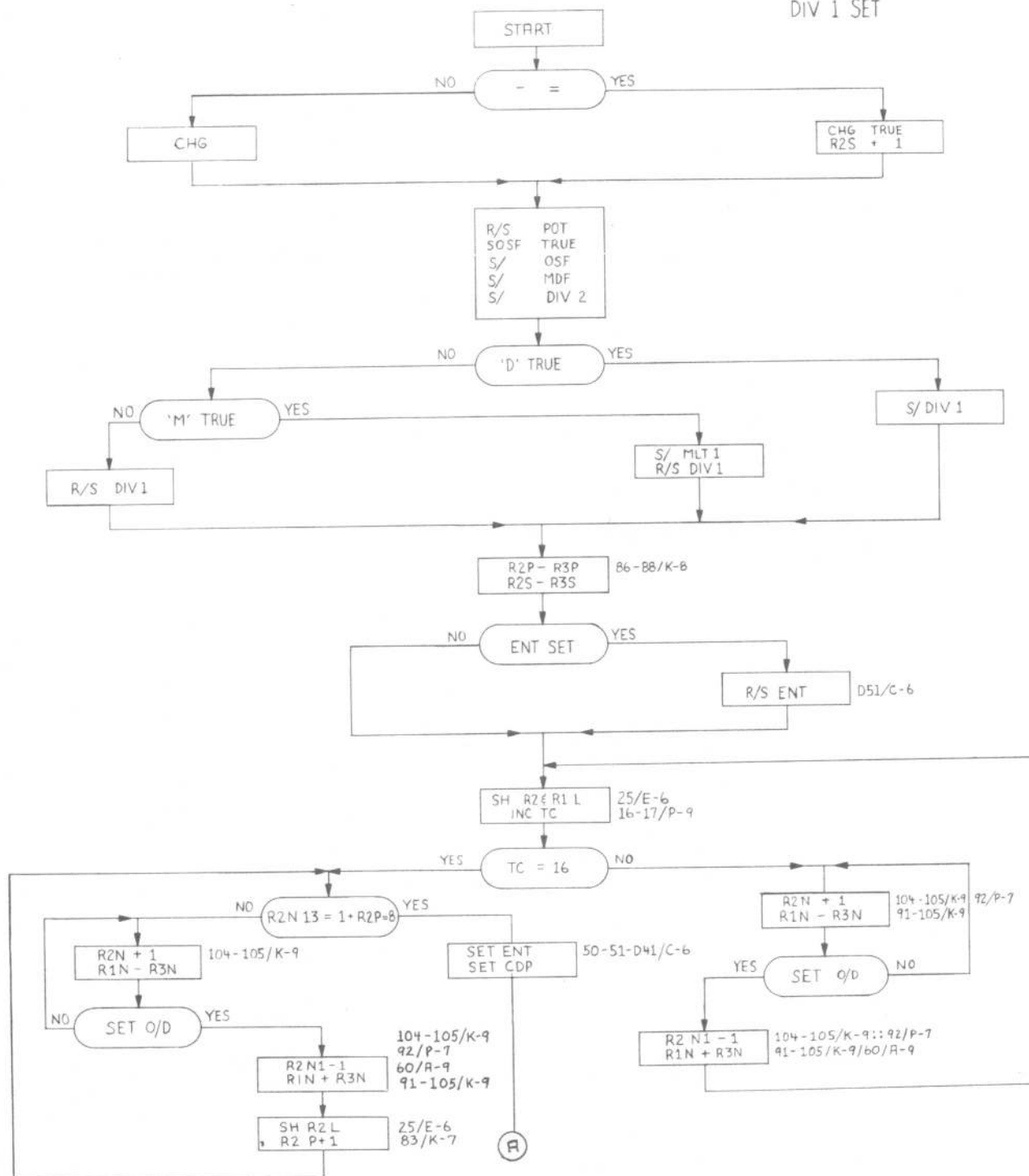
FLOW CHARTS

C. MULT (Cont.)



FLOW CHARTS

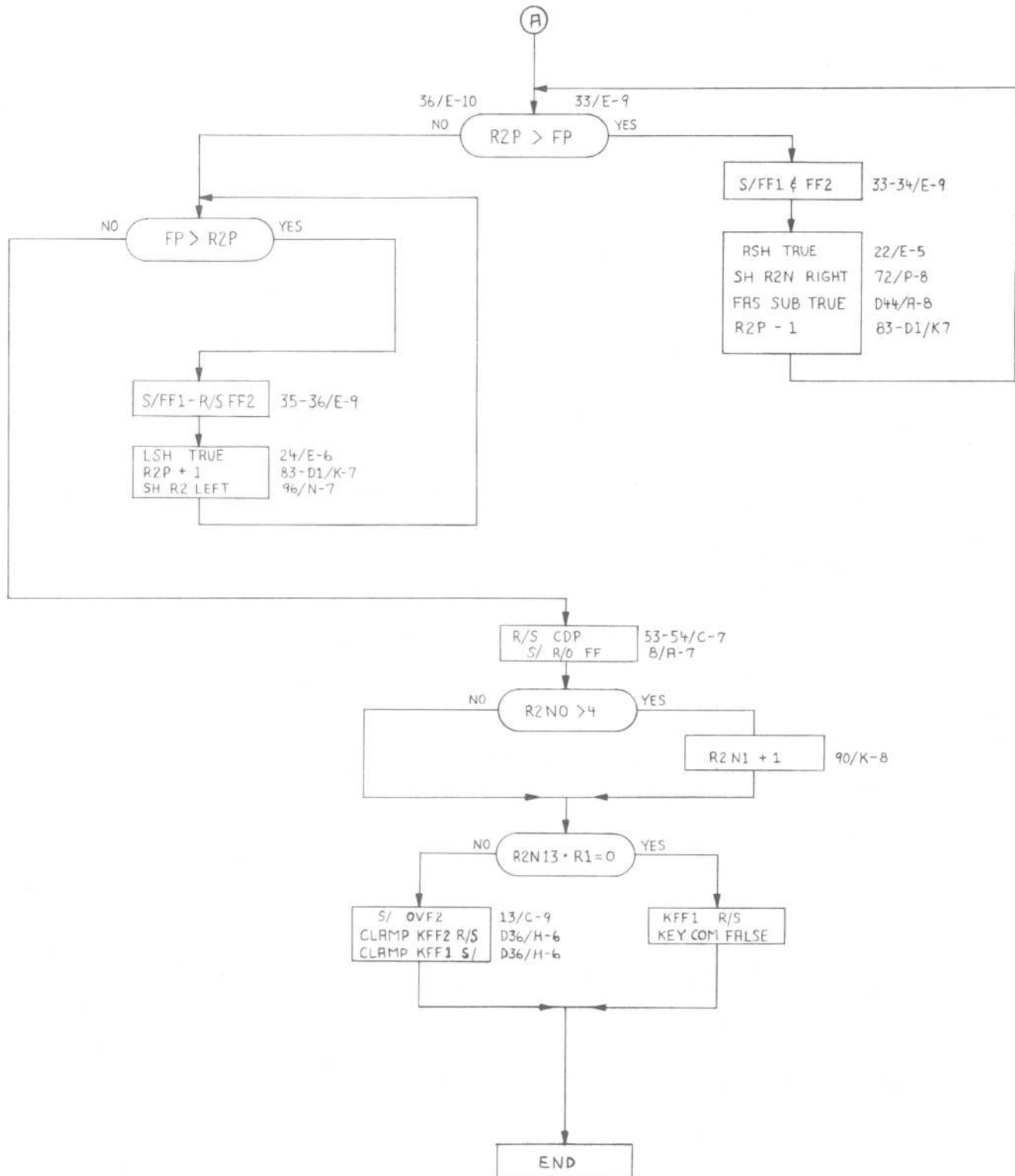
DIV 1 SET



1115 ELECTRONIC CALCULATOR

FLOW CHARTS

D. DIVIDE (Cont.)



1115 ELECTRONIC CALCULATOR

FLOW CHARTS

E. M, D, +=, -=

