INSTRUCTION MANUAL

TEKTRONIX
21 AND 31
CALCULATOR

(Preliminary)
SERVICE MANUAL

TEKTRONIX®

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(Preliminary) SERVICE MANUAL

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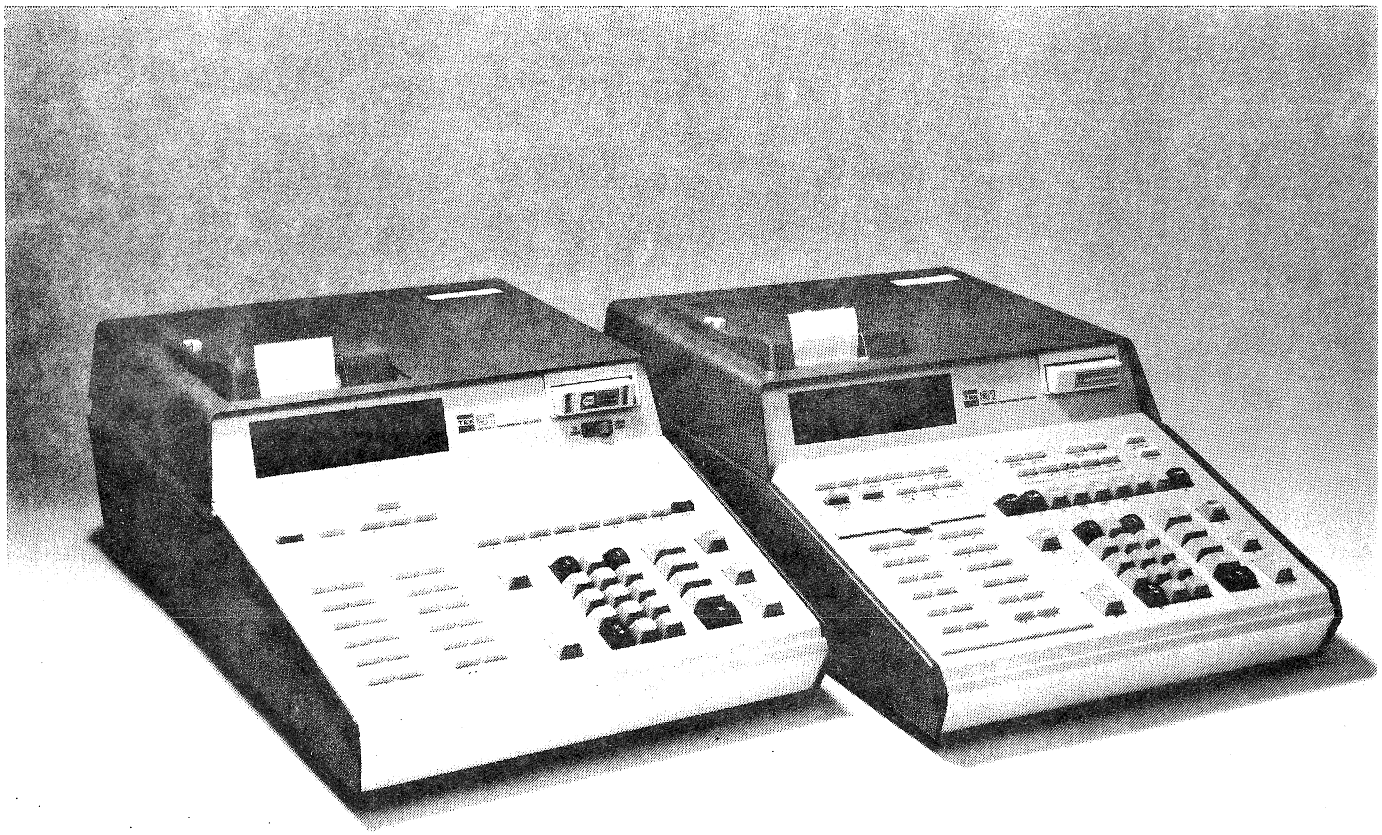


TEKTRONIX 21 TEKTRONIX 31

SERVICE MANUAL FOR TEKTRONIX 21 AND 31

SECTION I

DIAGNOSTIC PROCEDURE

Introduction

The TEK 21 and TEK 31 are programmable desk top calculators. The servicing requirements for the two calculators are simplified by the use of plug-in modules. This modular system departmentalizes the calculator into replaceable units, to allow faster servicing of the calculator.

The Service Manual is written with the modular system concept. All troubleshooting procedures are intended to diagnose the problem at the modular level.

There are eight replaceable modules in the TEK 21, and nine in the TEK 31. These are:

A. Modules for Tektronix 21

1. Calculator Board
2. Printer Logic Board/f(x) Board
3. Display/Keyboard/Front Panel Assembly
4. Interface Board
5. Power Supply
6. Printer
7. Mag Card Assembly
8. Fan Assembly

B. Modules for Tektronix 31

1. Calculator Board
2. Programmer Board/Memory Board
3. Auxiliary Memory Board

B. Modules for Tektronix 31 (Cont)

4. Display/Keyboard/Front Panel Assembly
5. Interface Board
6. Power Supply
7. Printer
8. Mag Tape Assembly
9. Fan Assembly

The removal and replacement of the above listed modules are covered under Disassembly Procedures.

Quick Calculator Checks

A few simple checks may be made at the start of a diagnostic session, to yield a rapid solution to the existing calculator problem.

Several observations can be made by simply turning the calculator on. The display should light with flashing numbers showing in the display. The BUSY light will be on for a brief period depending on the length of time required to clear the memory, and the RAD light will be on indicating the initial trigonometric operating mode. At times, the LEARN light will come on with the BUSY light. This is a normal condition. No other indicator lamp should be lit at this time.

At this point it is reasonable to assume that the Power Supply, Display, Calculator board, and Programmer board are working. A later check may reveal problems in one of these areas.

DIAGNOSTIC PROCEDURE

If these checks work, further checks can be made, utilizing the calculator to check its own operations.

Power Supply Checks

Before proceeding with any further checks it is necessary to ascertain that the Power Supply is working properly. If the Power Supply is not working, other assemblies may appear to malfunction. To avoid later misleading information from these and other checks, the unregulated +300 VDC, the regulated +15 VDC, the +5 VDC, and the -13 VDC supplies should be measured with respect to chassis ground for the proper levels. These checks will verify most of the Power Supply circuits. The calculator checks found elsewhere in this manual assume the Power Supply to be working properly.

Display Checks

If the display does not come on after the initial power up sequence, check the fuse on the back of the Calculator. If the fuse is good, the cooling fan should be running. With no display and the fan operating, press K: the ADDR INCOMP light (lower right corner of display) should come on. The light should be extinquished by pressing any number from zero to nine.

If the display is still blank, even though the ADDR INCOMP light came on, the problem is most likely in the +300 VDC supply voltage, the fuse located inside the calculator on the Power Supply, the Display board, or a combination of the above. If the

ADDR INCOMP light does not light, the problem is probably in the Power Supply or a short somewhere in the system. If the +300 V are present and the +5 V are present, and there still is no display, replace the calculator board.

After the initial power up sequence, if the DEG light is on instead of the RAD light, the problem is probably on the Calculator board. If any of the LEARN, STOP or ADDR INCOMP lights are on, the problem is probably the Programmer/Memory board in the TEK 31 or the f(x) board in the TEK 21. If the BUSY light is on, the problem is probably in the Calculator or f(x) board in the TEK 21 or in the Calculator or Programmer/Memory board in the TEK 31. A problem may also exist in the Printer if the display indicates the Calculator is in the BUSY mode.

With the display flashing and the RAD light on, push CLEAR. The display should clear and show ten zero's. If CLEAR doesn't appear to function, the problem is probably in the Programmer/Memory board in the TEK 31, or the f(x) board in the TEK 21.

Programmer Board Check

Press LEARN (green key). The display will go to all zeros with two spaces and no exponent showing. The display mode format will appear as follows: 0000 000 0. Press $\boxed{\text{LEARN}}$ again. The display should return to ten zeros and the RAD light should remain on. If this does not occur, replace the Programmer/Memory board assembly.

DIAGNOSTIC PROCEDURE

Try running a simple program. Turn the Printer off.

Enter the following program:

RST	LRN	R	0	0	+	1	=	R	0	0	PRINT DISP	PAUSE	START	LRN

To run the program, press:

RESET	START

The program should count at the rate of approximately one count per second. To stop the count, press $\boxed{\text{STOP}}$. If the program does not run, replace Programmer/Memory board assembly. If the program still does not run, replace the Calculator board.

Calculator Board Check

To quickly check the Calculator board a simple calculation is performed.

Press	1	+	2	x	3	x↑A	(	9	-	3	0	÷	3	$\sqrt{\Sigma x^2}$	4	)	=

The display should read: 0000000055.

If the display does not appear as above, replace the Calculator board. If the Programmer/Memory board has been replaced, the problem is definitely the Calculator board. If the Calculator board has been replaced, replace the Programmer/Memory board.

If the previous calculation cannot be entered into the Calculator, and assuming the Programmer/Memory board has already been replaced, the problem is probably in the keyboard and it should be replaced.

Printer Check

Turn the printer OFF; push the PAPER FEED button on the Printer Module next to the printer power ON button. The paper should feed in a normal manner. If there is no paper in the printer, load the paper following the directions on the printer cover. Turn the printer ON and repeat the paper feed test. This tests the power supply for the printer, the paper feed switch, the stepper motor (which advances the paper), and a small portion of the logic circuitry. If the power supply unregulated +20 VDC is present and the paper feed doesn't work, replace the Printer Module.

A further check of the printer can be performed by trying to run the program listed under Programmer board checks.

Enter the program into the calculator. Turn the printer on. Press | RESET | START |. The printer should now printer numbers in sequence. If it does not, and the Programmer/Memory board has already been replaced, the problem is in the printer module, which should be replaced.

Test Procedures

Introduction

The test procedures used in this section will eliminate all but the extreme, hard to separate problems. After each test, the area or module most likely to be causing the problem is indicated. If two or more modules are listed, an order of replacement preference is indicated. By the process of elimination, the failing module should be isolated and the problem eliminated. It is practically impossible to make a cut-and-dried modular replacement-troubleshooting procedure, since each module is interrelated to the other modules.

In the final analysis, the ingenuity and knowledge of the troubleshooter, may be the only ingredient to a successful diagnostic procedure.

Tests for TEKTRONIX 21

Mag Card Reader

A functional test of the card reader must determine that the unit will read a program from memory onto a card, and write the same program into memory. In addition, the card reader's write-protect feature should be checked. The write-protect feature prevents over-writing of a card accidentally if the tape is cut in a manner such that a hole in the tape is not sensed by the light sensor. Removing the hole causes the sensor to be dark throughout the complete transit of the tape through the reader.

Functional Test Procedure:

1. Generate a program.

CLR	GO TO	fØ	LEARN

1	1	1	1	1	1	1	1	1	1	+/-	10^{00}	1	1	+/-	END	LEARN

2. Check Program

CLR	fØ

The program should be executed, and -1 1 1 1 1 1 1 1 1 1 -1 1 will appear in the display.

If the program does not run replace the f(x) board.

3. Load Memory into Card

GO TO	fØ	TO CARD

Insert the CARD into the left side of the reader, bevelled part down. Remove the card after it has been drawn through the cartridge.

If the card does not feed properly, check the Mag Card drive mechanism and repair it if necessary.

4. Erase Memory

Turn the calculator OFF and then back ON. This scrambles the memory.

5. Load Memory from Card

GO TO	fØ	FROM CARD

Run the card through the cartridge as before.

6. Check Program

CLR	fØ

The program should be executed, and -1 1 1 1 1 1 1 1 1 1 -1 1 will appear in the display.

If the program did not load or remained scrambled, a problem exists in the Mag Card module. If the problem cannot be immediately solved, replace the Mag Card module.

7. Write Protect Test

   A. Write-protect the card containing a program by cutting off the end of the card which contains the hole.

   B. Turn calculator OFF and then back ON.

   C. Attempt to load the scrambled memory onto the protected card.

GO TO	fØ	TO CARD

   Run the card through the cartridge and remove.

   D. Load program into memory

GO TO	fØ	FROM CARD

   Run the card through the cartridge and remove.

   E. Check the program.

CLR	GO TO	fØ	CONT

   The program should execute.

   If the above tests do not work, replace the Mag Card module and run the test again. If a problem still exists replace the f(x) board.

Programming Test

In general, the tests in this section will indicate a problem on the f(x) board. The following Programming tests will be performed:

DIAGNOSTIC PROCEDURE

A. f(x) Key test

B. Programming Keys

C. Indirect Addressing

1. Programming tests for 21

A. f(x) key

					Observe in Display
	CLR	GO TO	f(∅)	LEARN	000 00 100
LEARN	CLR	GO TO	f(1)	LEARN	001 00 060
LEARN	CLR	GO TO	f(2)	LEARN	002 00 052
LEARN	CLR	GO TO	f(4)	LEARN	004 00 012
LEARN					0000000000

B. f(x) Key Programming Check

GO TO	f(∅)	LRN	1	2	3	STOP	≥ 0	f(∅)

4	5	6	GO TO	f(1)	END	LRN

GO TO	f(1)	LRN	7	8	9	+/-	END	LRN

To run the program press CLEAR DISPLAY | f(∅) | CONT.

0000000123 will appear in the display. Press CONT again and 0000123123 will appear in the display. Continual pressing of CONT will cause 123 to march across the display, until the display is completely full.

To check the negative side of the program press CLEAR DSPLY | CONT | +/- | CONT

0123456789 will appear in the display.

If this program does not run as outlined replace the f(x) board module.

C. Indirect Address of "K" stores

GO TO	fØ	LEARN													
K	Ø	+	1	=	K	Ø	=	K	K	Ø	CD	9	-	K	Ø
)	IF≥Ø	fØ	f2	END	LEARN										
GO TO	f2	LEARN													
CD	K	1	PRT												
CD	K	2	PRT												
CD	K	3	PRT												
CD	K	4	PRT												
CD	K	5	PRT												
CD	K	6	PRT												
CD	K	7	PRT												
CD	K	8	PRT												
CD	K	9	PRT												
CD	K	0	PRT												
END	LEARN														
CD	=	K	Ø	GO TO	fØ	CONT									

The printout should be

1 .
2 .
3 .
4 .
5 .
6 .
7 .
8 .
9 .
10 .

Each K STORE should contain its own number: 1 in K1, 2 in K2, etc., except KØ contains 10.

If the program fails to run replace the f(x) board module.

Keyboard and Display Check

These checks provide assurance that the calculator is working properly. If any of the checks fail to run properly, the problem is probably in the Calculator board. The following features are exercised and observed:

1. Data Entry
2. Log Function
3. Trig Function
4. Factorial Key
5. "K" Storage
6. Σ Keys
7. Δ 3 Key
8. Product 4 Key
9. Miscellaneous Keys
   - A. Paper Feed
   - B. Integer Key
   - C. Print Display
   - D. Clear Display

DIAGNOSTIC PROCEDURE

1. Data Entry	OBSERVE IN DISPLAY
Turn Calculator on. Observe flashing display.	
Press [CLEAR]	0 0 0 0 0 0 0 0 0 0
EXECUTE	
[1] [1] [1] [1] [1] [1] [1] [1] [1] [1]	1 1 1 1 1 1 1 1 1 1
[CLR] [2] [2] [2] [2] [2] [2] [2] [2] [2] [2]	2 2 2 2 2 2 2 2 2 2
[CLR] [4] [4] [4] [4] [4] [4] [4] [4] [4] [4]	4 4 4 4 4 4 4 4 4 4
[CLR] [8] [8] [8] [8] [8] [8] [8] [8] [8] [8]	8 8 8 8 8 8 8 8 8 8

If any doubt exists as to whether these operations are being performed properly, all numbers from 1 to 9 may be exercised. As each number is pressed, the number should advance across the display filling the display with the number.

[CLR] [.] [1] [1] [1] [1] [1] [1] [1] [1] [1] [1]	. 1 1 1 1 1 1 1 1 1 1

As each number is pressed, after the decimal point has been pressed, the decimal point will move across the display, filling the indicated number in behind the decimal point.

[+/-] Press several times.	The sign of the mantissa should change with each keystroke.
[x10^{00}] Two "0" will appear in the exponent location.	0000000000 00

$\boxed{+/-}$	Press several times	The exponents sign will change with each keystroke.
$\boxed{9 \mid 9}$ $\boxed{8 \mid 8}$ $\boxed{7 \mid 7}$ . . . $\boxed{0 \mid 0}$ Press numbers in pairs.		The digits in the exponent should change with each keystroke.

If any of the above procedures fail to run, the problem is probably in the Calculator board module, although a problem may exist in the Display/Keyboard module. Replace the above modules one at a time and rerun the test. If the program does not run successfully, go back to the programming test.

If tests 2, 3, 4, 5, 6, 7, and 8 fail to run the problem is most likely in the Calculator board module.

2. Log Function Test

EXECUTE	OBSERVE
CLR | 1 | 0 | $\lvert X \rvert^a$ | 5 | = | logX	5 ..
X^2 | X^2 | X^2 | $\sqrt{X}$ | $\sqrt{X}$ | $\sqrt{X}$	5 ..
lnX | lnX | lnX | e^x | e^x | e^x	5 .
$\frac{1}{x}$ | $\frac{1}{x}$ | $\frac{1}{x}$ | $\frac{1}{x}$	5 .
π	3 . 1 4 1 5 9 2 6 5 3
= The last digit in the number should change when = is pressed.	3 . 1 4 1 5 9 2 6 5 4
DEG/RAD	1 8 0 .
DEG/RAD	3 . 1 4 1 5 9 2 6 5 4
CLR | 2 | 0 | lnX | - | 2 | . | 9 | 9 | 5 | 7 | 3 | 2 | 2 | 7 | 4 | =	- 4 . 5 0 0 0 0 0 0 0 0 - 1 0

3. Trig Function Test

EXECUTE					OBSERVE
CLR	.	2			. 2
sinX	arc	sinX			. 2
cosX	arc	cosX			. 2
CD	.	2			. 2
tanX	arc	tanX			. 2
hyper	sinX	arc	hyper	sinX	. 2
hyper	cosX	arc	hyper	cosX	. 2
CD	.	2			. 2
hyper	tanX	arc	hyper	tanX	. 2

4. Factorial Key

EXECUTE					OBSERVE
CLR	2	5	x !		1 . 5 5 1 1 2 1 0 0 4 25
CLR	6	9	x !		1 . 7 1 1 2 2 4 5 2 4 98
CLR	7	0	x !	flashing	9 . 9 9 9 9 9 9 9 9 9 99

5. "K" Storage Test

EXECUTE											OBSERVE
CLR	1	2	4	8	=	K	0	=	K	1	1 2 4 8 .
CLR	K	0									1 2 4 8 .
CLR	K	1									1 2 4 8 .

6. "Σ" Keys

EXECUTE	OBSERVE
CLR | 1 | 1 | = | K | 0 | = | K | 1 | = | K | 2 | = | K | 3	1 1 .
Σ_0 | Σ_0 | Σ_0 | K | 0	4 4 .
K | 1	1 1 .
Σ_1 | Σ_1 | Σ_1 | K | 1	4 4 .
$3\Sigma_2$ | $3\Sigma_2$ | $3\Sigma_2$ | K | 2	4 4 .

7. Δ_3 Key

EXECUTE	OBSERVE
CLR | 30 | = | K | 3	3 0 .
$\Delta 3$ | K | 3	- 3 .

8. Π_4

EXECUTE	OBSERVE
CLR | 4 | = | K | 4	4 .
Π_4 | K | 4	1 6 .

9. Miscellaneous Keys

A. Paper Feed

Press $\boxed{\text{PAPER FEED}}$ a few times and insure that paper is fed one line each time the key is depressed.

B. Integer

Press $\boxed{\pi}\boxed{\text{intX}}$ observe 3 .

C. Print Command (if option one is present and turned on)

Key in a display and press | PRINT DISPLAY |

The print-out and display should be identical (except for leading zeros).

Press | CLR | PRINT DISPLAY | display should be all zeros.

Print should be: Ø. If more than one zero appears, replace the printer logic board.

If this test does not run, the problem is probably in the Printer module. If the problem is mechanical, it may be possible to repair it in the field. If the problem is electrical, replace the Printer module.

D. Clear Display

Press | CLR | 1 | + | 1 | CD | 4 | = | display should read 5.

If this test does not run, the problem is most likely in the Calculator board.

Power Supply Checks

The power supply provides:

1. Fan power +115 VAC.
2. +300 VDC for the display.
3. +15 VDC unregulated (≃+20V) for the printer.
4. +15 VDC regulated for the tape reader or card reader or calculator board or printer.
5. +5 VDC unregulated (≃+7V) for the tape or card reader.
6. +5 VDC regulated used throughout the calculator.

DIAGNOSTIC PROCEDURE

7. −13 VDC regulated used throughout the calculator.
8. +5 VDC power supply over-voltage (crow-bar) protection.
9. +5 VDC, +15 VDC, and −13 VDC power supplies are short circuit protected.
10. MASTER CLEAR on energizing to initiate the calculator.

The following procedure checks these functions without requiring the removal of the power supply from the calculator.

Check Procedure:

1. The fan should operate when the main power switch (on the back of the calculator) is turned on.

2. The +300 VDC power supply is used to light the digits on the display. The connector on the top of the printed circuit board labeled +300 should be +300 VDC ± 40 to ground chassis.

3. The connector labeled +20 VDC on the power supply printed circuit board provides power for the printer. This is the unregulated +15 V supply. It should measure +20 VDC $\pm$ 6 to ground.

4. The regulated + 5 VDC can be measured at the pin labeled +15 V. This voltage can be adjusted with the potentiometer labeled +15 V ADJ. This voltage should be +15 VDC ± 0.15.

5. The unregulated + 5 V can be measured at the pin labeled +7 V. Check for 7 $\pm$ 1 VDC.

6. The regulated +5 VDC can be measured at the surface labeled +5 V.

7. The -13 VDC can be measured at the labeled -13 V point near the ON/OFF switch. This regulated voltage can be adjusted with the potentiometer labeled -13 V ADJ. It should measure -13 VDC ±0.13.

8. The +5 VDC regulated power supply is over-voltage protected, by the use of a crowbar circuit, which shorts the +5 VDC to chassis ground. The crowbar circuit can be activated by shorting across the zener diode UR1 located at the left rear of the power supply circuit board. The output should decrease to approximately 1 VDC and remain there after the jumper is removed. The output will return to normal after the power switch has been turned off and back on.

9. The regulated +5 VDC power supply has low voltage (short circuit) protection. The output can be shorted to ground without damage to the calculator or power supply. The output can be jumpered to ground and the output will be reduced to zero. Removal of the ground will allow the power supply to return to normal without turning the main power switch OFF and ON again.

10. The power supply provides a master clear for the calculator on initial turn on. $\overline{\text{MASTER CLEAR}}$ can be monitored at the etched circuit board run labeled $\overline{\text{MASTER CLEAR}}$. This

function can be checked in respect to the 5 VDC regulated output by triggering an oscilloscope trace with the +5 VDC power supply and observing that the MASTER CLEAR line remains low (0 volts) for approximately 70 milliseconds after the +5 VDC is present on the output line.

Printer Field Calibration

This adjustment and calibration procedure is designed to allow field adjustments of the printer without removing it from the calculator.

1. Turn the printer and the calculator ON.
2. Load the paper using the lever arm.
3. Turn the printer power switch off (raised position) check that the [PAPER FEED] push button on the printer causes continuous paper feed when depressed.
4. Turn the printer back ON.
5. Press [PAPER FEED] on keyboard. Insure that the paper feeds one line with each activation of the [PAPER FEED] button.
6. Press [CD] [PRINT DSPLY] .

   Ø. will be printed.
7. Check for proper quadrant sequence:

   Press

CD	1	1	1	2	2	2	3	3	3	4	$x10^{00}$	4	4	PRINT DSPLY

   1112223334 +44 should be printed.

8. Print Head adjustment. Turn power OFF.

If the print is too light or displays non-uniformity of print, the print head can be adjusted without removing the printer from the calculator. The keyboard is loosened and moved forward without disconnecting it from the calculator, by removing the top cover plate, the mag card insert, and two machine screws holding the keyboard to the frame, and then sliding the keyboard up and back until the front lower lip is free from its retaining slot.

Place a suitable insulator between the Keyboard and the printed circuit board.

The Keyboard can be slid forward far enough to allow access space between the back of the display board and the front of the printer assembly.

WARNING

+300 V is on the back of the display board when energized if the lead to +300 V is connected to the power supply.

Remove the +300 V wire from the power supply. (A display isn't necessary when adjusting the print head).

Partially loosen both nuts on both print head adjustment plates. Screwdriver access to the print head adjustment slots is available between the back of the display board and the printer unit.

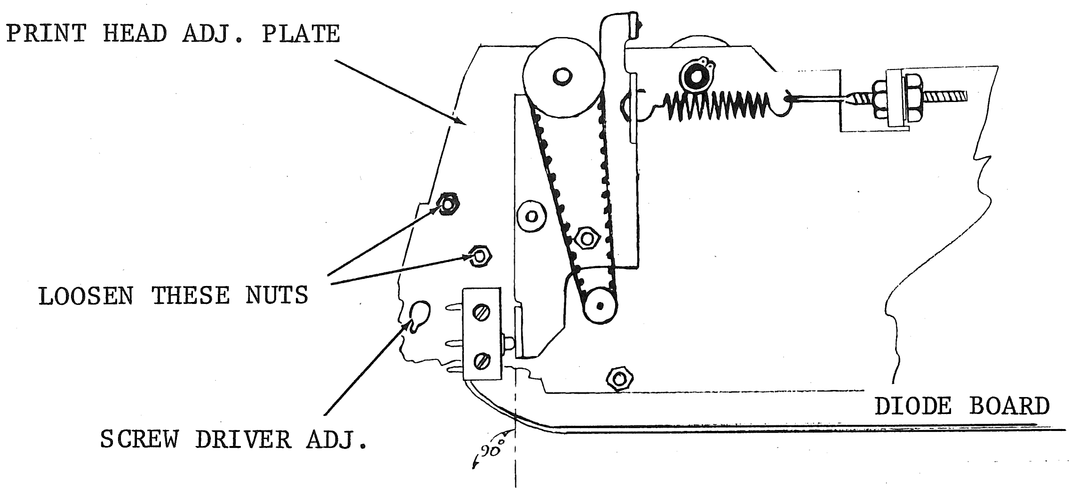


Fig. 1-1

Reconnect +300 V.

Make certain that the short harness between the mag card reader and the TO CARD switch on the keyboard had not been pulled loose. Being disconnected will not cause damage when energized; however, the f(x) board is disabled and will not allow the calculator to go into the LEARN mode.

Turn the calculator ON.

Program the following:

CLR	GO TO	fØ	LEARN

8	8	8	8	8	8	8	8	8	8	+/-	10^{00}	8	8	+/-	PRINT DSPLY

CLR DSPLY	6	9	x!	CLR DSPLY	GO TO	fØ	LEARN	fØ

The printer should print (-8888888888. -88) per line at a rate of one line per second.

Adjust print head adjustment slots for the best dot intensity and uniformity of print. To stop the program, press $\boxed{\text{STOP}}$ until the program stops.

8. Paper bail shut off test.

Turn ON the calculator and short paper bail roller to ground with a suitable jumper. A busy light should result.

9. No back-lash should be observed in the print out. Back-lash is shortening of the printed data due to mechanical problems.

Tests for TEKTRONIX 31

Programming Test

1. Factorial and Indirect Addressing Test
2. Mag Tape Write and Record Test
3. Editing Test
4. Clear File Test
5. Remaining (Upper) Programming Keys
6. Alpha/Numeric Characters

1. Factorial and Indirect Addressing Test

EXECUTE		OBSERVE
CLR = R□□ 0 0 0 1 = R□□ 0 1		1 .
LRN R□□ 0 0 + 1 = R□□ 0 0 x		
R□□ 0 1 = R□□ 0 1 = R□□ R□□ 0 0		
STOP START LRN START		1 .
CONT		2 .
CONT		6 .
CONT		2 4 .
R□□ 0 0		4 .
R□□ 0 1		2 4 .
CONT		1 2 0 .
CONT		7 2 0 .
CONT	Press until display shows:	1 . 5 5 1 1 2 1 0 0 4 . 2 5
R□□ 0 0		2 5 .
CONT		4 . 0 3 2 9 1 4 6 1 1 . 2 6
CONT	Press until display shows:	1 . 7 1 1 2 2 4 5 2 4 . 9 8
R□□ 0 0		6 9 .
CONT	FLASHING	9 . 9 9 9 9 9 9 9 9 . 9 9

If this test fails to run properly, replace the Programmer/ Memory module. Run the test again, if the test still fails to run, replace the Calculator board module.

2. Mag Tape Write and Record Test

Turn off Calculator momentarily and then turn Calculator on.

EXECUTE

RESET	CLR	LRN	1	PAUSE	2	PAUSE	3	PAUSE	4	PAUSE
5	PAUSE	6	PAUSE	7	PAUSE	8	PAUSE	9	PAUSE	
0	PAUSE	PAUSE	PRNT	CLR	PAPR	START	LRN			
START										

The digits 1 through 0 should appear in the display, moving from right to left at 1 second intervals. When the display is filled, the result will be printed, a paper feed will occur, the display will clear, and the program will repeat until stopped.

STOP		(Observe the display)
CONT		(The program should resume)
STOP	RESET	
LIST		(Printer will run a program list)

When "NULL" appears at step 25 press:

STOP	RESET

Place a blank tape cartridge in the transport. Insure that the write-enable button is in place.

TO TAPE	(The "ADDRESS INCOMP" light will illuminate)
1	(The "ADDRESS INCOMP" light will extinguish and the "BUSY" light will illuminate)

When data transfer to the tape is complete, the "BUSY" light will extinguish. Then remove the cartridge. Momentarily place the "POWER" switch OFF and then back ON. Re-insert the tape cartridge.

Note: It is only necessary to remove the tape cartridge when sequencing the power if the write-enable button is on the cartridge.

CLR	FROM TAPE	1

(The "ADDRESS INCOMP" and "BUSY" lights should illuminate and extinguish as above.)

START
STOP

(The program should run identical to the keyed-in program)

If this test fails, replace the Mag Tape module. If the test fails to run after the Mag Tape has been replace, replace the Programmer/Memory module.

Check write protect.

Remove the tape cartridge from the reader and remove the rubber write enable actuator button from the cartridge.

Attempt to load memory into Block 0.

RESET	TO TAPE	Ø

The display should indicate an E8 error message.

If this test fails replace the Mag Tape module. Run the test again, if the test still fails to run, replace the Programmer/Memory module.

3. Editing Test

EXECUTE	OBSERVE
GO TO 0 0 1 0 LRN	Check that you are at STEP 0010
STEP STEP STEP STEP	Step number should increase
STEP STEP STEP STEP	Step number should decrease

DIAGNOSTIC PROCEDURE

Keystrokes	Remarks
INSERT INSERT INSERT INSERT INSERT	Wait for "BUSY" light to extinguish between keystrokes
CLR CLR CLR CLR CLR	
LRN RESET LIST	Compare this program list to the previous one. Step number 0010 of the first list should now be 0015, etc.
STOP	When "NULL" appears at step 30.
GO TO 0 0 1 0 LRN	
DELETE DELETE DELETE DELETE DELETE	Wait for "BUSY" light
LRN RESET LIST	
STOP	When "NULL" appears at step 25. (This list should be identical to the first one.)
RESET DISPLAY PROGRAM	
STEP STEP STEP STEP	Step number should increase
STEP	Error Message "E-4" should appear. This key is operative only in "LEARN" mode
RESET	

If this test fails to run, the problem is probably in the Programmer/Memory module. However, if one of the above editing functions does not work, the program might be found in the keyboard operation. Replacing one or both modules should clear up the problem.

4. Clear File Test

EXECUTE	OBSERVE
CLR 1 2 4 8 = $R_{\boxed{\wedge}\boxed{\wedge}\boxed{\wedge}}$ 0 2 3 = $R_{\boxed{\wedge}\boxed{\wedge}\boxed{\wedge}}$ 1 2 3	1 2 4 8 .
CLR R FILE 0 $R_{\boxed{\wedge}\boxed{\wedge}\boxed{\wedge}}$ 0 2 3	0
$R_{\boxed{\wedge}\boxed{\wedge}\boxed{\wedge}}$ 1 2 3	1 2 4 8 .
CLR R FILE 1 $R_{\boxed{\wedge}\boxed{\wedge}\boxed{\wedge}}$ 1 2 3	0

If this program fails to run, replace the Programmer/ Memory module.

5. Remaining (Upper) Programming Keys

LRN	EXECUTE	LABEL	END	RETURN ADDRESS	GO TO DISPLAY	CLEAR FLAG	
SET FLAG	≥ 0	=0	<0	FLASH	IF FLAG	ADDRESS	LRN

Compare the printer tape display as each key is depressed. If this program fails to run,replace the Programmer/Memory module.

6. Alpha/Numeric Characters

LRN

Hold HOLD FOR ALPHA key down. Depress each key containing a light blue alpha-numeric character on the keyboard bezel. The TAB, BELL, and SPACE keys are operational only with certain peripherals and will appear on the program list as a space.

LRN

DIAGNOSTIC PROCEDURE

If this test fails to run, replace the Programmer/Memory module. If this does not correct the problem, the printer may be at fault. Refer to the printer diagnostic procedures in this manual.

Keyboard and Display Checks

TEKTRONIX 31 lower keys. These checks provide assurance that the calculator is working properly. If any of the checks fail to run properly the problem is most likely in the Calculator board. The following features are exercised and observed.

1. Data Entry
2. Log Function
3. Trig Function
4. Factorial Key
5. "K" Storage
6. Σ Keys
7. Δ_3 Key
8. Product 4 Key
9. Miscellaneous Keys
    A. Paper Feed
    B. Integer Key
    C. Print Display
    D. Clear Display

DIAGNOSTIC PROCEDURE

1. Data Entry	OBSERVE IN DISPLAY
Turn Calculator on. Observe flashing display.	
Press [CLEAR]	0 0 0 0 0 0 0 0 0 0
EXECUTE	
[1] [1] [1] [1] [1] [1] [1] [1] [1] [1]	1 1 1 1 1 1 1 1 1 1
[CLR] [2] [2] [2] [2] [2] [2] [2] [2] [2] [2]	2 2 2 2 2 2 2 2 2 2
[CLR] [4] [4] [4] [4] [4] [4] [4] [4] [4] [4]	4 4 4 4 4 4 4 4 4 4
[CLR] [8] [8] [8] [8] [8] [8] [8] [8] [8] [8]	8 8 8 8 8 8 8 8 8 8

If any doubt exists, as to whether these operations are being performed properly, all numbers from 1 to 9 may be exercised. As each number is pressed, the number should advance across the display filling the display with the number.

[CLR] [.] [1] [1] [1] [1] [1] [1] [1] [1] [1] [1]	. 1 1 1 1 1 1 1 1 1 1

As each number is pressed after the decimal point has been pressed, the decimal point will move across the display, filling the indicated number in behind the decimal point.

[+/-] Press several times.	The sign of the mantissa should change with each keystroke.
[x10^{00}] Two "0" will appear in the exponent location.	0000000000 00

[+/-]	Press several times	The exponents sign will change with each keystroke.
[9] [9] [8] [8] [7] [7] . . . [0] [0] Press numbers in pairs.		The digits in the exponent should change with each keystroke.

If any of the above procedures fail to run, the problem is probably in the Calculator board module, although a problem may exist in the Display/Keyboard module. Replace the above modules one at a time and rerun the test. If the program does not run successfully, go back to the programming test.

If tests 2, 3, 4, 5, 6, 7, and 8 fail to run the problem is most likely in the Calculator board module.

2. Log Function Test

EXECUTE	OBSERVE
CLR | 1 | 0 | $\lvert X\rvert^a$ | 5 | = | logX	5 .
X^2 | X^2 | X^2 | $\sqrt{X}$ | $\sqrt{X}$ | $\sqrt{X}$	5 .
lnX | lnX | lnX | e^x | e^x | e^x	5 .
$\frac{1}{x}$ | $\frac{1}{x}$ | $\frac{1}{x}$ | $\frac{1}{x}$	5 .
π	3 . 1 4 1 5 9 2 6 5 <u>3</u>
= The last digit in the number should change when = is pressed.	3 . 1 4 1 5 9 2 6 5 <u>4</u>
DEG/RAD	1 8 0 .
DEG/RAD	3 . 1 4 1 5 9 2 6 5 4
CLR | 2 | 0 | lnX | - | 2 | . | 9 | 9 | 5 | 7 | 3 | 2 | 2 | 7 | 4 | =	- 4 . 5 0 0 0 0 0 0 0 0 - 1 0

3. Trig Function Test

EXECUTE					OBSERVE
CLR	.	2			. 2
sinX	arc	sinX			. 2
cosX	arc	cosX			. 2
CD	.	2			. 2
tanX	arc	tanX			. 2
hyper	sinX	arc	hyper	sinX	. 2
hyper	cosX	arc	hyper	cosX	. 2
CD	.	2			. 2
hyper	tanX	arc	hyper	tanX	. 2

4. Factorial Key

EXECUTE					OBSERVE	
CLR	2	5	x !		1 . 5 5 1 1 2 1 0 0 4	25
CLR	6	9	x !		1 . 7 1 1 2 2 4 5 2 4	98
CLR	7	0	x !	flashing	9 . 9 9 9 9 9 9 9 9 9	99

5. "K" Storage Test

EXECUTE											OBSERVE
CLR	1	2	4	8	=	K	0	=	K	1	1 2 4 8 .
CLR	K	0									1 2 4 8 .
CLR	K	1									1 2 4 8 .

6. "Σ" Keys

EXECUTE	OBSERVE
CLR 1 1 = K 0 = K 1 = K 2 = K 3	1 1 .
Σ_0 Σ_0 Σ_0 K 0	4 4 .
K 1	1 1 .
Σ_1 Σ_1 Σ_1 K 1	4 4 .
$3\Sigma_2$ $3\Sigma_2$ $3\Sigma_2$ K 2	4 4 .

7. Δ_3 Key

EXECUTE	OBSERVE
CLR 30 = K 3	3 0 .
Δ3 K 3	- 3 .

8. Π_4

EXECUTE	OBSERVE
CLR 4 = K 4	4 .
Π_4 K 4	1 6 .

9. Miscellaneous Keys

A. Paper Feed

Press PAPER FEED a few times and insure that paper is fed one line each time the key is depressed.

B. Integer

Press π intX observe 3 .

C. Print Command

Key in a display and press $\boxed{\text{PRINT DISPLAY}}$

The print-out and display should be identical.

Press $\boxed{\text{CLR}}\boxed{\text{PRINT DISPLAY}}$ display should be all zeros.

Print should be: Ø. If more than one zero appears, replace the printer logic board.

If this test does not run, the problem is probably in the Printer module. If the problem is mechanical, it is possible to repair it in the field. If the problem is electrical, replace the Printer module.

D. Clear Display

Press $\boxed{\text{CLR}}\boxed{1}\boxed{+}\boxed{1}\boxed{\text{CD}}\boxed{4}\boxed{=}$ display should read 5.

If this test does not run, the problem is most likely in the Calculator board.

Power Supply Checks

The power supply provides:

1. Fan power +115 VAC.
2. +300 VDC for the display.
3. +15 VDC unregulated (≃+20V) for the printer.
4. +15 VDC regulated for the tape reader or card reader or calculator board or printer.
5. +5 VDC unregulated (≃+7V) for the tape or card reader.
6. +5 VDC regulated used throughout the calculator.

7. -13 VDC regulated used throughout the calculator.

8. +5 VDC power supply over-voltage (crow-bar) protection.

9. +5 VDC, +15 VDC, and -13 VDC power supplies are short circuit protected.

10. MASTER CLEAR on energizing to initiate the calculator.

The following procedure checks these functions without requiring the removal of the power supply from the calculator.

Check Procedure:

1. Unit fan should operate when the main power switch (on the back of the calculator) is turned on.

2. The +300 VDC power supply is used to light the digits on the display. The connector on the top of the printed circuit board labeled +300 should be +300 VDC ±40 to ground chassis.

3. The connector labeled +20 VDC on the power supply printed circuit board provides power for the printer. This is the unregulated +15 V supply. It should measure +20 VDC ± 6 to ground.

4. The regulated + 5 VDC can be measured at the pin labeled +15 V. This voltage can be adjusted with the potentiometer labeled +15 V ADJ. This voltage should be +15 VDC ±0.15.

5. The unregulated + 5 V can be measured at the pin labeled +7 V. Check for 7 ±1 VDC.

6. The regulated +5 VDC can be measured at the surface labeled +5 V.

7. The -13 VDC can be measured at the labeled -13 V point near the ON/OFF switch. This regulated voltage can be adjusted with the potentiometer labeled -13 V ADJ. It should measure -13 VDC ± 0.13.

8. The +5 VDC regulated power supply is over-voltage protected, by the use of a crowbar circuit, which shorts the +5 VDC to chassis ground. The crowbar circuit can be activated by shorting across the zener diode UR1 located at the left rear of the power supply circuit board. The output should decrease to approximately 1 VDC and remain there after the jumper is removed. The output will return to normal after the power switch has been turned off and back on.

9. The regulated +5 VDC power supply has low voltage (short circuit) protection. The output can be shorted to ground without damage to the calculator or power supply. The output can be jumpered to ground and the output will be reduced to zero. Removal of the ground will allow the power supply to return to normal without turning the main power switch OFF and ON again.

10. The power supply provides a master clear for the calculator on initial turn on. $\overline{\text{MASTER CLEAR}}$ can be monitored at the etched circuit board run labeled $\overline{\text{MASTER CLEAR}}$. This

function can be checked in respect to the 5 VDC regulated output by triggering an oscilloscope trace with the +5 VDC power supply and observing that the MASTER CLEAR line remains low (0 volts) for approximately 70 milliseconds after the +5 VDC is present on the output line.

Printer Field Calibration

This adjustment and calibration procedure is designed to allow field adjustments on the printer without removing it from the calculator.

1. Turn the printer and the calculator ON.
2. Load the paper using the lever arm.
3. Turn the printer power switch off (raised position) check that the [PAPER FEED] push button on the printer causes continuous paper feed when depressed.
4. Turn the printer back ON.
5. Press [PAPER FEED] on keyboard. Insure that the paper feeds one line with each activation of the [PAPER FEED] button.
6. Press [CD] [PRINT DSPLY] .

   Ø. will be printed.
7. Check for proper quadrant sequence:

   Press

CD	1	1	1	2	2	2	3	3	3	4	x10^{00}	4	4	PRINT DSPLY

   1112223334 +44 should be printed.

8. Print Head adjustment. Turn power OFF.

If the print is too light or displays non-uniformity of print, the print head can be adjusted without removing the printer from the calculator. The keyboard is loosened and moved forward without disconnecting it from the calculator, by removing the top cover plate, the mag tape cartridge, and two machine screws holding the keyboard to the frame, and then sliding the keyboard up and back until the front lower lip is free from its retaining slot.

Place a suitable insulator between the Keyboard and the printed circuit board.

The Keyboard can be slid forward far enough to allow access space between the back of the display board and the front of the printer assembly.

WARNING

+300 V is on the back of the display board when energized if the lead to +300 V is connected to the power supply.

Remove the +300 V wire from the power supply. (A display isn't necessary when adjusting the print head).

Partially loosen both nuts on both print head adjustment plates. Screwdriver access to the print head adjustment slots is available between the back of the display board and the printer unit.

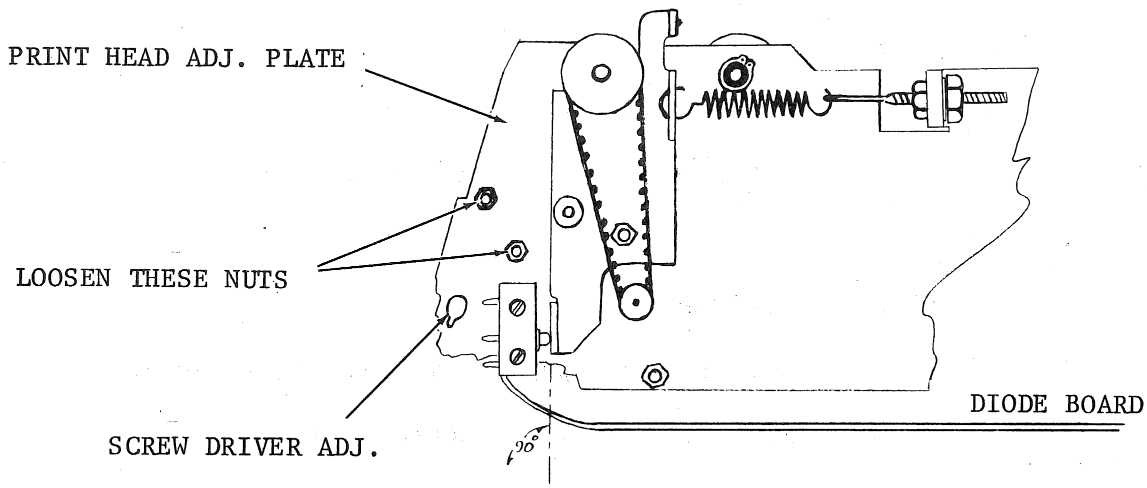


Fig. 1-2

Reconnect +300 V.

Make certain that the short harness between the mag card reader and the "to card" switch on the keyboard had not been pulled loose. Being disconnected will not cause damage when energized; however, the f(x) board is disabled and will not allow the calculator to go into the LEARN mode.

Turn the calculator ON.

Program the following:

CLR	GO TO	fØ	LEARN

8	8	8	8	8	8	8	8	8	8	+/-	10^{00}	8	8	+/-	PRINT DSPLY

CLR DSPLY	6	9	x!	CLR DSPLY	GO TO	fØ	LEARN	fØ

The printer should print (-8888888888. -88) per line at a rate of one line per second.

Adjust print head adjustment slots for the best dot intensity and uniformity of print. To stop the program, press STOP until the program stops.

8. Paper bail shut off test.

Turn ON the calculator and short paper bail roller to ground with a suitable jumper. A busy light should result.

9. No back-lash should be observed in the print out. Back-lash is shortening of the printed data due to mechanical problems.

SECTION II

MAINTENANCE

GENERAL MAINTENANCE

Introduction

The Tektronix 21 and 31 calculators should be cleaned as often as operating conditions require. An accumulation of dirt in the instrument can cause component breakdown. Dirt on components acts as an insulating blanket and prevents efficient heat dissipation. Dirt also provides an electrical conduction path which may result in instrument failure.

Loose dust that accumulates on the outside of the calculator can be brushed off or removed with a soft cloth dampened in a mild detergent and water solution. Abrasive cleaners should not be used.

CAUTION

> Avoid the use of chemical cleaning agents which might damage the plastics used in this instrument. Avoid chemicals which contain benzene, toluene, xylene, acetone, or similar solvents.

Cleaning the Display Window

The red display window should be cleaned with a soft, lint-free cloth dampened in denatured alcohol. A cotton swab may also be used for this cleaning operation. At times, a Q tip is useful for reaching out-of-the-way areas on the calculator.

Cleaning the Keyboard

The keyboard can be cleaned with a soft, bristled brush or with a lint-free cloth, dampened with denatured alcohol. If liquids other than water are accidentally spilled on the calculator keyboard, wash them from the outside of the calculator, with a damp cloth moistened with water or denatured alcohol, and allow the calculator to thoroughly dry. If foreign liquid material gets inside the cabinet, the calculator must be disassembled and each contaminated part washed with water or denatured alcohol and thoroughly dried. The areas around the keyboard push buttons must be thoroughly cleaned, to keep keys from sticking.

If the calculator fails to operate, after a spill has been cleaned, contact your local Tektronix Field Office or representative, or see disassembly procedured in this manual.

Cleaning the Fan Assembly

The fan filter element, located on the rear panel of the calculator, may be removed for cleaning purposes. The filter is held in place by a housing, which is removed by unscrewing the four holding screws. This allows access to, and facilitates removal of the filter element. The filter should be washed in warm soap and water, and dried before re-assembly.

MAINTENANCE

SERVICING THE TEKTRONIX 21

Cleaning the Transport Mechanism

Two areas of the transport mechanism require periodic maintenance. These are the capstan and the tape head. Both objects are cleaned with a cotton swab moistened with denatured alcohol. Care should be taken not to scratch any of the parts being cleaned. Sharp metallic objects should not be used near the actual mechanism or tape head.

In order to facilitate cleaning, the capstan is rotated while a swab is used to remove any foreign material that is lodged on the mechanism. To rotate the capstan, turn on the calculator, remove the mag card insert and depress one of the white microswitches located on either side of the entrance to the transport mechanism. The capstan will stop rotating upon deactivation of the microswitches.

Disassembly Procedure for Tektronix 21

A. Removal of cover

1. Unscrew two #6-40 screws, lockwashers, and flat washers in the rear of the calculator. (Place the flat washers against the body of the calculator).

2. Hold sides of top cover plate, and pull to each side, while lifting upward.

B. Removal of calculator board (This is the farthest point in disassembly of the calculator.)

1. Remove the keyboard by unscrewing two #8-40 screws, lock-washers, and flat washers. Gently lift up on the keyboard

and push it toward the back of the calculator. (The front of the keyboard fits into a groove on the base of the calculator). Disconnect the mag card cable and the 300VDC lead. The keyboard may now be set aside. If the keyboard is to be completely removed, the two large ribbon cables must be disconnected. The short cable plugs into the keyboard, and the long cable plugs into the display board.

2. Remove the printer: (The printer assembly must always be removed before the power supply, because of mechanical interference.)
   a. Remove the fan and the +22VDC supply leads. (When re-assembling, the harmonica connector, with the white stripe leads,connects to the +22VDC supply. Be sure that the index pointer is aligned with the index-pointer-indicator on the circuit board.)
   b. Remove the mounting hardware, which consists of two #8-40 screws, lockwashers, and flat washers on the module support bar, and one #6-40 screw, lockwasher, and flat washer on the rear of the assembly.
   c. Lift the assembly up gently and set it aside.
3. Remove the mag card.
   a. Disconnect the capstan driving motor lead and the +15VDC supply lead from the power supply.

b. The mounting hardware consists of two #8-40 screws, lockwashers, and flat washers on the module support bar, and one #6-40 screw, lockwasher and flat washer on the rear of the assembly.

c. Lift the assembly up gently and set it aside.

4. Remove the power supply.

   a. Loosen two #8-40 screws in the rear of the calculator. (The screws need not be removed as they fit into slotted guides.)

   b. Remove two #8-40 screws, lockwashers, and flat washers at the front of the power supply.

   c. Lift the power supply up gently. The power supply edge connector fits onto the edge connector of the interface board.

5. To remove circuit boards on the TEK 21.

   a. There are 8 screws holding the circuit boards to the base. 5 are long, running through the Printer Logic board and the f(x) board, going through the calculator board to the base; 3 are shorter, running through the f(x) board and the calculator board to the base.

   b. With the mounting hardware removed, pull the f(x) board and the Printer Logic boards gently towards the front of the calculator. The Printer Logic and f(x) boards come out as a package.

c. To separate the Printer Logic from the f(x) boards, two #14-40 screws must be removed from the posts on the f(x) board. In addition one long #4-40 screw must be removed from the middle of the printer logic board; that screw goes through a spacer on the f(x) board and fastens to a nylon spacer on the rear of the f(x) board.

6. To remove the calculator board, pull it gently towards the front of the calculator and lift it out.

7. Both the calculator board and the f(x) board, fit into black plastic guides in back of the calculator base.

Reassembly

For reassembly of the calculator, use the same procedure in reverse. There is an alignment problem on the module support bar. The bar is held in place loosely by two #8-40 screws, lockwashers, and flat washers. Put the power supply in place and tighten the screws on the rear. Align the holes of the bar with the holes on the front of the power supply and tighten the bar in place. Tighten the two remaining screws on the front of the power supply.

When replacing the f(x) and printer logic boards, make sure that the edge connect is properly aligned. Improper alignment will cause the +5VDC etched circuit board run to be shorted to ground.

After the f(x) and printer logic boards have been properly placed, the cables may be reconnected to the keyboard and calculator board.

Turn the calculator ON. If RAD light comes on and the display does to all zeros when CLEAR is pressed, the calculator is properly operating.

SERVICING THE TEKTRONIX 31

Cleaning the Transport Mechanism

Two areas of the transport mechanism require periodic maintenance. These are the capstan and the tape head. Both objects can be cleaned with a cotton swab moistened with denatured alcohol. Care should be taken not to scratch any of the parts being cleaned. Sharp metallic objects should not be used near the actual mechanism or tape head.

In order to facilitate cleaning, the capstan should be rotated while a swab is used to remove any foreign material that is lodged on the mechanism. Before the capstan can be rotated, an orange microswitch must be depressed. The microswitch is located at the rear of the opening into the transport mechanism, on the left side as viewed from the front of the calculator. See Figure 2-2 .

To rotate the capstan for cleaning purposes, depress the orange microswitch with the eraser end of a pencil, then press $\boxed{\text{FROM TAPE}}\boxed{0}$. The capstan will continue to rotate without further activation of the microswitch. To stop its rotation press $\boxed{\text{STOP}}$.

Disassembly Procedure for Tektronix 31

A. Removal of cover

1. Unscrew two #6-40 screws, lockwashers, and flat washers in the rear of the calculator. (Place the flat washers against the body of the calculator.)
2. Hold sides of the cover plates, and pull to each side, while lifting upward.

B. Removal of calculator board (This is the farthest point in disassembly of the calculator.)

1. Remove the keyboard by unscrewing two #8-40 screws, lockwashers, and flat washers. Gently lift up on the keyboard and push it toward the back of the calculator. (The front of the keyboard fits into a groove on the base of the calculator.) Set the keyboard upside down on the right side of the calculator. If the keyboard is to be removed, the two large ribbon cables must be disconnected. The short cable plugs onto the keyboard, and the longer cable plugs into the display board.
2. Remove the printer: (The printer assembly must always be removed before the power supply, because of mechanical interference.)
   a. Remove the fan and the +22VDC supply leads. (When reassembling, the harmonica connector with the white stripe leads connects to the +22VDC supply. Be sure

that the index pointer is aligned with the index-pointer-indicator on the circuit board.)

b. Remove the mounting hardware, which consists of two #8-40 screws, lockwashers, and flat washers on the module support bar, and one #6-40 screw, lockwasher, and flat washer on the rear of the assembly.

c. Lift the assembly up gently and set it aside.

3. Remove the mag tape.

a. Disconnect the capstan driving motor lead and the +15VDC supply lead from the power supply.

b. The mounting hardware consists of two #8-40 lockwashers, and flat washers on the module support bar, and one #6-40 screw, lockwasher and flat washer on the rear of the assembly.

c. Lift the assembly up gently and set it aside.

4. Remove the power supply.

a. Loosen two #8-40 screws in the rear of the calculator. The screws need not be removed as they fit into slotted guides.

b. Remove two #8-40 screws, lockwashers, and flat washers at the front of the power supply.

c. Lift the power supply up gently. Power supply bottom fits onto the card of the interface board.

5. Remove circuit boards on the Tektronix 31:

   a. There are 8 screws holding the circuit boards to the base of the calculator. These screws are all the same length unless there is an Auxiliary Memory board included, then three of these screws are longer.

   b. With the mounting hardware removed, pull the Programmer/ Memory boards gently towards the front of the calculator. (There is a clearance problem with the module support bar. If problems occur while removing the boards, the bar can easily be removed by unscrewing two #8-40 screws, lockwashers, and flat washers from the sides of the calculator.)

   c. To separate the Main Memory board from the Programmer board disconnect six #4-40 screws that are fastened to posts on the Programmer board. Three of these screws are longer, two of them hold black card guides on to the 30 pin edge connector located at the rear of the Main Memory board. The third long screw is located in the center of the Main Memory board, and is screwed into a nylon post under the Programmer board. At this point the boards are still held together by 42 square pins. To separate the boards, pry gently apart until the pins are disengaged. This also releases the nylon post in the center of the board.

6. To remove the calculator board pull it gently towards the front of the calculator and lift it out.
7. Both the calculator board and the f(x) board fit into black plastic guides in back of the calculator base.

Reassembly

For reassembly of the calculator, use the same procedure in reverse. There is an alignment problem on the module support bar. The bar is held in place loosely by two #8-40 screws, lockwashers, and flat washers. Put the power supply in place and tighten the screws on the rear. Align the holes of the bar with the holes on the front of the power supply and fasten the bar into place. Tighten the two remaining screws on the front of the power supply.

An illustration of the TEKTRONIX 31 in a semi-disassembled state is included, for the purpose of identifying the major modules that make up the instrument. See Fig. 2-3 at the end of this section.

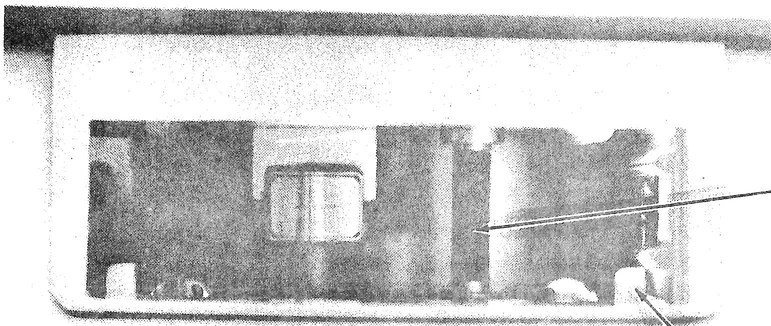


Fig. 2-1

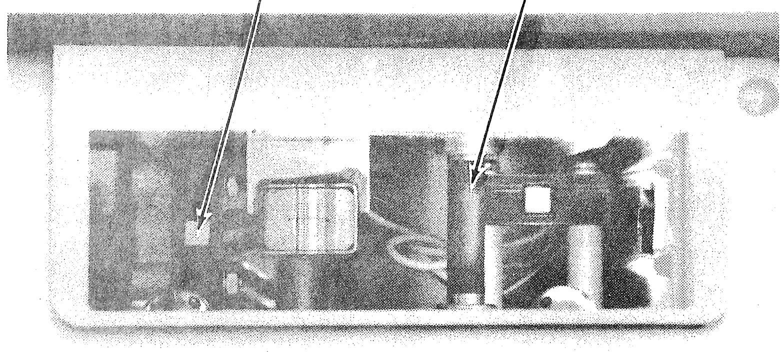


Fig. 2-2

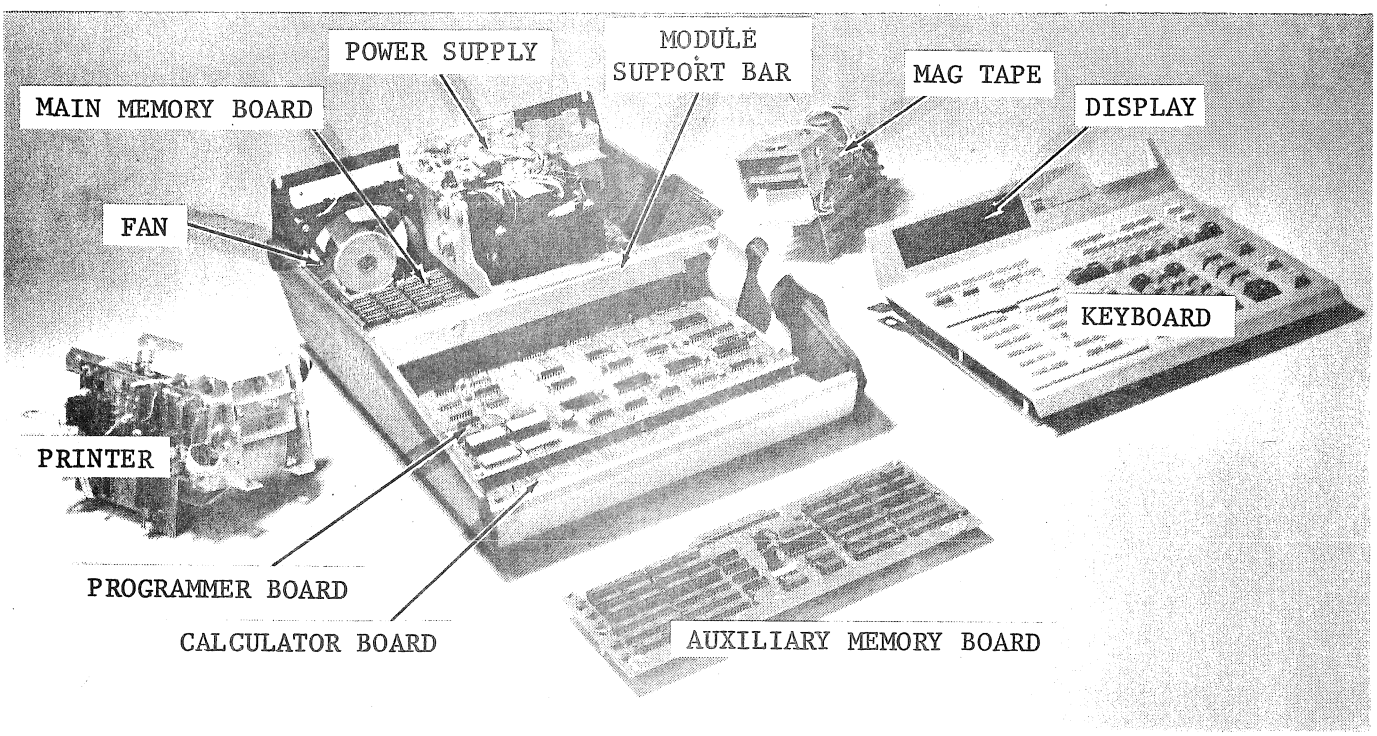


Fig. 2-3

SECTION III

OPERATIONAL PROCEDURES

Introduction

This section is included as a quick reference guide, giving an operational description for each calculator's keyboard function. For the Tektronix 31 the alpha keys are shown along with their respective octal codes. The brief description given for each key of the calculator is intended, to provide the troubleshooter with a quick understanding of the calculator's primary functions and operations.

Included in this section are the error codes generated by the TEK 31.

KEY	OCTAL CODE	
DEG RAD	101	Changes trigonometric operating mode from degrees to radians and vice versa. Affects the trigonometric keys ARC, TAN, COS, SIN. Used also to convert displayed numbers from radians to their equivalent in degrees, and vice versa.
ARC	102	Used in conjunction with other trigonemetric keys when finding inverse arguments of displayed trigonometric variables.
HYPER	103	Used in conjunction with trigonometric keys when finding hyperbolic functions.
TAN (X)	104	Tangent of the displayed angle.
COS (X)	105	Cosine of the displayed angle.
SIN (X)	106	Sine of the displayed angle.
X!	107	X Factorial of the integer of the displayed number.
Π_4	110	Multiplies K_4 by display and stores the result in K_4.
Δ_3	111	Multiplies contents of K_3 register by -0.1 and stores result in K_3.
$_3\Sigma_2$	112	Adds contents of K_3 to K_2 and stores the result in K_2
Σ_1	113	Adds display to K_1 and stores the result in K_1.
Σ_0	114	Adds display to K_0 and stores the result in K_0.
LN (X)	115	Natural log of displayed number.
LOG (X)	116	Log (base ten) of displayed number.
INT (X)	117	Integer value of displayed number.
$\sqrt{\Sigma x^2}$	120	Square root of the sum of the squares. Operates on sequentially entered numbers, execute with = or).
$\lvert X \rvert^a$	121	Raises display to a power subsequently entered. Execute with) or =.
REMOTE	122	Used to address peripheral devices (when followed by two digits).

KEY	OCTAL CODE	
e^x	123	e, the base of naperian logarithms (2.71 . . .) is raised to the displayed power and put into display.
x^2	124	The display is squared.
$\sqrt{x}$	125	Takes square root of displayed number.
1/x	126	Takes the reciprocal of the displayed number.
π	127	Puts π (= 3.14159...) into the display.
PAPER FEED	130	Advances paper in printer one line at a time.
X 10^{00}	131	Used to enter exponent or convert a number to scientific notation.
(	050	Opens a parenthetical entry
$\pm$	134	Changes sign in display
(	051	Closes a parenthetical expression, Two, will always close a statement.
0 1 2 3 4 5 6 7 8 9	060 061 062 063 064 065 066 067 070 071	Used for numerical entry.
.	056	Decimal point.
$K_\square$	100	Used to access data registers. Register is identified and recalled by digit that follows. Display storage into these registers is accomplished by preceding K and its following digit with =; = K 9, for example.
÷	057	Divide.
×	052	Multiply.
-	055	Subtract.
+	053	Add.

KEY	OCTAL CODE	
=	075	Equals. Causes accumulation of all entered arithmetic statements. Also causes display storage in a data register when followed by a data register address. (See Storage Operations and Data Registers.)
CLEAR	045	Resets calculator to begin again on a new set of operations and data entries.
PRINT DISPLAY	044	Print the display.
CLEAR DISPLAY	040	Clears display to all zeros. Does not alter previously entered operations.
CONT	132	The continue key resumes program execution.
STOP	043	The stop key is used to halt program execution.
STEP	NA	Step is used to examine memory locations within a memory block (Learn Mode), or execute individual program steps, one at a time (Idle Mode).
LIST	NA	List causes the printer to print program.
END	004	The end key ends program execution and sets the calculator back to the beginning of its memory (Location 000 00).
IF$\geq$Ø GO TO	001	The conditional go to key, ≥ 0, provides conditional branching capabilities in the idle or busy modes. It is programmable and must be followed by a memory block address, f_d.
GO TO	137	A GO TO keystroke precedes a memory block address key (f_0 through f_7) in the Idle mode. The calculator branches to the beginning of the specified memory block and stops.
LEARN f(x)	NA	Learn allows entry and exit from the Learn mode, in which the calculator "remembers" keystrokes.
TO CARD FROM CARD	NA	Transfers program to or from MAG CARD to or from memory of calculator.
f0 f1 f2 f3 f4 f5 f6 f7	054 073 072 007 010 011 003 002	The memory block address keys, f_0 through f_7, cause the calculator to branch to the beginning of the specified memory block and resume or begin program execution.

ALPHA	OCTAL CODE	KEY	OCTAL CODE	
A	301	DEG RAD	101	Changes trigonometric operating mode from degrees to radians and vice versa. Affects the trigonometric keys ARC, TAN, COS, SIN. Used also to convert displayed numbers from radians to their equivalent in degrees, and vice versa.
B	302	ARC	102	Used in conjunction with other trigonometric keys, when finding inverse arguments of displayed trigonometric variables.
C	303	HYPER	103	Used in conjunction with trigonetric keys when finding hyperbolic functions.
D	304	TAN (X)	104	Tangent of the displayed angle.
E	305	COS (X)	105	Cosine of the displayed angle.
F	306	SIN (X)	106	Sine of the displayed angle.
G	307	X!	107	X Factorial of the integer of the displayed number.
H	310	Π_4	110	Multiplies K_4 by the display and stores the result in K_4.
I	311	Δ_3	111	Multiplies contents of K_3 register by -0.1 and stores result in K_3.
J	312	$_3\Sigma_2$	112	Adds contents of K_3 to K_2 and stores the result in K_2.
K	313	Σ_1	113	Adds display to K_1 and stores the result in K_1.
L	314	Σ_0	114	Adds display to K_0 and stores the result in K_0.
M	315	LN (X)	115	Natural log of displayed number.
N	316	LOG (X)	116	Log (base ten) of displayed number.

ALPHA	OCTAL CODE	KEY	OCTAL CODE	
O	317	INT (X)	117	Integer value of displayed number.
P	320	$\sqrt{\Sigma x^2}$	120	Square root of the sum of the squares. Operates on sequentially entered numbers. Executed with an = or a).
Q	321	$\lvert X\rvert^{a}$	121	Raises display to a power subsequently entered. Execute with a) or an =.
R	322	REMOTE □□	122	Used to address peripheral devices (when followed by two digits).
S	323	e^{x}	123	e, the base of naperian logarithms (2.71 . . .), is raised to the displayed power and put into display.
T	328	x^2	124	The display is squared.
U	325	x	125	Takes square root of displayed number.
V	326	1/x	126	Takes the reciprocal of the displayed number.
W	327	π	127	Puts π (3.14159...) into the display.
X	330	PAPER FEED	130	Advances paper in printer one line at a time.
Y	331	X 10^{oo}	131	Used to enter exponent or convert a number to to scientific notation.
(	250	(	050	Opens a parenthetical entry.
/	334	+	134	Changes sign in the display.
)	251	)	051	Closes a parenthetical expression. Two, will always close a statement.
0 1 2 3 4 5 6 7 8 9	260 261 262 263 264 265 266 267 270 271	0 1 2 3 4 5 6 7 8 9	060 061 062 063 064 065 066 067 070 071	Used for numerical entry.

ALPHA	OCTAL CODE	KEY	OCTAL CODE	
.	256	.	056	Decimal point.
@	300	$K_{\square}$	100	Used to access data registers. Register is identified and recalled by a digit that follows. Display storage into these registers is accomplished by preceding K and its following digit with =; For example = K 9.
/	257	÷	057	Divide.
*	252	x	052	Multiply.
-	255	-	055	Subtract.
+	253	+	053	Add.
=	275	=	075	Equals. Causes accumulation of all entered arithmetic statements. Also causes display storage in a data register when followed by a data register address. (See Storage Operations and Data Registers.)
%	245	CLEAR	045	Resets calculator to begin again on a new set of operations and data entries.
$	244	PRINT DISPLAY	044	Print the display (and alpha, if entered).
SPACE	240	CLEAR	040	Clears display to all zeros. Does not alter previously entered operations.
Z	332	CONT	132	The continue key, resumes program execution.
#	243	STOP	043	The stop key, is used to halt program execution.

The following steps are programmable only as subroutine labels in the Hold for Alpha Mode.

BLANK	223	$\overrightarrow{\text{STEP}}$		In the idle mode, executes program step by advancing counter one step at a time. In learn mode, allows examination of memory locations within a memory block.
BLANK	220	$\overleftarrow{\text{STEP}}$		Decrements counter. In the idle mode, requires Learn mode or E4 error message will be displayed.

Keystroke Functions TEK 31

ALPHA	OCTAL CODE	KEY	OCTAL CODE	
BLANK	221	INSERT		Increments indexed step and all program steps after indexed step one location in memory. Next programmable keystroke is inserted at indexed location. In Idle mode, Learn mode is required or E4 error message will be displayed.
BLANK	222	DELETE		Deletes presently indexed step from program. Decrements all subsequent steps one location in memory. In Idle mode, requires Learn mode or E4 error message will be displayed.
BLANK	224	LIST		Starts a program list starting at presently indexed location.
BLANK	225	DISPLAY PROGRAM		Displays present location, keycode of program step stored at that location, and presently opened file number.
		HOLD	NO CODE Activates Alpha Mode	While key is activated any keystroke is taken as an alpha keystroke and may be used while storing alpha keystrokes in memory. (The only non-Programmable key.)
BLANK		LEARN		Causes entry and exit from Learn mode. In Learn mode, the calculator "remembers" keystrokes.

The following steps are programmable.

	276	IF $\geq\emptyset$	076	These keys have no effect in Idle mode. When any of these conditions are fulfilled, program steps following the IF statement are executed. Otherwise, the program branches to the next programmed CONT.
?	277	IF $=\emptyset$	077	
	274	IF $<\emptyset$	074	
!	241	IF FLASH	041	
↑	336	IF FLAG	136	
,	254	RESET	054	Branches to 0000. If in Idle mode, stays in this mode and enters Idle mode.
;	273	START	073	Starts program execution at 0000. Stores address in address register.

Keystroke Functions TEK 31

ALPHA	OCTAL CODE	KEY	OCTAL CODE	
:	272	ADDRESS	072	Used when specifying mag-tape transfers. Always is followed by a GO TO or one of the R keys.
BELL	207	GO TO □□□□	007	An unconditional branch command when followed by address digits. Will branch to a specified location. Will continue at a specified location under program control.
Space ←	210	Rxxx □□□	010	Causes recall of stored contents of register specified by digit keystrokes that follow. The first digit indicates the file, and the second two digits indicate the R-register in the indicated file.
TAB	211	Rxx □□□	011	Causes recall of stored contents of register specified by the digit keystrokes that follow. Recall is from current file. Note: When an = precedes either of the above, the display is stored in the specified register.
BLANK	203	TO TAPE	003	Used in mag-tape transfers of information to tape. This keystroke is followed by a single digit indicating the tape block to which the information is to be transferred.
BLANK	202	FROM TAPE	002	Used when transferring information from mag-tape to the calculator's memory. Followed by single digit keystroke indicating the tape block from which the information is to be taken.
BLANK	204	EXECUTE	004	Causes execution of labeled subroutine when followed by labeling keystroke. Under program control END is not recognized.
BLANK	201	LABEL	001	Causes counter to index to the program step indicated by the labeling keystroke. Under program control indicates beginning of symbolically labeled subroutine.
-	337	END	137	When subroutine is executed under program control, END is ignored. When executed from Idle mode, END causes termination of execution of the subroutines.

Keystroke Functions TEK 31

ALPHA	OCTAL CODE	LEU	OCTAL CODE	
[	333	RETURN ADDRESS	133	Puts contents of the return address register into display
]	335	GO TO DISPLAY	135	Branches to displayed location (last four digits) and remains in Idle mode. Under program control branches to displayed location and continues execution.
'	247	CLEAR FLAG	047	Clears flag.
"	242	SET FLAG	042	Sets flag.
BLANK	205	CLEAR R FILE □	005	Clears all R-registers in file indicated by following keystroke.
&	246	PAUSE	046	Under program control, causes a pause in program execution of about one second in duration.

To aid the operator, the TEK 31 has been provided with a series of error codes which will show in the display in place of the exponent. The code indicates the type of error as follows:

Error Codes

0 - End of memory

1 - No such step

2 - No such register

3 - Requires a digit or label

4 - Requires LEARN mode

5 - No such label

6 - Illegal code in memory

7 - No mag-tape cartridge or block or no paper in printer

8 - Write protected (mag-tape cartridge)

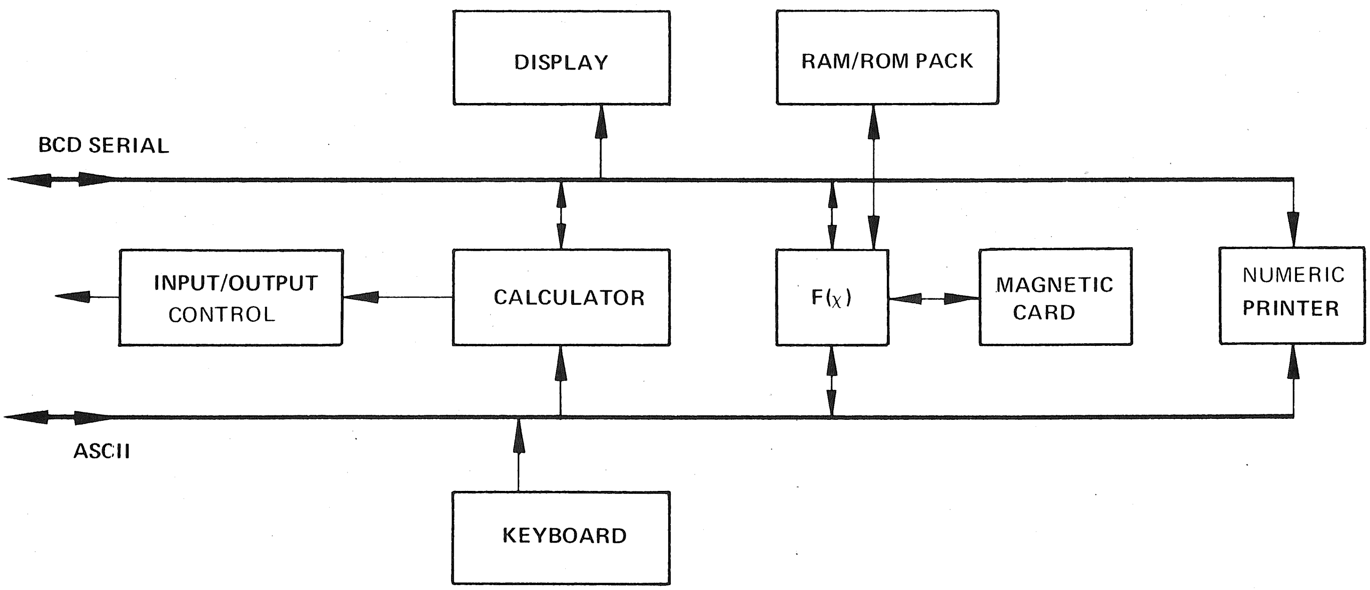
9 - Bit error (mag tape transfer)

SECTION IV

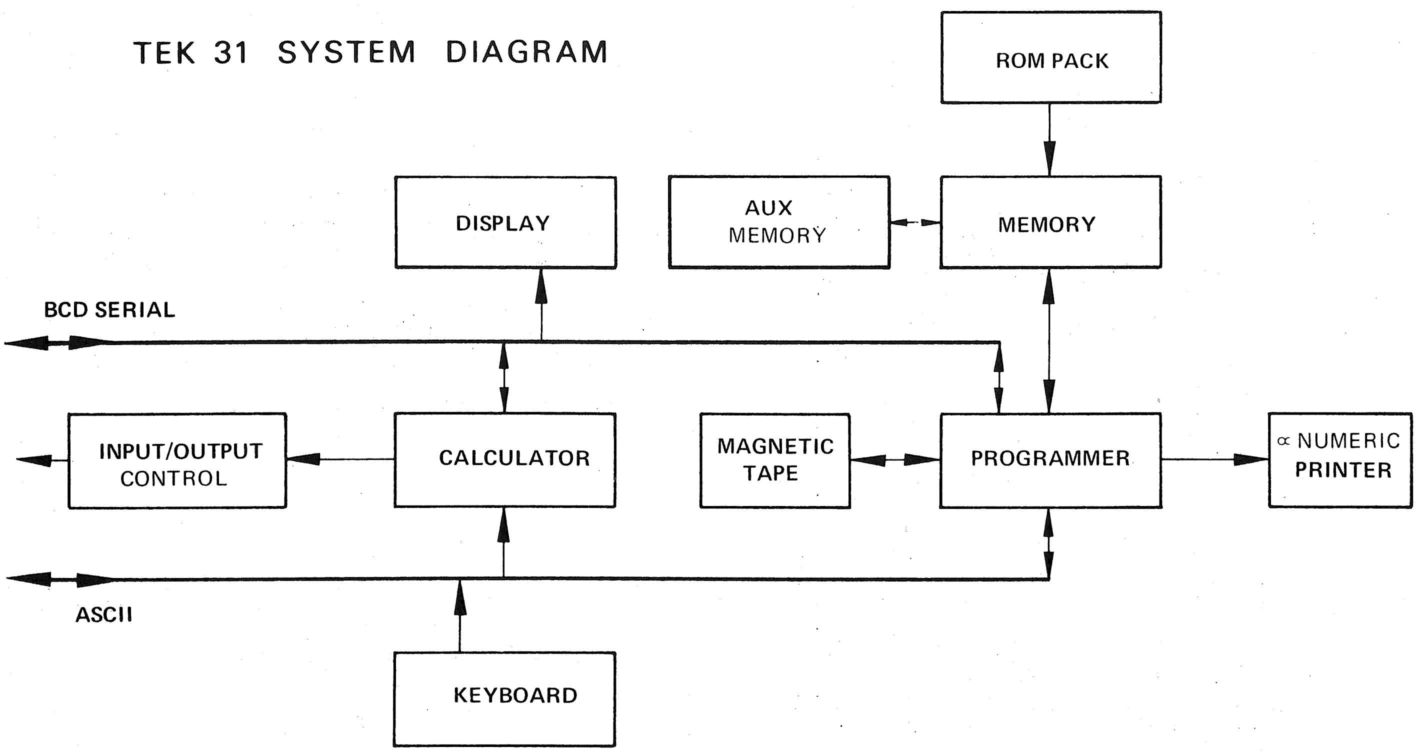
THEORY OF OPERATION

BLOCK DIAGRAM

TEK 21 SYSTEM DIAGRAM



TEK 31 SYSTEM DIAGRAM



SECTION IV

THEORY OF OPERATION

CIRCUIT DESCRIPTION TEK 21

MAG CARD

Introduction

The TEK 21 Magnetic Card unit utilizes a two-channel, self-clocking data recording technique. The bit density is approximately 572 bits per inch. The card speed is approximately 7 inches per second and data is written serially with about 250 μs between each bit. There is a "ones" data channel and a "zeros" data channel. When no data has been recorded on a section of the tape, that section is erased. Each bit is recorded in the appropriate channel as a magnetic flux reversal on the tape. For example, if 00110010 is recorded on the tape, the flux is sequentially reversed twice in the "zeros" channel, twice in the "ones" channel, twice again in the "zeros" channel, once in the "ones" channel and finally once in the "zeros" channel. When this section of tape is played back, the corresponsing channel amplifier outputs look like the illustration in fig. 4-1.

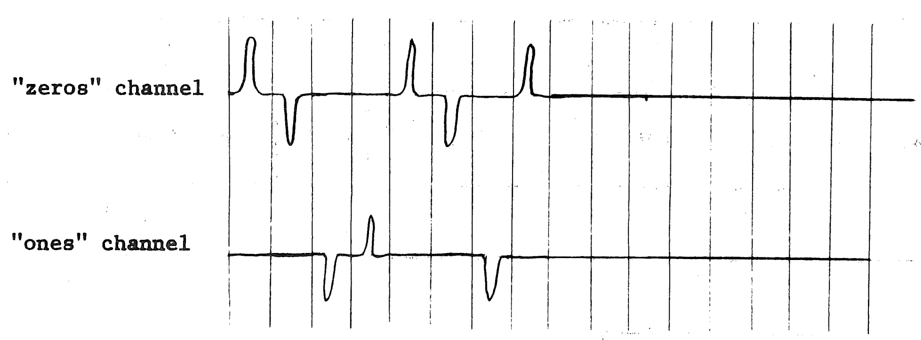


Fig. 4-1

Notice that when data is present, there is output from one of the two data channels. When there is no data present, there is no output from either channel.

The mag card can store up to 2048 bits (256 steps).

Write Circuits

To write or record on the mag card, the TO CARD-FROM CARD switch (S3) is set in the TO CARD position. When the card is inserted, switch S1 closes; this applies approximately +7V from the regulator to the motor and approximately +4V through divider R7-R8 to pin 10 of U4C ($\overline{\text{CLEAR ALL}}$). When pin 10 of U4C is low all the flip-flops are held clear. As the card passes between the light source DS1 and the photo transistor Q4 the signal at TP-5 will go low. (There is a 45° mirror inside the cartridge to reflect the light from its source to the photo transistor.) This sets Start flip-flop U4B-U4C. The output at pin 8 of U4C is inverted by U6C. The output of U6C tells the f(x) board that a Mag Card is present (line MCP); also, pin 13 of U4D and pin 2 of U6A are now high.

When the hole in the card passes between the light source and the photo transistor, TP5 goes high if the card is not write protected. Now both pins 12 and 13 of U4D are high, and pin 11 goes low. This sets the Write OK flip-flop U6A-U6B and pin 6 of U6B goes high. Now pins 12 and 13 of U6D are both high and pin 11 ($\overline{F}$) goes low. Q3 is also saturated when $\overline{F}$ occurs which turns on the write current. The $\overline{F}$ signal is also inverted by U3B which removes the clear from One's

Channel flip-flop U8A and Zero's Channel flip-flop U8B and enables U10 A, B, C, D. Approximately 125 ms after $\overline{F}$ occurs, the first RECORD CLOCK appears at pins 1 and 5 of U8A and U8B respectively.

The DO and $\overline{DO}$ lines change according to the information stored in f(x) and are clocked into the J-K flip-flops U8A and U8B every 250 s. Any change in the outputs of U8A and U8B (through U10, A, B, C, D) is recorded as a bit (flux change) in that channel. This operation continues until the end of f(x) is reached.

If the card is write-protected, TP-5 will never go high and $\overline{F}$ will not occur. Therefore the card can never be written on again.

CR8, CR12, CR11, CR9, CR10 and R43 protect the inputs of the read amplifiers from voltages greater than +5V which occur when the inductive head is switched.

Read Circuits

To read from the mag card the TO CARD-FROM CARD switch (S3) is set in the FROM CARD position. When the card is inserted $\overline{\text{CLEAR ALL}}$ occurs the same as during the write mode. When the card passes between the light source and phototransistor, TP5 goes low. This sets the Start flip-flop (U4B-U4C). Pin 6 of U4B goes high and is connected through the TO CARD-FROM CARD switch to pins 2 and 12 of U2A and B. TP5 going low also triggers the Read Delay one-shot (U1B). Pin 12 of &1B (which is connected to pins 5 and 9 of U2A and B) will go low for approximately 72 ms. This inhibits any output of the read amplifiers until the point on the card where the write curren comes on (while the card is being recorded) is given time to pass the head. The write current coming on is the same as a flux change and would cause an error if the read amplifiers were not turned off during this time.

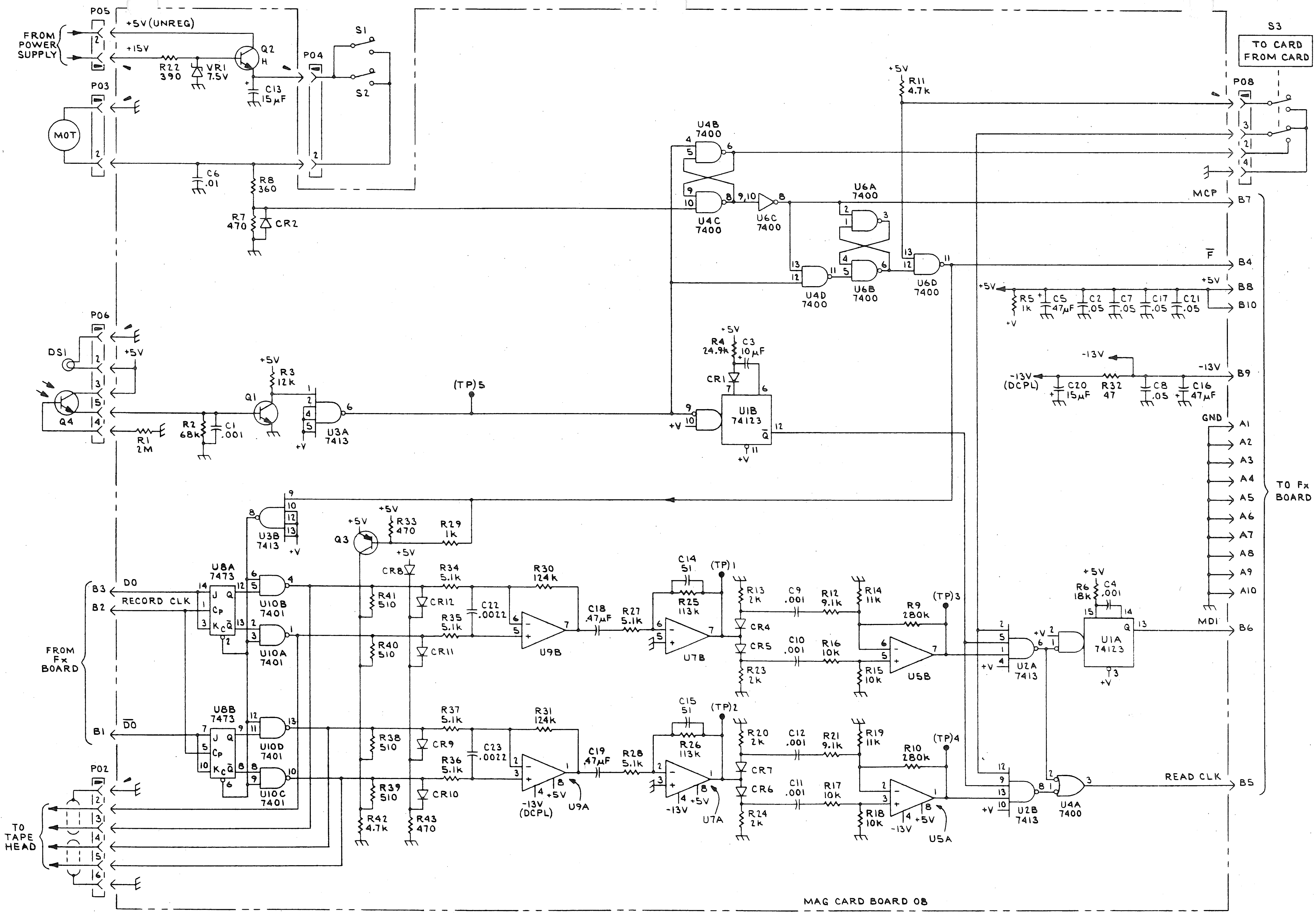
The read amplifier operation for the one's channel will be described. The operation of the zero's channel is the same.

Approximately 8 mV peak-to-peak is seen at the head. This signal is amplified by about 24 by U9B and ac coupled (to eliminate any DC offset) to U7B. C22 and C14 are used for high frequency noise suppression. The signal is again amplified by about 22 by U7B approximately 4 V peak-to-peak should be seen at TP1, with an average value of zero. The signal to noise ratio at this point should be less than 10:1, the noise being the residual signal left from previously recorded data and 60 Hz. The diodes CR4 and CR5 will remove approximately 1.2 V peak-to-peak from the center of the 4 V peak-to-peak signal, which in turn removes the noise.

The signal is then differentiated (to narrow the pulse width) by C9, R12 and R14 on one side and by C10, R16 and R15 on the other side. The signal is now fed to both the + and - inputs of amplifier U5B. A positive going signal (must be greater than 2V) will be seen at TP-3 for either a positive or negative going signal seen at TP-1.

The output at TP-3 (one's channel) is fed into schmitt-trigger U2A and the output at TP4 (zero's channel) is fed into schmitt-trigger U2B. The outputs of U2A and U2B are applied to OR gate U4A.

The output of U4A, called READ CLK, is fed to the f(x) board. The output of U2A is also connected to the one-shot U1A. The Q output of U1A (fixed pulse width) is called MDI and is fed to the f(x) board (along with the READ CLK) where it is loaded into memory.



TEK 21

MAG CARD

TEK 21/31 POWER SUPPLY

Theory of Operation

The TEK 21/31 power supply is the module which provides unregulated and regulated voltages to the other internal modules and to the Main Interface Board. The table below indicates these supply voltages.

Voltage	Current rating	Protected
+300	10 mA	yes, with a 100mA fuse
+15 unregulated	3.2A Peak, 2A Avg	no
+15	400 mA	yes
+5 unregulated		no
+5	10 A	yes, current foldback
GROUND		REFERENCE POINT
-13	400 mA	yes

The +15 VDC and -13 VDC regulated voltage supplies use integrated circuit (IC) regulator devices. They contain short circuit protection, thermal overload sensing circuitry, and a voltage reference as integral parts of the devices. The +5 VDC is made available to the magnetic storage module. This voltage is regulated in that module and is used to power the dc motor of the transport assembly. The unregulated +300 VDC is made available to the display assembly. This voltage is regulated at the display to provide the voltage to operate the Sperry seven-segment devices.

TEK 21-31 POWER SUPPLY

The power supply module contains a power fail circuit which generates a $\overline{\text{MASTER CLEAR}}$ signal upon power-up of the calculator or during a momentary power interruption. In addition, the module contains a square pin jumper arrangement to match certain input line voltages. A description of the procedure for changing the input voltage is contained in the TEK 21 or TEK 31 Service Manual.

Circuit Description

The +5 VDC regulated supply is capable of delivering 10A of current at a typical voltage of +5 volts DC. The unregulated voltage is developed from T1, CR7, CR8 and C6. The series pass transistor Q1 form a darlington connection. R8 is connected between the base of Q1 and the emitter of Q4 to provide a low impedance path for the leakage currents of Q1. This is necessary due to the very high current gain of the darlington connection. U1 is a differential operational amplifier which has a current limited output of about 17mA. The voltage reference for the circuit is derived from the adjusted +15 VDC supply through divider network of R1 and R2. The regulated point is on the main interface circuit board and is connected to U1 via the +5V SENSE signal line. R13 permits normal circuit operation when the +5V SENSE signal line is open circuited. R3 is the current sensing resistor and develops a portion of the voltage necessary to turn on current limiting transistor Q4. Voltage divider

R4 and R5 provide the other portion of voltage necessary to turn on Q4. R3, R4 and R5 function together to provide the "fold-back current limit" circuit. This means that the current limit value changes as a function of the actual voltage on TP1. For example: when TP1 is at about +5 volts DC, the current limit value is about 11 amperes. When TP1 is at about 0 VDC due to a short, for instance, the current limit value is about 2 amperes. This fold-back action controls the power dissipation in Q2, reducing the current level when the voltage across Q2 increases. C5, C8 and C9 provide frequency stability for their respective circuits. VR1, C2, R6 and Q3 provide a crowbar type overvoltage protection for the +5V supply. The silicon controlled rectifier (SCR) Q3 is turned through VR1 when the actual voltage of TP1 exceeds about +6 Volts DC. R11, CR10 and CR9 diode clamp their respective points to within about 0.7 VDC on the opposite side of the ground reference, TP2. The +5 VDC unregulated supply is connected to the magnetic storage module through P04. The +5 VDC regulated supply is connected to the main calculator circuit boards through the main interface board.

The +15 VDC regulated voltage supply is capable of delivering up to 1 amp of current, dependent upon the case temperature of the IC regulator U5. R17 and R15 provide a divider network to adjust the output of U5 to +15 VDC. T1, CR3, CR4 and C1 form a full-wave rectifier circuit with sufficient capability to supply the thermal printer module via P03, in addition to the U5 regulator circuit.

The regulated +15 supply is connected to the magnetic storage module through P04 and to the main calculator circuit boards through the main interface board.

The -13 V regulated voltage supply is substantially identical in operation to the +15 V supply.

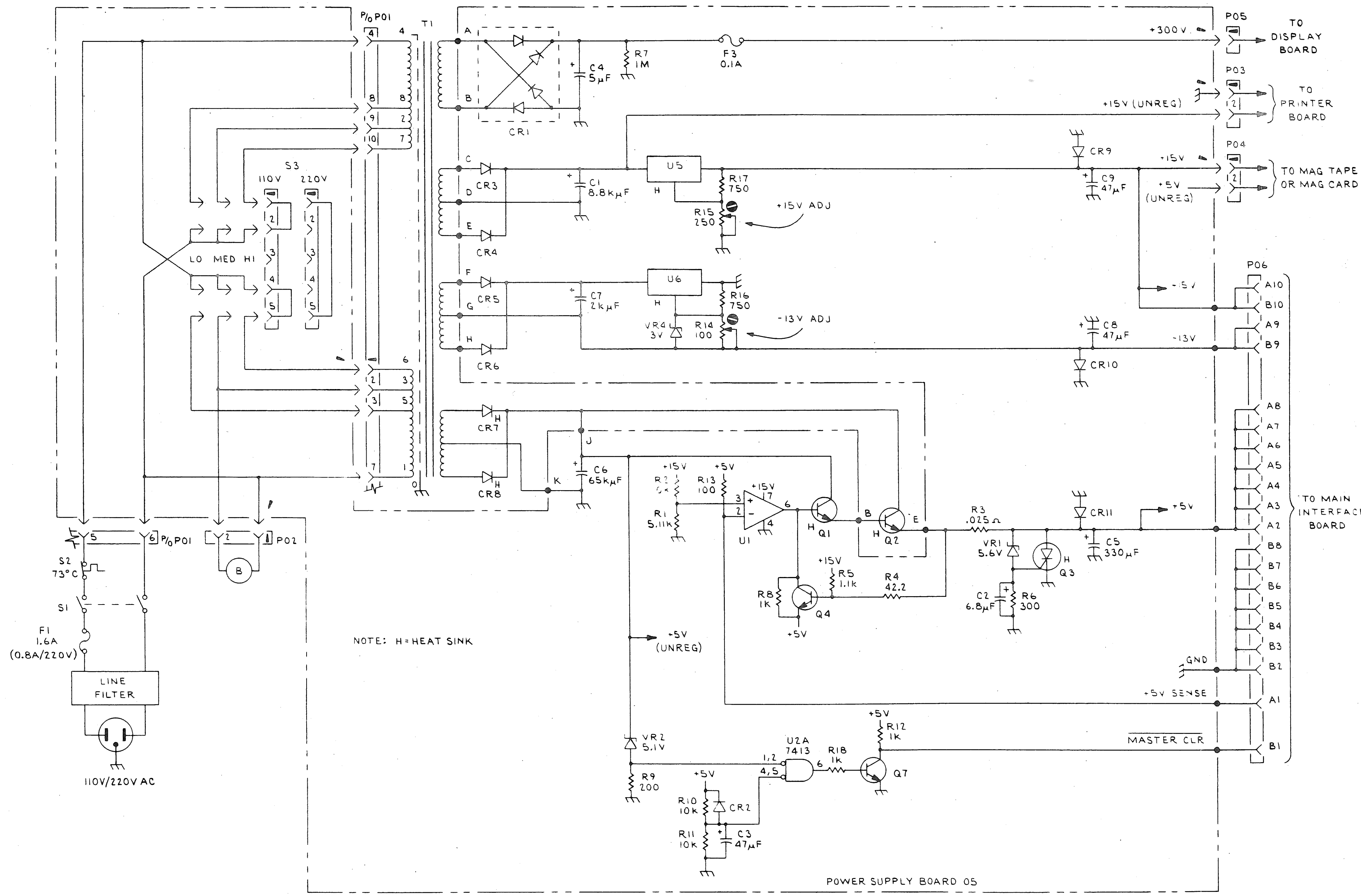
The +300 VDC unregulated supply is composed of T1, CR1, C4, R7 and F3. CR1 and C4 make up a bridge rectifier circuit. R7 discharges C4 when the power is turned off. R7 and F3 are included as safety measures. The +300 supply is connected to the display assembly with P05.

U2A, Q7 and their associated components provide a TTL $\overline{\text{MASTER CLEAR}}$ signal which is high when the +5 Volt supply is operational. When the power is first applied to the calculator (normally with power switch S1) the voltage at TP1 reaches about +5.1 VDC after about 10 - 20 ms. VR2 and R9 cause one of the inputs of U2A to go to a high level at the same time. The other input of U2A is connected to the network which consists of R10, R11, CR2 and C3. C3 charges through R10 and the input of U2A. C3 takes longer than 30 ms to reach a high level for the input of U2A. At that time both inputs are high and the $\overline{\text{MASTER CLEAR}}$ signal (coupled by R12, R18 and Q7) goes high, indicating that the +5 Volt supply is operational. If the +5 Volt supply is momentarily shorted, CR2 discharges C3 and the $\overline{\text{MASTER CLEAR}}$ signal goes low until C3 charges as before. If the main AC power source is interrupted, the input of U2A connected to

R9 will go low causing the $\overline{\text{MASTER CLEAR}}$ signal to go low. The $\overline{\text{MASTER CLEAR}}$ signal is connected to the main interface board.

Cooling fan B uses 110 VAC, 50 to 60 Hz, and delivers ___ CFM. It is connected to T1 by P02. P02 and P03 should never be interchanged.

T1 is connected to the power supply board with P01. P01 also connects the circuit board to thermal cutout switch S2, to main power switch S1, the primary fuse F1 and to the IEC power connector and line filter. S3 provides the input voltage selection. For 100/110/120 AC operation, the harmonica selector switch should have two loops of wire as shown which parallel connect the appropriate windings of T1. For 200/220/240 AC operation, the harmonica selector switch should have only one loop of wire as shown, which series-connects the appropriate windings of T1.



TEK 21/31

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POWER SUPPLY

CIRCUIT DESCRIPTION TEK 31

MAG TAPE

Introduction

The TEK 31 Magnetic Tape unit utilizes a two-channel, self-clockin g data recording technique. The bit density is approximately 7 inches per second and data is written serially in groups of 8 bits each with about 500 μs between each bit. There is a "ones" data channel. When no data has been recorded on a section of the tape, that section is erased. Each bit is recorded in the appropriate channel as a magnetic flux reversal on the tape. For example, if 00110010 is recorded on the tape, the flux is sequentially reversed twice in the "zeros" channel, twice in the "ones" channel, twice again in the "zeros" channel. When this section of tape is played back, the corresponding channel amplifier outputs appear as in Fig. 4-2.

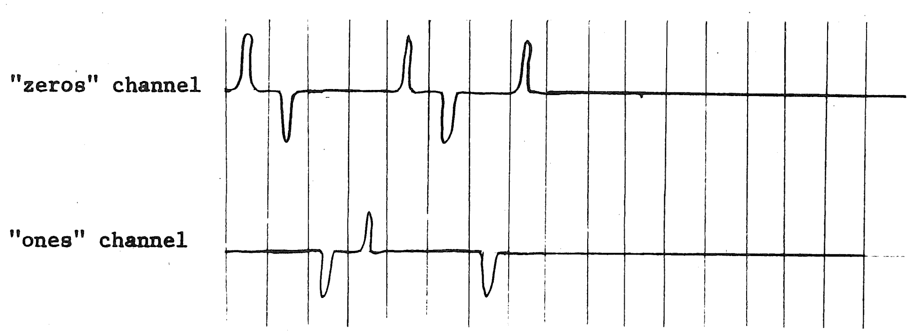


Fig. 4-2.

Notice that when data is present, there is output from one of the two data channels. When there is no data present, there is no out from either channel.

The mag tape cartridge contains six blocks (zero through five), which are identified by groups of holes in the tape, referred to as spots. A particular block can be detected by counting the number of spots occurring in a specific time (about 300 ms) and then subtracting 2. Block zero is identified by two spots, block one by three spots, etc. A single spot defines the end of a block.

If, when a tape transfer is attempted, an error code appears in the extreme right of the display, and is defined as follows:

a) E7 means that either a nonexistent block was selected (six or greater) or that there is no cartridge properly seated in the mag tape module.

b) E8 means that to tape was attempted and that the mag tape cartridge was write protected (no rubber bumper on the inside surface).

c) E9 means that a from tape operation was performed and that there was not an even number of 8-bit bytes of data transferred. The transferred data may or may not be correct, and should be examined or retransferred from tape.

The TEK 31 Mag Tape module circuit board 08 contains a pair of write circuits, a pair of read amplifiers, a spot amplifier and miscellaneous control logic.

The Write Circuits

The write circuits are composed of U7, U2, U4 and U8. U7 buffers the WRITE CLOCK and provides inverted SERIAL DATA IN. U2 generates the complementary drive signals for the head drivers in U4. U2 is a dual J-k flip-flop. One half of U2 will toggle and the other half of U2 will remain unchanged when a WRITE CLOCK pulse occurs. If the SERIAL DATA IN is near a 3 volt level (a one) then U2A will toggle and cause a flux reversal in the "ones" channel connected to the "ones" channel drivers U4A and U4B. Since Serial Data in is inverted through U7D, U2B will not change state and the "zeros" channel connected to U4C and U4D will not be changed. When SERIAL DATA IN is near a 0.2 volt level (a zero) U2B is the half that changes state, causing a flux reversal in the "zeros" channel through the "zeros" channel drivers U4C and U4D.

Before any writing can actually take place, the $\overline{\text{RESET SPOT/START MOTOR}}$ pulse must set the flip-flop composed of U8C and U8D. The setting of this flip-flop applies about +7 volts to the DC motor through Q_1 and Q_4.

After the motor has run for a certain period of time and after the appropriate block has been found, the $\overline{\text{CLOCK WRITE CURRENT ON}}$ pulse sets the flip-flop composed of U8A and U8B. This flip-flop provides a write current of about 10mA to the two data channels through Q_1 and S_2. (S_2 is activated by the rubber bumper in the hole in the end of the mag tape cartridge.)

After normal data transfer, this write current always flows through both channels of the head as long as flip-flop U8A-U8B is set. This causes the rest of the tape from the end of the data to just beyond the end of the block to be saturated, effectively erasing the data that may have been previously written.

A $\overline{\text{RESET}}$ pulse resets flip-flop U8C-U8D and flip-flop U8A-U8B. Resetting U8C-U8B stops the motor. Resetting U8A-U8B turns off the write-current-enable to the head drivers in U7. The $\overline{\text{POWER UP RESET}}$ pulse is equivalent to $\overline{\text{RESET}}$ and occurs at initial power-on of the calculator, or when the power is momentarily interrupted.

The CR2, CR3, CR4, CR5, CR6, R11 and C3 network protects the inputs of the read amplifiers connected to the head from voltages greater than +5 volts which may occur when the inductive head is switched.

The Read Circuits

The read amplifiers U1, U6 and their associated components are always connected to the head. When data is being written, the read circuit outputs are ignored. When data is being read, the head drivers in U7 are disabled and are effectively disconnected from the head. The flux reversals caused during data writing, occur as 4mV peak-to-peak pulses, one pulse per flux reversal. The pulses occur on either the "ones" channel or the "zeros" channel, but never on both channels at the same time. The pulses on a given channel alternate in polarity (See Theory of Operation). No information can be gained from the polarity of the pulse, and in fact, U10-U11 absolute value amplifiers change the pulses into larger amplitude pulses, of only one polarity.

The read circuit operation for the "ones" channel will now be described. The operation of the "zeros" channel is substantially identical. When a flux reversal on the mag tape moves by the tape head, a 4mV pulse is produced between P05 pins 4 and 5. This pulse is amplified by about 100 by the differentially connected amplifier U1 and its associated components. jC5, in conjunction with R18 and R19, provides high frequency noise suppression. U1, R18 and R20 provide an inverting gain of about 100. U1, R19 and R20 provide a noninverting gain of about 100. U1 and its associated components provide a differential input, single ended output circuit with large common-mode rejection (mostly for rejection of 60 Hz). C7 AC-couples the signal (to remove any DC offset) to the R24, R22, C9 filter network which provides additional high frequency noise suppression.

The signal at TP5 should be about 800 mV peak-to-peak with zero average value. The signal-to-noise ratio should be about 20:1, with the dominant noise mechanism being either the residual signal left from previously recorded data or a 60 Hz signal.

U11 is both a dual polarity to single polarity pulse converter and a threshold sensitive dual comparator (an amplifier whose outputs are a TTL low level when the input exceeds the input threshold of about ±100 mV). When the input pulse at TP5 exceeds +100 mV, TP3 goes low. When the input pulse at TP5 is more negative than -100 mV, TP4 goes low. When TP3 or TP4 goes low, flip-flop U9A-U9C is set, indicating that a "one" bit has been read from the tape.

If a "zero" channel flux reversal had caused a pulse to occur at TP7, TP2 or TP1 would have gone low instead, resetting the flip-flop U9A, U9C. Since a pulse on the "ones" channel cannot occur simultaneously with a pulse on the "zeros" channel, only one of the test points 1, 2, 3 or 4 will go low for each bit thereby either setting or resetting flip-flop U9A, U9C.

The calculator reads data from the mag tape, one bit at a time. The circuitry which detects the presence of a valid data bit includes U5A and U3A. U3A is first reset with the $\overline{\text{READ ENABLE}}$ pulse as part of the initialization procedure. The calculator then continually tests the output of U3A which is called READ CLOCK. When the first pulse at TP1, TP2, TP3 or TP4 occurs, U3A is set by U5A, and U7B, an and the U9A-U9C flip-flop contains the information. A pulse in the "ones" channel would have set the U9A-U9C flip-flop and a pulse in the "zeros" channel resets the U9A-U9C flip-flop. Either pulse sets U3A via U5A and U7B. With the READ CLOCK at a TTL high level, the calculator reads the bit of data on the $\overline{\text{SERIAL DATA OUT}}$ signal line, sends the $\overline{\text{READ ENABLE}}$ again to reset U3A, and then tests the READ CLOCK signal while waiting for the next bit to come along.

When 8 bits have been read, the calculator writes these 8 bits into the main memory and returns to testing the READ CLOCK signal. The time necessary for the calculator to read the bit from the $\overline{\text{SERIAL}}$

DATA OUT signal line reset U3A and return to testing the READ CLOCK signal is much less than the time between successive bits on the tape (The time between successive bits is about 500 s).

The Spot Circuit

The six blocks on the tape are identified by groups of holes (called spots) in the magnetic tape spaced about 0.3 inch apart. The block number is equal to the number of spots minus two. A single spot identifies the end of a block. When TTP_ or FTP_ is followed by a digit, the calculator first checks to see if the number entered was Ø through 5. If not, it signals an E7 error in the display. If the digit was Ø through 5 and a cartridge is present, the mag tape motor starts and the search for the correct block begins after a one-half second delay for the motor to accelerate. To a write protected tape an E8 error is displayed. The calculator then begins looking for the selected block by testing the SPOT signal line.

P02 connects light source DS5 and photosensing transistor Q5 to the circuit board. There is a 45° mirror inside the cartridge to flect light from the source through the holes in the tape activating Q5. R1 and R2 provide gain stability for Q5 and C1 provides high frequency noise suppression. Q3 amplifies the signal from Q5. U5B is a schmidt-trigger which provides a set signal for U3B (in conjunction with U7B).

When the motor is running (U8C-U8D flip-flop is set) the $\overline{\text{RESET SPOT/START MOTOR}}$ pulse only resets spot flip-flop U3B. After appropriate initialization to account for possible start up in the middle of a group of spots, the calculator is testing the SPOT signal, waiting for a group of spots. When the first spot is found, the calculator counts for about 300 ms which is long enough to count the largest group of spots on the tape (seven, for block number five). The calculator then compares the number of spots minus two with the number of the selected block. If they are equal, the selected block has been found, if they are unequal, the entire procedure of looking for the first spot is restarted.

When the selected block has been found, the tape transfer begins according to the timing figure at the end of this section. The calculator continues to check for spots while it is reading or writing data. Due to the amount of data that can be put on one block (1000 bytes = 8000 bits, maximum), and the tape speed of about 7 ips, enouch tape has been provided per block (4 feet) so that the data will always end before occurrence of the single spot that identifies the end of the block. When sensed the single spot signals the end of the data transfer, which turns off the motor with a $\overline{\text{RESET}}$, according to the timing in Fig. 4-3.

Event	Time
first spot found	
counting of spots completed	300ms
if TTP_, CLOCK WRITE CURRENT ON	0ms
if FTP_ $\overline{\text{READ ENABLE}}$ pulse occurs	90ms
data begins	90ms
data may end here	≈ 5 seconds
data will end by this point end of block (a single spot)	
if FTP_, RESET turns motor off	0ms
if TTP , RESET turns motor off and turns write current off	300ms

Fig. 4-3.

The times in Fig 4-3 are times for reoccurring events to take place. Mag tape timing assumes that the selected block has been found.

Miscellaneous Control Logic Circuits:

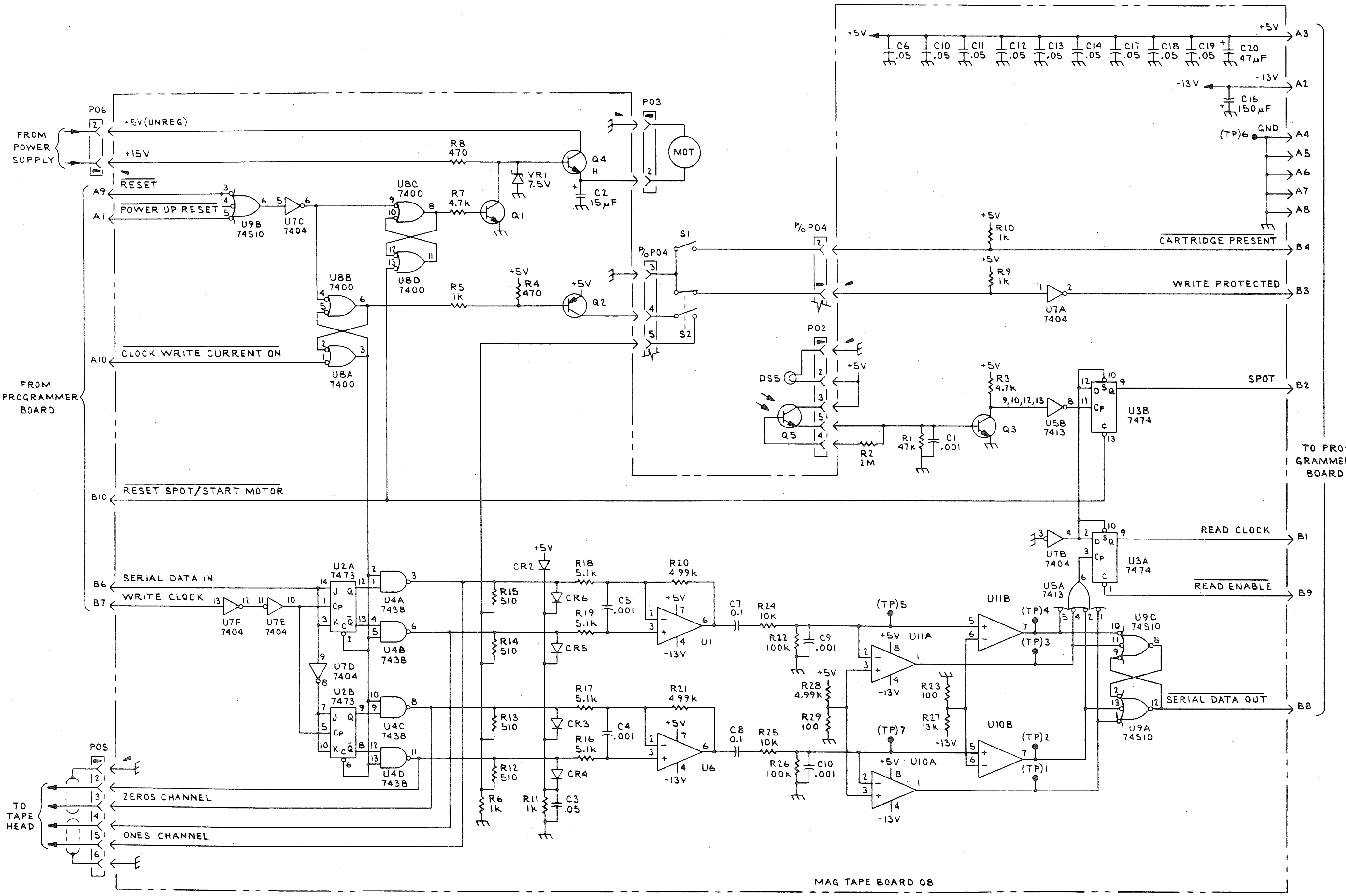
The mag tape module has two microswitches. S1 tells the calculator if a tape cartridge is present. S2 provides write protect information and interrupts the write current to the head, if the tape is write protected (The absence of a rubber bumper on the tape cartridge provides write protection.

S1 is normally open when no cartridge is present and the $\overline{\text{CARTRIDGE PRESENT}}$ signal is then approximately +5 volts. The presence of a properly positioned cartridge in the module should close the normally open contacts and cause $\overline{\text{CARTRIDGE PRESENT}}$ to go low.

The normally closed contacts of S2 provide the WRITE PROTECT signal that the calculator tests when a TO TAPE command is executed. Normally open contacts of S2 provide no path for the write current to the head unless the rubber bumper is in place to cause S2 to actuate. The actuation of S2 permits execution of a TO TAPE command, and provides a path for the write current to flow through the head, when Q_1 turns on.

Note: It is possible for extraneous bits of data to be written onto the tape under certain conditions during power-on and power-off of the calculator, if the tape cartridge is in its proper position

<u>and</u> if the rubber bumper is in position to actuate S2. When the tape is write-protected, there is little danger of any data being written onto the tape.



TEK 31

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MAG TAPE

TEK 21/31 POWER SUPPLY

Theory of Operation

The TEK 21/31 power supply is the module which provides unregulated and regulated voltages to the other internal modules and to the Main Interface Board. The table below indicates these supply voltages.

Voltage	Current rating	Protected
+300	10 mA	yes, with a 100mA fuse
+15 unregulated	3.2A Peak, 2A Avg	no
+15	400 mA	yes
+5 unregulated		no
+5	10 A	yes, current foldback
GROUND		REFERENCE POINT
-13	400 mA	yes

The +15 VDC and -13 VDC regulated voltage supplies use integrated circuit (IC) regulator devices. They contain short circuit protection, thermal overload sensing circuitry, and a voltage reference as integral parts of the devices. The +5 VDC is made available to the magnetic storage module. This voltage is regulated in that module and is used to power the dc motor of the transport assembly. The unregulated +300 VDC is made available to the display assembly. This voltage is regulated at the display to provide the voltage to operate the Sperry seven-segment devices.

TEK 21-31 POWER SUPPLY

The power supply module contains a power fail circuit which generates a $\overline{\text{MASTER CLEAR}}$ signal upon power-up of the calculator or during a momentary power interruption. In addition, the module contains a square pin jumper arrangement to match certain input line voltages. A description of the procedure for changing the input voltage is contained in the TEK 21 or TEK 31 Maintenance Manual (XXX-XXXX-XX or XXX-XXXX-XX).

Circuit Description

The +5 VDC regulated supply is capable of delivering 10A of current at a typical voltage of +5 volts DC. The unregulated voltage is developed from T1, CR7, CR8 and C6. The series pass transistor Q1 form a darlington connection. R8 is connected between the base of Q1 and TP1 providing a low impedance path for the leakage currents of Q1. This is necessary due to the very high current gain of the darlington connection. U1 is a differential operational amplifier which has a current limited output of about 17mA. The voltage reference for the circuit is derived from the adjusted +15 VDC supply through divider network of R1 and R2. The regulated point is on the main interface circuit board and is connected to U1 via the +5V SENSE signal line. R13 permits normal circuit operation when the +5V SENSE signal line is open circuited. R3 is the current sensing resistor and develops a portion of the voltage necessary to turn on current limiting transistor Q4. Voltage divider

R4 and R5 provide the other portion of voltage necessary to turn on Q4. R3, R4 and R5 function together to provide the "fold-back current limit" circuit. This means that the current limit value changes as a function of the actual voltage on TP1. For example: when TP1 is at about +5 volts DC, the current limit value is about 11 amperes. When TP1 is at about 0 VDC due to a short, for instance, the current limit value is about 2 amperes. This fold-back action controls the power dissipation in Q2, reducing the current level when the voltage across Q2 increases. C5, C8 and C9 provide frequency stability for their respective circuits. VR1, C2, R6 and Q3 provide a crowbar type overvoltage protection for the +5V supply. The silicon controlled rectifier (SCR) Q3 is turned through VR1 when the actual voltage of TP1 exceeds about +6 Volts DC. R11, CR10 and CR9 diode clamp their respective points to within about 0.7 VDC on the opposite side of the ground reference, TP2. The +5 VDC unregulated supply is connected to the magnetic storage module through P04. The +5 VDC regulated supply is connected to the main calculator circuit boards through the main interface board.

The +15 VDC regulated voltage supply is capable of delivering up to 1 amp of current, dependent upon the case temperature of the IC regulator U5. R17 and R15 provide a divider network to adjust the output of U5 to +15 VDC. T1, CR3, CR4 and C1 form a full-wave rectifier circuit with sufficient capability to supply the thermal printer module via P03, in addition to the U5 regulator circuit.

The regulated +15 supply is connected to the magnetic storage module through P04 and to the main calculator circuit boards through the main interface board.

The -13 V regulated voltage supply is substantially identical in operation to the +15 V supply.

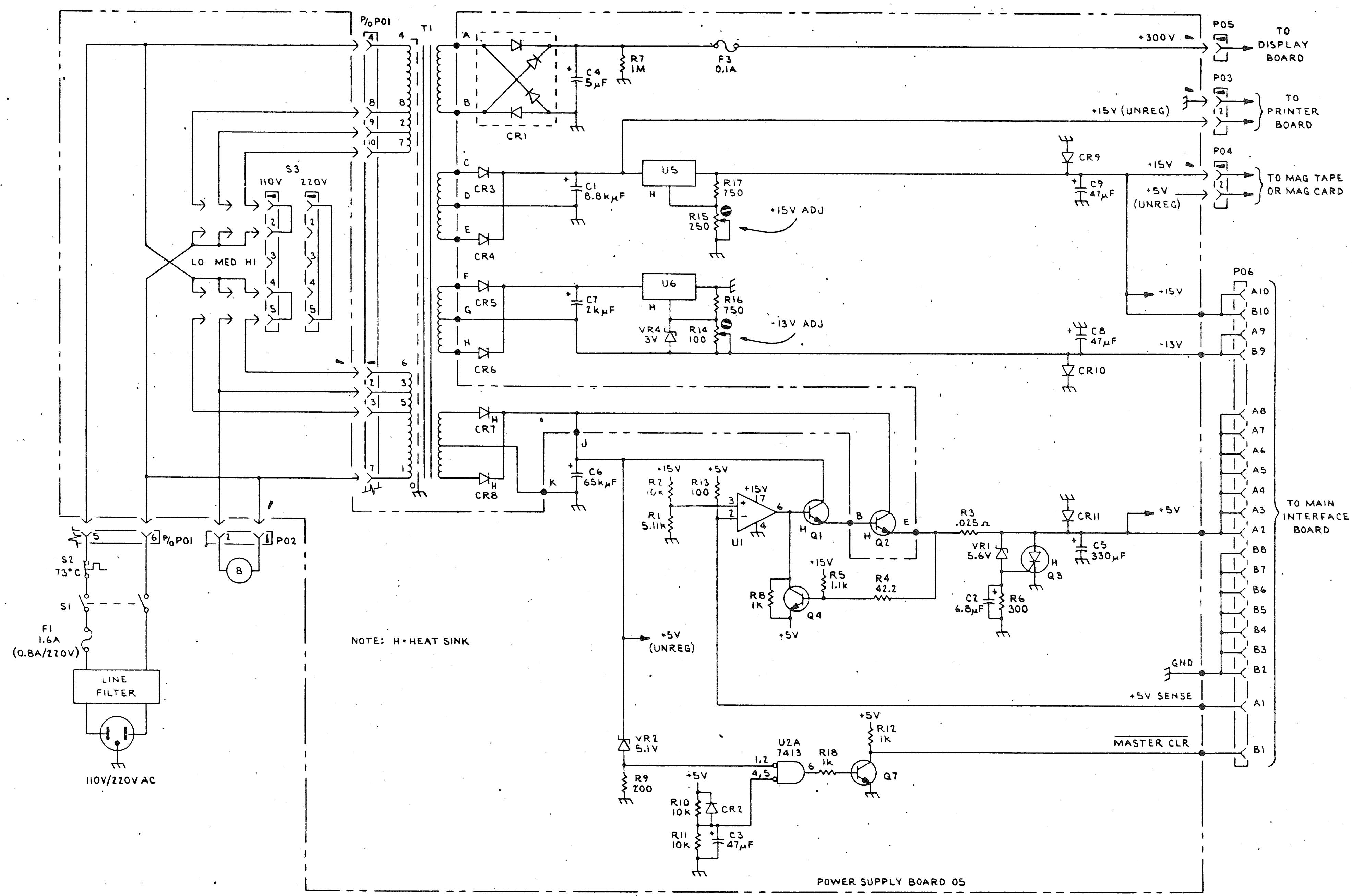
The +300 VDC unregulated supply is composed of T1, CR1, C4, R7 and F3. CR1 and C4 make up a bridge rectifier circuit. R7 discharges C4 when the power is turned off. R7 and F3 are included as safety measures. The +300 supply is connected to the display assembly with P05.

U2A, Q7 and their associated components provide a TTL $\overline{\text{MASTER CLEAR}}$ signal which is high when the +5 Volt supply is operational. When the power is first applied to the calculator (normally with power switch S1) the voltage at TP1 reaches about +5.1 VDC after about 10 - 20 ms. VR2 and R9 cause one of the inputs of U2A to go to a high level at the same time. The other input of U2A is connected to the network which consists of R10, R11, CR2 and C3. C3 charges through R10 and the input of U2A. C3 takes longer than 30 ms to reach a high level for the input of U2A. At that time both inputs are high and the $\overline{\text{MASTER CLEAR}}$ signal (coupled by R12, R18 and Q7) goes high, indicating that the +5 Volt supply is operational. If the +5 Volt supply is momentarily shorted, CR2 discharges C3 and the $\overline{\text{MASTER CLEAR}}$ signal goes low until C3 charges as before. If the main AC power source is interrupted, the input of U2A connected to

R9 will go low causing the $\overline{\text{MASTER CLEAR}}$ signal to go low. The $\overline{\text{MASTER CLEAR}}$ signal is connected to the main interface board.

Cooling fan B uses 110 VAC, 50 to 60 Hz, and delivers ___ CFM. It is connected to T1 by P02. P02 and P03 should never be interchanged.

T1 is connected to the power supply board with P01. P01 also connects the circuit board to thermal cutout switch S2, to main power switch S1, the primary fuse F1 and to the IEC power connector and line filter. S3 provides the input voltage selection. For 100/110/120 AC operation, the harmonica selector switch should have two loops of wire as shown which parallel connect the appropriate windings of T1. For 200/220/240 AC operation, the harmonica selector switch should have only one loop of wire as shown, which series-connects the appropriate windings of T1.



TEK 21/31

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POWER SUPPLY

SECTION V

INSTALLATION

AC Line Voltage Selection

The TEK 21 and TEK 31 calculators operate in one of two voltage ranges: from 100 to 120 and from 200 to 240 volts AC. Satisfactory operation will be achieved within $\pm10\%$ of these voltages. On the back panel an indicator shows the rated voltage set by the factory. This is normally set at 120 volts AC unless the user has requested a voltage range other than standard.

WARNING

Dangerous potentials exist at several points throughout this instrument. When the instrument is operated with the cover removed, do not touch exposed connections or components. Disconnect power before cleaning the instrument.

CAUTION

Each of the two voltage ranges requires a different fuse. Use 1.6 A slow-blow fuse for 100 to 120 volts AC operation; use 0.5 A slow-blow fuse for 200 to 240 volts AC operation.

To change the rated voltage, the steps outlined below should be followed.

INSTALLATION

1. Disconnect the calculator from the power source.

2. Remove the top cover plate as follows:

   a. Loosen the two screws on the back panel.

   b. Release the top cover plate by springing out the vertical surfaces of the top cover plate as shown shown below. (See Fig. 5-1).

   c. Lift the top cover plate straight up and set it aside.

3. The power supply board has three rows of four pins each. The pins are jumpered by a connecting block which contains a pair of jumper wires. Remove the block by pulling it loose from one of the rows of pins. Then position the jumper wires in the block according to the voltage range desired. (See Fig. 5-2). When the 200 to 240 volt range is used, one end of the spare single jumper wire may be connected to the middle space of the block, and the other end of the jumper may be connected to an available spare connection on the block.

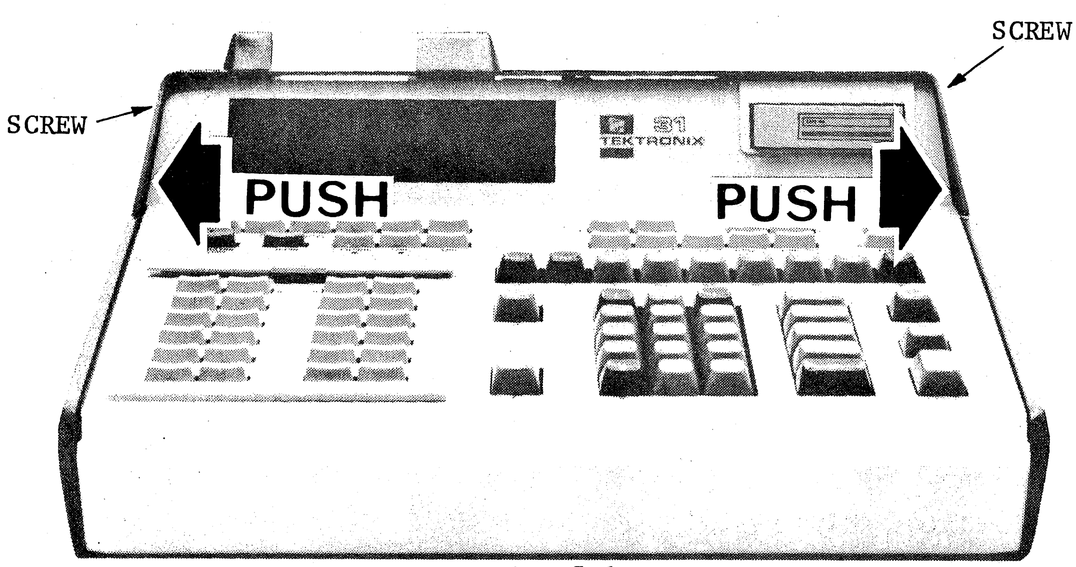

Fig. 5-1.

4. Insert the jumper block onto the pins according to the desired voltage rating. (See Fig. 5-2).

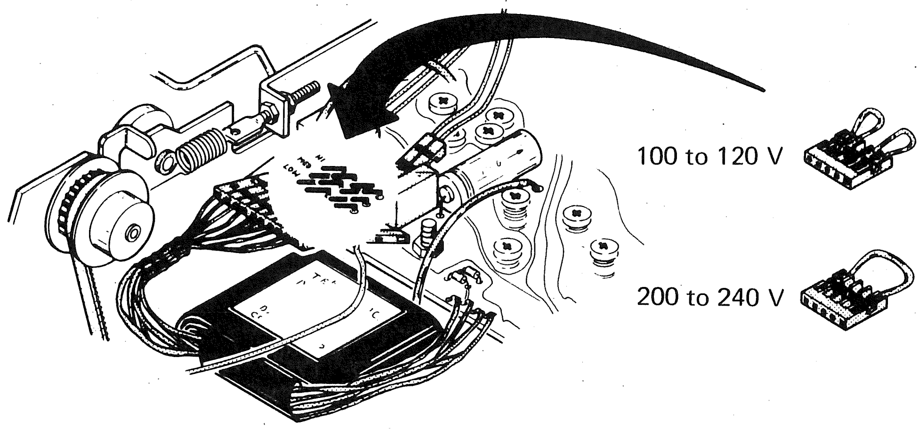

Fig. 5-2.

5. Reinstall the top cover plate and change the fuse if necessary.
6. Indicate the new voltage rating on the back panel.

Optional Equipment Installation - TEK 21

Printer

The field installation of the thermal printer is an easy and straightforward operation, with only slight variations between the Tektronix 21 and 31.

Listed below are the procedures which should be followed when installing the printer in the field.

1. Disconnect calculator from the power source.
2. Remove top cover. See disassembly procedures under Servicing.

3. Remove keyboard. See disassembly procedures under Servicing.

4. Install printer logic board.

   Before the printer logic board can be installed the F(x) board must be removed. See instructions in this manual. The printer logic board is installed by inserting the boards edge connector into the receptable located on the inside back panel underneath the power supply.

   As the F(x) board and printer logic board is pushed into place, be sure that the two plastic clips on each side of the chassis are engaged, firmly holding the board. The board is further secured by five #6-40 screws and two #4-40 screws. The #4-40 screws hold down the back corners, while the #6-40 screws hold down the middle and front of the board.

5. Install the printer module.

   Position the printer over the left side of the calculator with the printer board facing the outside panel. Align the edge connector of the printer circuit board with the receptacle, on the printer logic board and press gently downward until the printer is resting on the subchassis assembly of the calculator. At this time it is convenient to locate the printer power leads (two wires colored red stripe on white, and brown stripe on white) and make sure that they are not confined by the printer. Plug the power leads into the 20 volt point on the left side of the power supply. (Middle module of the calculator). The printer may now be secured to the chassis by two #8-40 screws holding the front of the printer in place and one #6-40 screw holding the back of the printer in place.

6. Reposition the keyboard.

   See procedures for keyboard replacement in SEC IV.

7. Replace top cover plate.

   The top cover plate of the calculator must be replaced with a new plate, which has been especially modified for the printer option.

<u>Optional Equipment Installation - TEK 31</u>

<u>Printer</u>

Listed below are the procedures which should be followed when installing the printer in the field.

1. Disconnect the calculator from the power source.
2. Remove top cover. See disassembly procedures under Servicing.

3. Remove keyboard. See disassembly procedures under Servicing.

4. Install the printer.

   Position the printer over the left side of the calculator with the printer board facing the outside panel. Align the edge connector of the printer circuit board with the receptacle on the programmer board and press gently downward until the printer is resting on the subchassis assembly of the calculator. At this time it is convenient to locate the printer power leads (two wires colored red stripe on white, and brown stripe on white) and make sure that they are not confined by the printer. Plug the power leads into the 20 volt point on the left side of the power supply. (Middle module of the calculator). The printer may now be secured to the chassis by two #8-40 screws holding the front of the printer in place and one #6-40 screw holding the back of the printer in place.

5. Reposition the keyboard.

   See procedures for keyboard replacement in SEC IV.

6. Replace top cover plate.

   The top cover plate of the calculator must be replaced with a new plate, which has been especially modified for the printer option.

Auxiliary Memory Installation

In the TEK 31, an Auxiliary Memory board may be installed, giving the calculator expanded read-write memory. The installation of the Auxiliary Memory board assumes that the main memory board has been fully expanded. (Option 4). The Auxiliary Memory board is connected to the Main Memory board by an edge connector. The addition of the Auxiliary Memory board makes it possible to select one of several combinations of steps and registers.

A complete program step requires 8 binary bits to hold a keycode in storage while a constant in a register requires 64 bits. In storing a large constant, it uses less memory to store the constant in a register than to store the constant in program steps.

The basic difference between a step and a register is the method in which information is stored in the calculator. The following table shows the possible combination available on the TEK 31:

Option 5	2048 steps	640 registers
Option 6	3584 steps	448 registers
Option 7	5120 steps	256 registers
Option 8	2048 steps	1000 registers
Option 9	5120 steps	640 registers
Option 10	8192 steps	256 registers

To install the Auxiliary Memory board, the top cover plate, keyboard, printer, and power supply must be removed. See Section II for these removal procedures.

After the above procedures have been completed, align the Auxiliary Memory board edge connector with the calculator Main Memory board, (top board in the stack of three) and gently push in until a firm connection is made. The Auxiliary board is fastened by three screws, which hold it in place, in front of the Main Memory board.

Before reassembly, it is necessary to select the number of program steps desired, in the calculator's memory. An internal wiring connection is made depending on whether options 5, 6, and 7, or options 8, 9, and 10 are installed on the Auxiliary Memory board.

Partial option. The partial option contains options 5, 6, and 7. The complete option contains options 5, 6, 7, 8, 9, and 10. The writing changes are dependent on the number of program steps in use. At the back of the calculator's Main Memory board (as viewed from the keyboard) 15 pins protrude from the board. A four pin harmonica connector or connecting bar is attached to them. (See Fig. 4-5.) The bar position is dependent on the number of steps selected, which is dependent on the option installed.

A useful formula for determining the position of the index pointer of the connecting bar is:

$$n = \frac{\text{total number of steps in calculator}}{512}$$

where n is the pin number that is connected to the bar's index pointer.

For example, if option 5 is selected, the proper pin for the harmonica's index pointer is given by:

$$n = \frac{2048}{512} = 4$$

Therefore, the index pointer is connected to pin four, and the remaining portion of the harmonica is connected to pins five, six, and seven. The chart below shows which pin to select for a given number of program steps.

Option 5	2048	pin 4
Option 6	3584	pin 7
Option 7	5120 steps	pin 10
Option 8	2048 steps	pin 4
Option 9	5120 steps	pin 10
Option 10	8192 steps	no connection

The above connections allow proper addressing for the ROM pack. The ROM is unusable when option 10 has been selected.

When the complete option is installed, a jumper must be connected on the Auxiliary Memory board. This jumper is labeled option E, and is located in the middle forward part of the Auxiliary Memory board as viewed from the front of the keyboard. When this jumper has been connected, the entire memory is addressable by the calculator.

An additional wiring change may be made which allows the selection of all steps, all registers, or 50% steps and 50% registers. The pins and jumper for this change are located in the middle of the Auxiliary Memory board. To select option 7 or 10 the index of the jumper is positioned over the word STEP printed on the circuit board. If 50% steps and 50% registers are desired, the index of the jumper is positioned over the middle four pins, giving options 6 and 9. If all registers are desired, the index is positioned over the word REG. This change gives options 5 or 8, depending on whether the option E jumper has been connected.

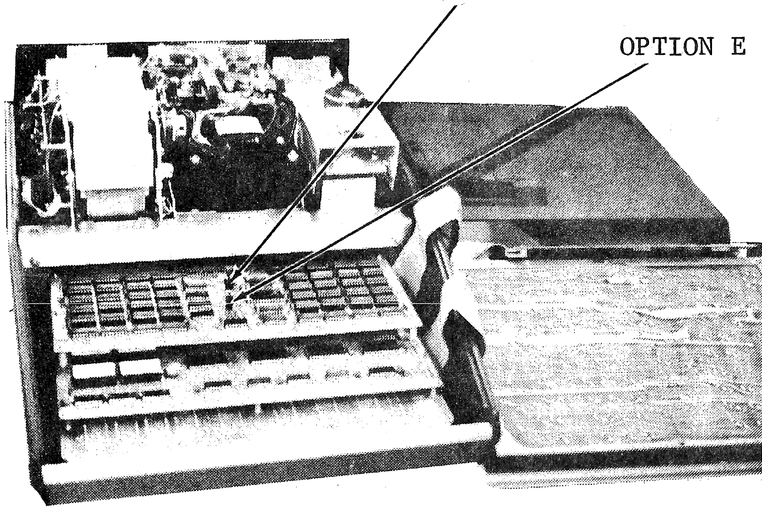

Fig. 5-3

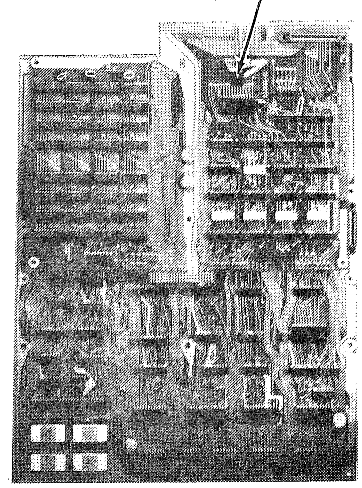

Fig. 5-4

TEK 21 VERIFICATION

A verification program is shipped with each calculator and consists of six pre-recorded 'VERIFICATION CARDS'. The programs recorded on these cards are intended to verify the operations of the internal logic of your TEK calculator.

To verify the calculator's operation,

1) Remove the plug-in memory module (if any).

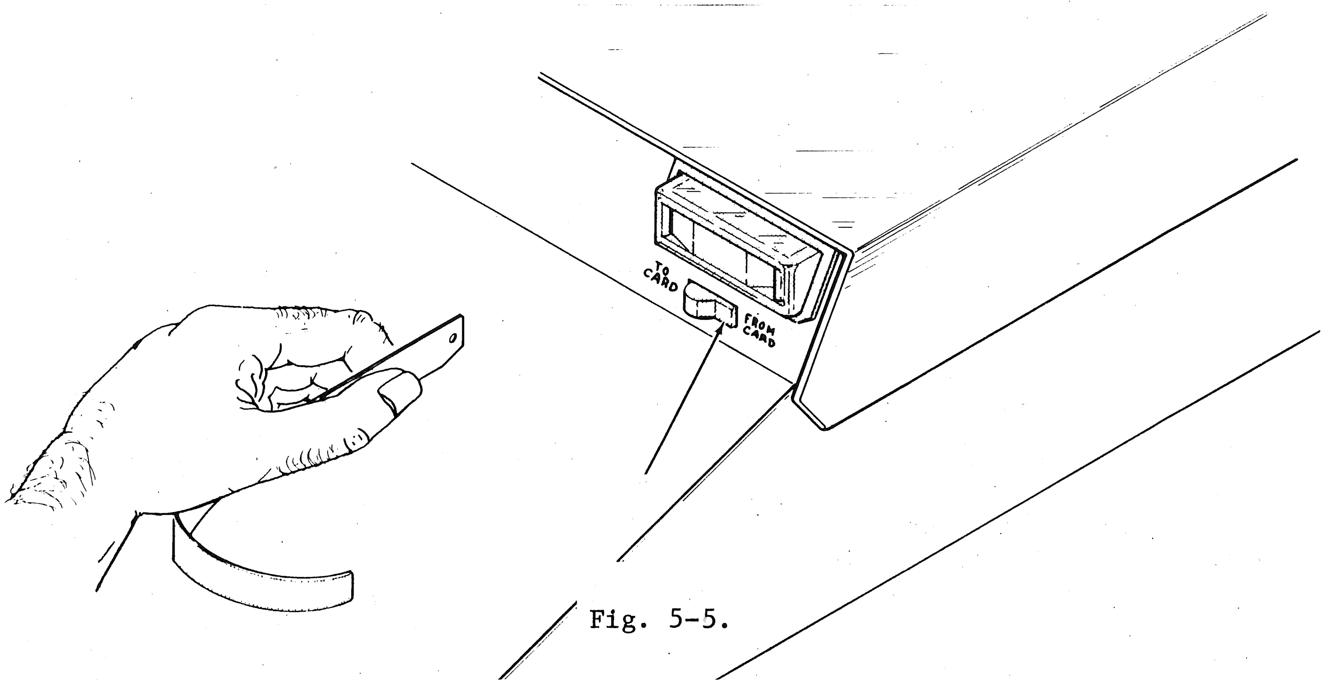

Fig. 5-5.

2) Set the card reader switch to the 'FROM CARD' position.

3) Initialize the transfer to f_0.

PRESS GO TO f_0

4) Insert card #1 into the left-hand slot of the reader until the leading edge of the card is engaged by the transport mechanism.

Release the card, it will be read and will subsequently emerge through the right-hand slot.

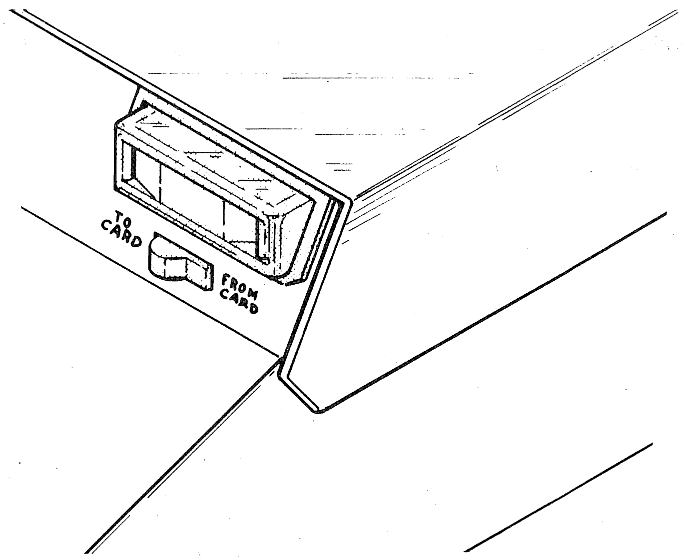

Fig. 5-6.

5) Remove the card from the reader.

6)	Press f_0	Display reads	1.
	Press CONT	Display reads	2.
	Press CONT	Display reads	3.
	Press CONT	Display reads	4.
	Press CONT	Display reads	5.
	Press CONT	Display reads	4.295669623
7)	insert card #2		
	Press f_0	Display reads	6.
	Press CONT	Display reads	7. (Flashing)
	Press CONT	Display reads	0000000000
8)	insert card #3		
	Press f_0	Display reads	8. (Flashing)
	Press CONT	Display reads	9. (Flashing)
	Press CONT	Display reads	10. (Flashing)

	Press CONT	Display reads	0000000000
9)	insert card #4		
	Press f_0	Display reads	11. (Flashing)
	Press CONT	Display reads	0000000000
10)	insert card #5		
	Press f_0	Display reads	12. (Flashing)
	Press CONT	Display reads	13. (Flshing)
11)	insert card #6		
	Press f_0	Display reads	0
	Press CONT	Display reads	1.111111111 11
	Press CONT	Display reads	2.222222222 22
	Press CONT	Display reads	4.444444444 44
	Press CONT	Display reads	8.888888888 88
	Press CONT	Display reads	2.
	Press CONT	Display reads	2.2
	Press CONT	Display reads	2.22
	Press CONT	Display reads	2.2222
	Press CONT	Display reads	2.22222222
	PRESS	$\boxed{\text{CLEAR}}$ $\boxed{\text{REMOTE}}$	$\boxed{2}$ $\boxed{2}$

PROGRAM LISTING

In this listing, the verification program is listed as it actually appears on the verification card (and therefore in memory).

VERIFICATION CARD #1

f_0

CLR	=	π	÷	2	)	sin	STOP	+	1
)	hyp	sin	arc	hyp	sin				

f_1

STOP	$\sqrt{\Sigma x^2}$	5	$\sqrt{x}$	)	D/R	cos	arc	cos	D/R
STOP	+/-	+/-	×	1	Ø				

f_2

=	hyp	cos	1/x	×	3	5	+/-	hyp	cos
=	ln	int	STOP	CLR	+				

f_3

.	Ø	Ø	Ø	Ø	Ø	Ø	1	10^{oo}	+/-
2	+/-	=	K	Ø	K				

f_4

Ø	D/R	D/R	1/x	x^2	1/x	sin	cos	+	4
)	STOP	CLR	.	9	5				

f_5

+	.	0	5	)	×	6	10^{oo}	+/-	2
tan	arc	tan	sin	arc	cos				

f_6

arc	tan	arc	cos	+/-	arc	cos	10^{oo}	Ø	3
tan	10^{oo}	3	arc	tan	+				

f_7

.	1	)	tan	+	1	4	.	3	)
END									

PROGRAM STEPS

VERIFICATION CARD #2

f_0	cos	+	5	.	6	)	cos	+	4	.
	3	)	tan	÷	3	+/-				
f_1	-	.	4	1	5	Ø	1	6	8	Ø
	9	2	)	STOP	CLR	π				
f_2	cos	+/-	×	π	÷	2	)	cos	+	π
	÷	2	)	tan	+	.				
f_3	1	)	10^{oo}	+/-	+	)	10^{oo}	+/-	+	9
	6	10^{oo}	8	8	-	1/x				
f_4	)	+/-	10^{oo}	Ø	Ø	D/R	D/R	=	K	Ø
	CD	9	1/x	×	9	)				
f_5	÷	1	0	)	×	1	Ø	Ø	)	int
	=	K	K	Ø	K	3				
f_6	-	(	K	Ø	-	1	)	)	IF≥Ø	f_7
	CLR	END								
f_7	STOP	CLR	END							

PROGRAM STEPS

VERIFICATION CARD #3

f_0

CLR	8	0	10^{oo}	9	9	)	1/x	1/x	10^{oo}
0	9	)	1	tan	int				

f_1

.	2	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø
Ø	9	×	1/x	1/x	)				

f_2

10^{oo}	+/-	Ø	1	)	D/R	D/R	log	+/-	+
K	3	)	STOP	CLR	1				

f_3

10^{oo}	+/-	1	3	e^x	10^{oo}	3	e^x	1/x	+/-
10^{oo}	+/-	e^x	int	e^x	10^{oo}				

f_4

2	e^x	hyp	tan	×	6	)	D/R	D/R	Σ_0
K	Ø	STOP	CLR	$\sqrt{x}$	+/-				

f_5

.	1	$\sqrt{x}$	x^2	×	5	0	=	K	3
=	K	2	$_3\Sigma_2$	K	2				

f_6

STOP	+/-	IF≥Ø	f_0	CLR	END				

f_7

PROGRAM STEPS

VERIFICATION CARD #4

f_0

CLR	Δ_3	arc	hyp	cos	arc	sin	arc	cos	+/−
÷	1	Ø	)	arc	hyp				

f_1

cos	×	1	0	)	=	K	4	π	÷
2	=	K	5	−	K				

f_2

5	int	+	K	4	)	+/−	arc	sin	=
K	4	K	5	−	K				

f_3

5	int	−	K	4	)	+/−	arc	cos	+
1	)	arc	hyp	cos	−				

f_4

1	)	arc	cos	÷	2	)	int	arc	hyp
sin	×	1	3	)	arc				

f_5

hyp	cos	+/−	arc	hyp	sin	+/−	10^{oo}	1	2
arc	hyp	cos	10^{oo}	1	arc				

f_6

tan	10^{oo}	6	arc	tan	×	1	0	)	int
÷	1	0	+	K	Ø				

f_7

−	K	3	)	STOP	CLR	END			

PROGRAM STEPS

VERIFICATION CARD #5

f_0

CLR	+/-	1	÷	)	1/x	arc	sin	arc	cos
-	π	÷	2	)	ln				

f_1

10^{oo}	+/-	ln	+/-	+	2	0	)	e^x	hyp
sin	hyp	cos	÷	4	.				

f_2

3	8	5	+/-	10^{oo}	9	7	)	e^x	x!
+	2	)	x!	hyp	tan				

f_3

arc	hyp	tan	+/-	hyp	tan	arc	hyp	tan	int
x^a	1	x^a	1	x^a	2				

f_4

)	÷	2	)	int	+	x^a	)	+	sin
)	STOP	f_5							

f_5

CLR	1	3	10^{oo}	1	1	sin	x!	10^{oo}	Ø
Ø	÷	3	)	int	sin				

f_6

×	1	Ø	)	arc	sin	×	1	Ø	-
1	)	int	STOP	CLR	END				

f_7

PROGRAM STEPS

VERIFICATION CARD #6

f_0

CLR	=	K	0	9	$^1/x$	10^{oo}	1	2	=
K	1	x	2	10^{oo}	1				

f_1

1	=	K	2	x	2	10^{oo}	2	2	=
K	3	x	2	10^{oo}	4				

f_2

4	=	K	4	CLR	K	Ø	STOP	K	Ø
STOP	K	2	STOP	K	3				

f_3

STOP	K	4	STOP	CLR	Cont	Cont	Cont	Cont	2
=	K	Ø	2	=	K				

f_4

1	2	=	K	2	2	2	=	K	3
2	2	2	2	=	K				

f_5

4	CLR	K	Ø	STOP	K	1	STOP	K	2
STOP	K	3	STOP	K	4				

f_6

STOP	CLR	END							

f_7

TEK 31 VERIFICATION

Customer Verification Program

The TEK 31 customer verification program is designed to tell the customer that his instrument is in working order. It checks the operation of the bisic MOS chip set, the Data Registers, the Conditional Keys, the Clear File Key, subroutine execution (call and return), and some of the tape transfer commands. It does not directly verify the program step memory.

The software package is designed to operate in the basic TEK 31 configuration (512) steps, and does not require a printer.

Some information can be obtained from the program as to what the general nature of the problem is, in the event that the program does not run in a normal manner. (See the section on trouble-shooting hints).

Operating Instructions

If you feel that your calculator is not operating properly, the verification tape cartridge supplied with your calculator may be used to verify operation.

TEK 31 VERIFICATION

Press "RESET: :FROM TAPE" "0"

After the program has been transferred into the calculator memory, press START. The calculator will stop with a cleared display. Enter the total number of R-Registers in your calculator, and press CONTINUE.

The calculator will stop several times with various numbers in the display. Follow the table below to verify the operation of your calculator. (NOTE: the display should not be flashing unless so indicated.)

DISPLAYED NUMBER		PRESS	CONTINUE
1		"	"
2		"	"
3		"	"
4		"	"
5		"	"
6		"	"
7	FLASHING	"	"
8	FLASHING	"	"
9	FLASHING	"	"
10	FLASHING	"	"
11	FLASHING	"	"

After pressing "CONTINUE" the busy light will come on while the calculator loads the next set of program steps from the tape. After this search is completed, the program will automatically resume.

		PRESS	CONTINUE
12	FLASHING	"	"
13	FLASHING	"	"
14		"	"
15		"	"
16		"	"
17		"	"
18		"	"
19		"	"
20		"	"

After pressing "CONTINUE", the calculator will again search for the next series of program steps and the program will automatically resume.

21	PRESS	CONTINUE
22	PRESS	CONTINUE

PRESS CLEAR REMOTE □□ 2 2

TEK 31 VERIFICATION

At this point, if you have the printer option installed and turned on, the following will be printed:

```
ABCDEFGHIJKLM
NOPQRSTUVWXYZ

0123456789

.@(\)/÷-+=
$ %.:;#&↑!
<?>['"]_

3.1415926537

1234567890.E+12
1.234567890E-03
```

Troubleshooting Hints

The following table gives a list of the functions the various tests in the verification software are designed to verify. (A flashing display is abnormal unless designated as normal).

NORMALLY DISPLAYED NUMBER	POSSIBLE REASON FOR ABNORMAL DISPLAY
1 2 3 4 5 6 7 FLASHING 8 FLASHING 9 FLASHING 10 FLASHING 11 FLASHING 12 FLASHING 13 FLASHING	These tests are designed to verify the basic calculator functions. The fault may lie in the AMI MOS chip set or associated circuitry. If the display does not appear as indicated, replace calculator board.
14	R-Register addressing Test (Store register's address in the register). If display does not appear as indicated, replace programmer/memory module.

TEK 31 VERIFICATION

NORMALLY DISPLAYED NUMBER	POSSIBLE REASON FOR ABNORMAL DISPLAY
15	Clear File Test and storage of Ø's in all registers. If display does not appear as indicated, replace programmer/memory module.
16	Store 1's in all R-Registers.
17	Store 2's in all R-Registers.
18	Store 4's in all R-Registers.
19	Store 8's in all R-Registers. If display does not appear as indicated, replace programmer/ memory module.
20	Store a 7 in Decimal point digit of Data Word. If display does not appear as indicated, replace programmer/memory module.
21	Test IF conditions for true
22	condition. If display does not appear as indicated, replace programmer.

PROGRAM LISTING

TAPE BLOCK Ø

0000	CLR	
0001	STOP	Enter number of R-Registers & press "Continue"
0002	=	
0003	R.	
0004	5	
0005	CLR	
0006	=	
0007	PI	
0008	/	
0009	2	
0010	)	
0011	SIN	
0012	STOP	"1" is displayed
0013	CLDP	
0014	1	
0015	+	
0016	1	
0017	)	
0018	HYP	
0019	SIN	
0020	ARC	
0021	HYP	
0022	SIN	
0023	STOP	"2" is displayed
0024	CLDP	
0025	2	
0026	RSSQ	
0027	5	
0028	SQRT	
0029	)	
0030	DG/R	
0031	COS	
0032	ARC	
0033	COS	
0034	DG/R	
0035	STOP	"3" is displayed
0036	CLDP	
0037	3	
0038	+/-	
0039	+/-	
0040	*	
0041	1	
0042	0	
0043	=	
0044	HYP	
0045	COS	
0046	1/X	
0047	*	
0048	3	
0049	5	
0050	+/-	
0051	HYP	
0052	COS	
0053	=	
0054	LN	

```
0055  INT
0056  STOP              "4" is displayed
0057  CLR
0058  +
0059  .
0060  0
0061  6
0062  0
0063  0
0064  0
0065  0
0066  1
0067  *10↑
0068  +/-
0069  2
0070  +/-
0071  =
0072  K_
0073  0
0074  K_
0075  0
0076  DG/R
0077  DG/R
0078  1/X
0079  X↑2
0080  1/X
0081  SIN
0082  COS
0083  +
0084  4
0085  )
0086  STOP              "5" is displayed
0087  CLR
0088  .
0089  9
0090  5
0091  +
0092  .
0093  0
0094  5
0095  )
0096  +
0097  6
0098  *10↑
0099  +/-
0100  2
0101  TAN
0102  ARC
0103  TAN
0104  SIN
0105  ARC
0106  COS
0107  ARC
0108  TAN
0109  ARC
```

```
0110  COS
0111  +/-
0112  ARC
0113  COS
0114  *10↑
0115  0
0116  3
0117  TAN
0118  *10↑
0119  3
0120  ARC
0121  TAN
0122  +
0123  .
0124  1
0125  )
0126  TAN
0127  +
0128  1
0129  4
0130  .
0131  3
0132  )
0133  COS
0134  +
0135  5
0136  .
0137  6
0138  )
0139  COS
0140  +
0141  4
0142  .
0143  3
0144  )
0145  TAN
0146  /
0147  3
0148  +/-
0149  -
0150  .
0151  4
0152  1
0153  5
0154  0
0155  1
0156  6
0157  8
0158  0
0159  9
0160  2
0161  )
0162  STOP          "6" is displayed
0163  CLDP
0164  6
```

```
0165   X!
0166   CLR
0167   PI
0168   COS
0169   +/-
0170   ÷
0171   PI
0172   /
0173   2
0174   )
0175   COS
0176   +
0177   PI
0178   /
0179   2
0180   )
0181   TAN
0182   +
0183   .
0184   1
0185   )
0186   *10↑
0187   +/-
0188   +
0189   )
0190   *10↑
0191   +/-
0192   ÷
0193   9
0194   6
0195   *10↑
0196   8
0197   8
0198   -
0199   1/X
0200   )
0201   +/-
0202   *10↑
0203   0
0204   0
0205   DG/R
0206   DG/R
0207   +/-
0208   +/-
0209   =
0210   R___
0211   0
0212   0
0213   0
0214   =
0215   K_
0216   0
0217   CLDP
0218   9
0219   1/X
```

```
0220  +
0221  9
0222  )
0223  /
0224  1
0225  2
0226  )
0227  +
0228  1
0229  0
0230  6
0231  )
0232  INT
0233  =
0234  R__
0235  R__
0236  0
0237  0
0238  R__
0239  0
0240  3
0241  -
0242  (
0243  R__
0244  0
0245  0
0246  -
0247  1
0248  )
0249  )
0250  STOP
0251  CLR
0252  8
0253  0
0254  +10↑
0255  9
0256  9
0257  )
0258  1/X
0259  1/X
0260  +10↑
0261  0
0262  9
0263  )
0264  1
0265  TAN
0266  INT
0267  .
0268  2
0269  0
0270  0
0271  0
0272  0
0273  0
0274  0
```

Flashing "7" is displayed (at step 0250 STOP)

```
0275   0
0276   6
0277   0
0278   9
0279   ÷
0280   1/X
0281   1/X
0282   )
0283   *10↑
0284   +/-
0285   0
0286   1
0287   )
0288   DG/R
0289   DG/R
0290   LOG
0291   +/-
0292   +
0293   R__
0294   0
0295   3
0296   )
0297   STOP          Flashing "8" is displayed
0298   CLR
0299   1
0300   *10↑
0301   +/-
0302   1
0303   3
0304   E↑X
0305   *10↑
0306   3
0307   E↑X
0308   1/X
0309   +/-
0310   *10↑
0311   +/-
0312   E↑X
0313   INT
0314   E↑X
0315   *10↑
0316   2
0317   E↑X
0318   HYP
0319   TAN
0320   +
0321   6
0322   )
0323   DG/R
0324   DG/R
0325   SUM0
0326   K_
0327   0
0328   STOP          Flashing "9" is displayed
0329   CLR
```

```
0330  SQRT
0331  +/-
0332  .
0333  1
0334  SQRT
0335  X↑2
0336  +
0337  5
0338  0
0339  =
0340  K_
0341  3
0342  =
0343  K_
0344  2
0345  3SM2
0346  K_
0347  2
0348  STOP          Flashing "10" is displayed
0349  K_
0350  2
0351  SUM1
0352  CLR
0353  CLR
0354  DLT3
0355  ARC
0356  HYP
0357  COS
0358  ARC
0359  SIN
0360  ARC
0361  COS
0362  +/-
0363  /
0364  1
0365  0
0366  )
0367  ARC
0368  HYP
0369  COS
0370  *
0371  1
0372  0
0373  )
0374  =
0375  K_
0376  4
0377  PI
0378  /
0379  2
0380  =
0381  K_
0382  5
0383  +
0384  K_
```

```
0385  5
0386  INT
0387  +
0388  K.
0389  4
0390  )
0391  +/-
0392  ARC
0393  SIN
0394  =
0395  K.
0396  4
0397  K.
0398  5
0399  -
0400  K.
0401  5
0402  INT
0403  -
0404  K.
0405  4
0406  )
0407  +/-
0408  ARC
0409  COS
0410  +
0411  1
0412  )
0413  ARC
0414  HYP
0415  COS
0416  -
0417  1
0418  )
0419  ARC
0420  COS
0421  /
0422  2
0423  )
0424  INT
0425  ARC
0426  HYP
0427  SIN
0428  +
0429  1
0430  3
0431  )
0432  ARC
0433  HYP
0434  COS
0435  +/-
0436  ARC
0437  HYP
0438  SIN
```

```
0439  +/-
0440  *10↑
0441  1
0442  2
0443  ARC
0444  HYP
0445  COS
0446  *10↑
0447  1
0448  ARC
0449  TAN
0450  *10↑
0451  6
0452  ARC
0453  TAN
0454  *
0455  1
0456  0
0457  )
0458  INT
0459  /
0460  1
0461  0
0462  +
0463  K_
0464  0
0465  -
0466  K_
0467  3
0468  )
0469  STOP          Flashing "11" is displayed.
0470  CLR
0471  ADR
0472  GOTO
0473  0
0474  0
0475  0
0476  0
0477  FTP_
0478  1
0479  NULL
0480  NULL
0481  NULL
0482  NULL
0483  NULL
0484  NULL
```

PROGRAM LISTING

TAPE BLOCK 1

Continued verification of MOS calculator chip set

```
0000   CLR
0001   +/-
0002   1
0003   /
0004   )
0005   1/X
0006   ARC
0007   SIN
0008   ARC
0009   COS
0010   -
0011   PI
0012   /
0013   2
0014   )
0015   LN
0016   +10↑
0017   +/-
0018   LN
0019   +/-
0020   +
0021   2
0022   0
0023   )
0024   E↑X
0025   HYP
0026   SIN
0027   HYP
0028   COS
0029   /
0030   4
0031   .
0032   3
0033   8
0034   5
0035   +/-
0036   +10↑
0037   9
0038   7
0039   )
0040   E↑X
0041   X!
0042   +
0043   2
0044   )
0045   X!
0046   HYP
0047   TAN
0048   ARC
0049   HYP
0050   TAN
0051   +/-
0052   HYP
0053   TAN
0054   ARC
```

```
0055  HYP
0056  TAN
0057  INT
0058  X↑A
0059  1
0060  X↑A
0061  1
0062  X↑A
0063  2
0064  )
0065  /
0066  2
0067  )
0068  INT
0069  +
0070  X↑A
0071  )
0072  +
0073  SIN
0074  )
0075  STOP    Flashing "12" in Display
0076  CLR
0077  1
0078  3
0079  *10↑
0080  1
0081  1
0082  SIN
0083  X!
0084  *10↑
0085  0
0086  0
0087  /
0088  3
0089  )
0090  INT
0091  SIN
0092  *
0093  1
0094  0
0095  )
0096  ARC
0097  SIN
0098  *
0099  1
0100  0
0101  -
0102  1
0103  )
0104  INT
0105  STOP    Flashing "13" in Display
0106  CLR
0107  EXC_
0108  3       Initialize address Register RØØ and Return
0109  R__
```

ADDRESSING TEST

0110	0	
0111	0	Decrement Address Register and Test for negative address.
0112	-	
0113	1	
0114	=	If negative address, branch to subroutine "5".
0115	R__	
0116	0	
0117	0	
0118	IF<0	
0119	EXC_	
0120	5	
0121	CONT	
0122	=	
0123	R__	Store Register's address in itself
0124	R__	
0125	0	
0126	0	
0127	GOTO	
0128	0	
0129	1	Continue
0130	0	
0131	9	
0132	LBL_	LABEL 5
0133	5	
0134	EXC_	
0135	3	Initialize Address Register (RØØ) and return
0136	R__	
0137	0	
0138	0	
0139	-	
0140	1	
0141	=	Decrement Address Register
0142	R__	
0143	0	
0144	0	
0145	IF<0	
0146	CLR	Check for negative address
0147	1	
0148	4	If finished display "14" and stop
0149	STOP	
0150	EXC_	Branch to next test
0151	6	
0152	CONT	
0153	-	
0154	R__	
0155	R__	If not finished, verify correct register contents
0156	0	
0157	0	If correct continue test
0158	)	
0159	IF=0	
0160	GOTO	If <u>not</u> correct, display flashing "14" and stop
0161	0	
0162	1	
0163	3	
0164	6	

0165	CONT	
0166	CLR	
0167	1/X	
0168	CLDP	
0169	1	
0170	4	
0171	STOP	
0172	LBL_	
0173	6	LABEL 6
0174	CLDP	
0175	2	
0176	1	
0177	0	Clear file and store Zero Test
0178	-	
0179	(	
0180	K_	
0181	9	
0182	/	
0183	1	
0184	0	
0185	1	
0186	)	
0187	INT	
0188	*	
0189	2	Determine highest file number and branch
0190	)	to appropriate Clear File commands
0191	GODP	
0192	CFI_	
0193	9	
0194	CFI_	
0195	8	
0196	CFI_	
0197	7	
0198	CFI_	
0199	6	
0200	CFI_	
0201	5	
0202	CFI_	
0203	4	
0204	CFI_	
0205	3	
0206	CFI_	
0207	2	
0208	CFI_	
0209	1	
0210	CFI_	
0211	0	
0212	CLDP	
0213	=	
0214	K_	Initialize check register (K6) to zero
0215	6	
0216	=	
0217	K_	
0218	5	Initialize branch offset register (K5)
0219	EXC_	

0220	0	Verify all registers contain zero and return
0221	CLR	
0222	1	
0223	5	STOP with "15" displayed
0224	STOP	
0225	CLDP	
0226	+/-	
0227	1	
0228	*10↑	Generate Test numbers (1's, 2's, 4's, 8's)
0229	+/-	and store in KØ through K3
0230	1	
0231	0	
0232	*	
0233	9	
0234	1/X	
0235	=	
0236	K_	
0237	0	
0238	*	
0239	2	
0240	*10↑	
0241	+/-	
0242	1	
0243	1	
0244	=	
0245	K_	
0246	1	
0247	+	
0248	2	
0249	*10↑	
0250	+/-	
0251	2	
0252	2	
0253	=	
0254	K_	
0255	2	
0256	*	
0257	2	
0258	*10↑	
0259	+/-	
0260	4	
0261	4	
0262	=	
0263	K_	
0264	3	
0265	CLDP	
0266	1	Initialize branch offset Register (K5)
0267	0	
0268	=	
0269	K_	
0270	5	
0271	K_	
0272	0	
0273	=	Initialize K6 with number to be stored
0274	K_	

0275	6	
0276	EXC_	
0277	7	Store numbers and return
0278	EXC_	
0279	0	Check numbers and return
0280	CLR	
0281	1	
0282	6	
0283	STOP	STOP with "16" displayed
0284	K_	
0285	1	
0286	=	This sequence is now repeated with the
0287	K_	numbers 17, 18 and 19 displayed through
0288	6	step Ø323.
0289	EXC_	
0290	7	
0291	EXC_	
0292	0	
0293	CLR	
0294	1	
0295	7	
0296	STOP	
0297	K_	
0298	2	
0299	=	
0300	K_	
0301	6	
0302	EXC_	
0303	7	
0304	EXC_	
0305	0	
0306	CLR	
0307	1	
0308	8	
0309	STOP	
0310	K_	
0311	3	
0312	=	
0313	K_	
0314	6	
0315	EXC_	
0316	7	
0317	EXC_	
0318	0	
0319	CLR	
0320	1	
0321	9	
0322	STOP	
0323	EXC_	
0324	8	
0325	LBL_	LABEL Ø
0326	0	
0327	R AD	Save Return Address. Initialize address
0328	=	register by "EXC 3" and return
0329	K_	

```
0330  6
0331  EXC_
0332  3
0333  LBL_
0334     A
```

LABEL A

```
0335  R__
0336  0
0337  0
0338  -
0339  1
0340  =
0341  R__
0342  0
0343  0
0344  -
0345  1
0346  )
0347  IF<0
0348  K_
0349  8
0350  GODP
0351  CONT
0352  R__
0353  R__
0354  0
0355  0
0356  -
0357  K_
0358  6
0359  )
0360  IF=0
0361  GOTO
0362  0
0363  3
0364  3
0365  5
0366  CONT
0367  K_
0368  5
0369  +
0370  3
0371  7
0372  5
0373  )
0374  GODP
0375  CLR
0376  1/X
0377  CLDP
0378  1
0379  5
0380  STOP
0381  CLR
0382  K_
0383  8
0384  GODP
```

Subroutine "A" checks the number in K6 against all R-Registers and returns to the address stored in K8.

If the number in K6 doesn't agree with the number in an R-Register, the contents of the branch address register (K5) is added to 375 and a branch is performed to either Ø375 or Ø385 for error indication. After the error indication (Flashing "15" or flashing 9's) return is to the next test.

0385	CLR	
0386	1/X	
0387	STOP	
0388	CLR	
0389	K_	
0390	2	
0391	GODP	
0392	LBL_	
0393	3	LABEL 3
0394	K_	
0395	9	
0396	=	
0397	R___	Initialize the address register (R000)
0398	0	
0399	0	
0400	0	
0401	R AD	
0402	GODP	
0403	LBL_	
0404	7	LABEL 7
0405	R AD	
0406	=	
0407	K_	Subroutine "7" stores the number in K6
0408	8	in all the R-Registers and returns to the
0409	EXC_	calling sequence.
0410	3	
0411	R__	
0412	0	
0413	0	
0414	-	
0415	1	
0416	=	
0417	R__	
0418	0	
0419	0	
0420	IF<0	
0421	K_	
0422	8	
0423	GODP	
0424	CONT	
0425	K_	
0426	6	
0427	=	
0428	R__	
0429	R__	
0430	0	
0431	0	
0432	GOTO	
0433	0	
0434	4	
0435	1	
0436	1	
0437	LBL_	
0438	8	LABEL 8

```
0439   CLDP
0440   2
0441   .
0442   2          Check the decimal point location digit
0443   2          in the data word.
0444   2
0445   2
0446   2
0447   2
0448   2
0449   =          Put "20" in the display and stop
0450   K_
0451   6
0452   EXC_
0453   7
0454   EXC_       Search for next tape block
0455   0
0456   CLR
0457   2
0458   0
0459   STOP
0460   CLR
0461   ADR
0462   GOTO
0463   0
0464   0
0465   0
0466   0
0467   FTP_
0468   2
```

PROGRAM LISTING

TAPE BLOCK 2

0000	CLR	
0001	+/-	
0002	1	
0003	IF<0	
0004	+	
0005	1	
0006	)	
0007	IF>=	IF Condition (TRUE) Test
0008	IF=0	
0009	+	
0010	1	
0011	)	
0012	IF>=	
0013	CLR	
0014	S FG	
0015	IFFG	
0016	CLFG	
0017	1/X	
0018	IFFL	
0019	CLR	
0020	2	Stop with 21 in display
0021	1	
0022	STOP	
0023	GOTO	If Test is successful
0024	0	
0025	0	
0026	3	
0027	5	
0028	CONT	
0029	CLR	
0030	1/X	
0031	CLDP	
0032	2	Stop with flashing "21" displayed
0033	1	if Test is not successful
0034	STOP	
0035	CLR	
0036	IF<0	
0037	EXC_	
0038	IF<0	If Condition (FALSE) Test
0039	CONT	
0040	+/-	
0041	1	
0042	IF=0	
0043	EXC_	
0044	IF<0	
0045	CONT	
0046	IF>=	
0047	EXC_	
0048	IF<0	
0049	CONT	
0050	IFFL	
0051	EXC_	
0052	IF<0	
0053	CONT	
0054	IFFG	

0055	EXC_	
0056	IF<0	
0057	CONT	
0058	CLR	
0059	2	
0060	2	Stop with "22" in display if Test is successful
0061	STOP	
0062	GOTO	
0063	0	
0064	0	
0065	7	
0066	5	
0067	LBL_	
0068	IF<0	
0069	CLR	
0070	1/X	
0071	CLDP	Stop with flashing "22" in display if Test is not successful
0072	2	
0073	2	
0074	STOP	
0075	CLR	
0076	PAPR	
0077	PAPR	
0078	PAPR	
0079	PAPR	
0080	PAPR	
0081	PAPR	
0082	A	
0083	B	Alpha printer exercise
0084	C	
0085	D	
0086	E	
0087	F	
0088	G	
0089	H	
0090	I	
0091	J	
0092	K	
0093	L	
0094	M	
0095	0	
0096	N	
0097	O	
0098	P	
0099	Q	
0100	R	
0101	S	
0102	T	
0103	U	
0104	V	
0105	W	
0106	X	
0107	Y	
0108	Z	
0109	PAPR	

```
0110  PAPR
0111     0
0112     1
0113     2
0114     3
0115     4
0116     5
0117     6
0118     7
0119     8
0120     9
0121  PI
0122  PAPR
0123     .
0124     @
0125     (
0126     \
0127     )
0128     /
0129     *
0130     -
0131     +
0132     =
0133  PAPR
0134     $
0135
0136     %
0137     ,
0138     ;
0139     :
0140     #
0141     &
0142     ↑
0143     !
0144  PAPR
0145     <
0146     ?
0147     >
0148     [
0149     '
0150     "
0151     ]
0152     _
0153  PAPR
0154  PAPR
0155  PRNT
0156  CLR
0157  PAPR
0158  0
0159  1
0160  2
0161  3
0162  4
0163  5
0164  6
```

```
0165  7
0166  8
0167  9
0168  0
0169  ÷10↑
0170  1
0171  2
0172  FRNT
0173  +/-
0174  =
0175  FRNT
0176  CLR
0177  PAPR
0178  PAPR
0179  PAPR
0180  PAPR
0181  PAPR
0182  PAPR
0183  RSET
0184  NULL
0185  NULL
0186  NULL
0187  NULL
0188  NULL
0189  NULL
0190  NULL
0191  NULL
```

SECTION VI

SPECIFICATIONS

POWER REQUIREMENTS

Line Voltage Range:

Low	Med	Hi	
100	110	120	Operates between 90 V and 132 V RMS
200	220	240	Operates between 180 V and 264 V RMS

Maximum Line Voltage Input:

250 V RMS

Line Frequency:

48 Hz to 66 Hz, AC only

Power Consumption:

Maximum 190 watt @ 60 Hz, 115 Volt line

VOLTAGE SUPPLY

Voltage Supply	Requirement	Current Rating
+300 V	$\pm$40 V	10 mA
+115 VAC	Fan	
+22 V	+6 V, -5 V	2 A continuous 3 A surge
+15 V	adjusted to $\pm$1%	400 mA
+5 V	$\pm$5%	10 A
-13 V	adjusted to $\pm$1%	400 mA

PHYSICAL CHARACTERISTICS

Height:	7.9 inches - 20.1 cm	Weight:	32.0 lbs. - 14.5 kg
Length:	20.5 inches - 52.1 cm	Width:	14.3 inches - 36.3 cm

SPECIFICATIONS

ENVIRONMENTAL CHARACTERISTICS

Temperature:	Non-Operating	-55°C to 75°C
	Operating	0°C to 50°C
Altitude:	Non-Operating	50,000 feet
	Operating	15,000 feet

PRINTER RATE

2.4 lines/second, with no dots missing.

Should assert System Busy signal while printing

MAGNETIC TAPE FOR TEKTRONIX 31

Number of Channels: 2 self-clocking data channels

Bit Density: 285 bits per inch

Tape Speed: approximately 7 inches per second

Tape Length: approximately 24 feet

Block Length: Register storage 6400 bits. Steps storage 8000 bits

Contains 6 blocks capable of storing 1000 program steps per block or the contents of 100 R registers per block.

MAGNETIC TAPE FOR TEKTRONIX 21

Number of Channels: 2

Bit Density: 572 bits per inch

Card Speed: approximately 7 inches per second

Card Length: 7.5 inches

Block Length: 2048 bits

SPECIFICATIONS

TRANSFER RATE

2000 bits/second

TEKTRONIX 31 AUXILIARY MEMORY OPTION NUMBERS

Option		Steps	Registers
2		1024	128
3		1526	192
4		2048	256
5	First group on Aux. Memory board	2048	640
6		3584	448
7		5120	256
8	Second group on Aux. Memory board	2048	1000
9		5120	640
10		8192	256