2-1974

Macromodular Computer Design, Part 2, Volume 04, Electronic Package Assembly

Computer Systems Laboratory, Washington University

MACROMODULAR COMPUTER DESIGN PART 2 MANUFACTURING DESCRIPTION

VOLUME IV

ELECTRONIC PACKAGE ASSEMBLY

Technical Report No. 33

FINAL REPORT - FEBRUARY, 1974
CONTRACT SD-302 (ARPA)

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

MACROMODULAR COMPUTER DESIGN

FINAL REPORT - CONTRACT SD-302

FEBRUARY, 1974

Technical Report No. 33

PART 2 - MANUFACTURING DESCRIPTION

VOL. IV-ELECTRONIC PACKAGE ASSEMBLY

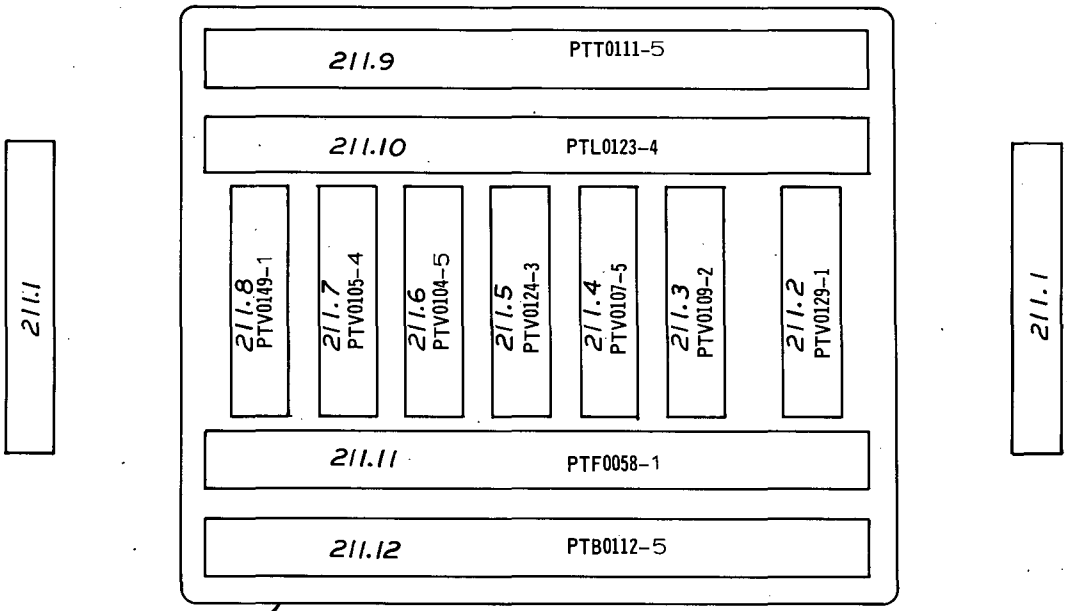
This work has been supported by the Advanced Research Projects Agency of the Department of Defense under Contract SD-302 and by the Division of Research Facilities and Resources of the National Institutes of Health under Grant RR-00396.

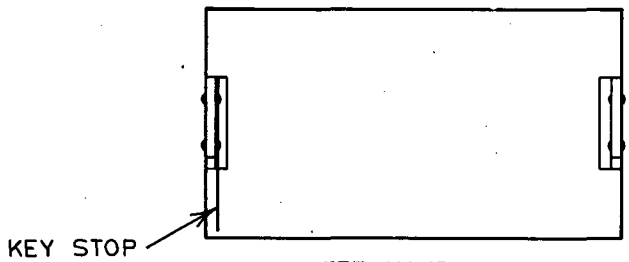
Computer Systems Laboratory
Washington University
St. Louis, Missouri

ABSTRACT

Manufacturing documents, including parts lists, assembly pictorials, and adjustment procedures for the MEMORY, GENERAL MEMORY CONTROLLER, INTERLOCK, MULTIPLY, D/A and FUNCTION CALLER macromodule electronic sub-assemblies are given.

INDEX





LEFT HAND SHROUD

CHANGE NO.	DATE	DESCRIPTION
1	1-28-74	E.C.O. 0304 HCL

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

MACROMODULAR PROJECT

TITLE ASSEMBLY SCHEMATIC & PARTS LIST
MEMORY
PART NO. 211

APPROVED BY	APPROVED FOR	APPROVED DATE	ENG	DRAWING NO.
C.	MANUF	7-19-72	HCL	211 .0D
			DRAWN BY PLL	
			CHECKED HCL	DATE 3-28-70

MEMORY

METALCRAFT "AUTOGRAPH" OR EQUIVALENT:
BLANK SIZE: $\frac{1}{4}$" X 2" SHEARED WITH
SQUARE CORNERS, WHITE LETTERS, VOGUE
BOLD 12 POINT BOLD FACE TYPE CENTERED
TOP, BOTTOM AND SIDES WITH 6 POINT
SPACING ON BLACK PMS 433 BACKING.
MANUFACTURED FROM .016 THICK ALUMINUM
WITH SOLVENT ACTIVATED PERMANENT
ADHESIVE BACKING.

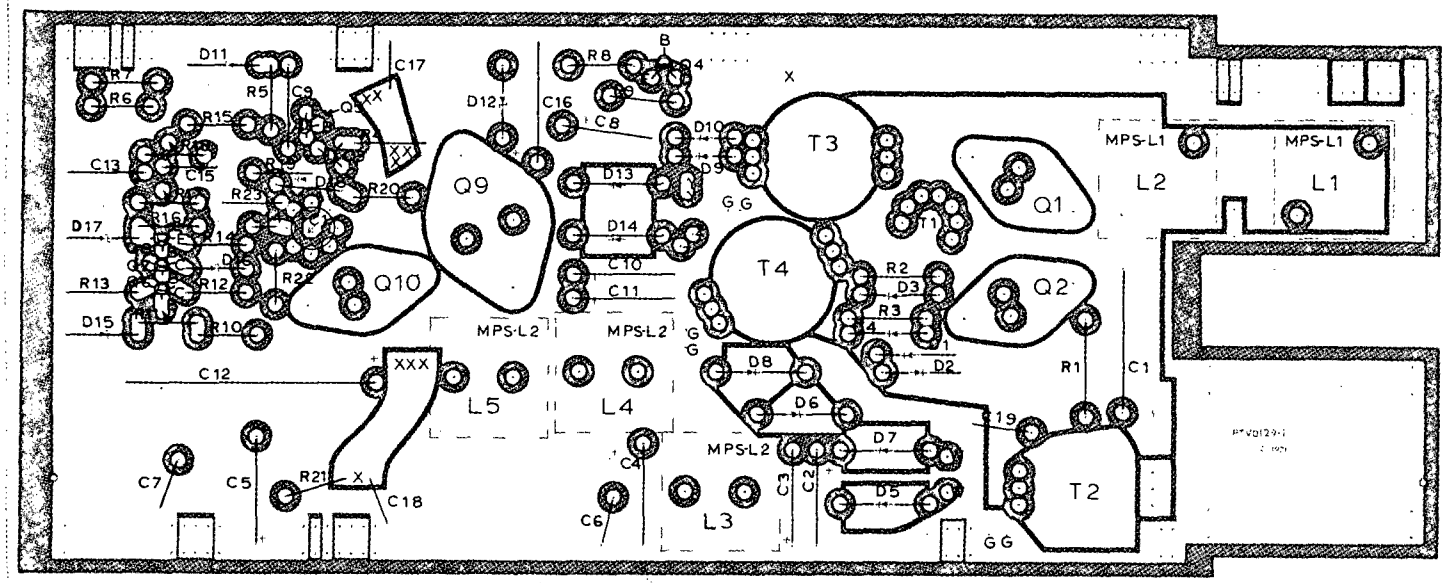
NOTE: PANTONE MATCHING SYSTEM (PMS)

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

MACROMODULAR PROJECT

TITLE
IDENTIFICATION LABEL
MEMORY MODULE
PART # 211.1

APPROVED			ENG	DRAWING NO.
BY	FOR	DATE	NTK	
maw	Prod.	7/28/70	DRAWN BY MBP	211.1D
Cam	Prod	7-19-72	CHECKED maw	DATE 7/23/70



NOTES:

1. Holes marked with a "G" (6 places) receive the twisted pair of wires from T2, T3, and T4.
2. Holes marked with a "Y" (2 places) receive the 2 wires, one each from T3 and T4, marked with a "7".
3. Holes marked with a "z" (2 places) receive the 2 wires, one each from T3 and T4, marked with a "9".
4. Holes marked with a "W" (2 places) receive the 2 single wires from T2 in any order.
5. L1, L2, L3, L4, L5, T2, T3 and T4 receive RTV silicone rubber per CSL 010, pages 36 and 37
6. Q1, Q2, and Q9 are mounted using a silicone heat sinking compound. (No insulating washers required.)
7. Holes marked with an "X" indicate plated through holes with no components installed. These must be kept free of solder. (10 places)
8. Install female amp modu connectors exactly as shown in drawing 200.50D2.

CHANGE NO.	DATE	DESCRIPTION
1	3-13-73	E.C.O. 0273

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

MACROMODULAR PROJECT

TITLE: COMPONENT IDENTIFICATION
MEMORY MODULE: POWER SUPPLY BOARD
PART NO. 211.2

APPROVED BY	FOR	DATE
	MANUF	7-19-72

ENG. TJC
DRAWN BY PLL
CHECKED HCL
DRAWING NO. 211.2D1
DATE 6-19-72

FIXED RESISTORS

ELECTRA/MIDLAND TYPE MF5C, CHAR. D
1/8 WATT ±1% 100 PPM/°C PRECISION FILM

RESISTANCE (OHMS)	REQUIRED	LOCATION
806	1	R10
1070	1	R13
1500	2	R12 R19
1960	1	R16
2260	1	R23
16200	1	R22

ALLEN–BRADLEY TYPE CB OR EQUIV.
1/4 WATT ±5% HOT MOLDED COMPOSITION

RESISTANCE (OHMS)	REQUIRED	LOCATION
130	1	R6
240	1	R4
330	1	R14
1000	1	R8
2400	1	R7
2700	1	R20
10,000	2	R5 R15
33,000	1	R9

ALLEN–BRADLEY TYPE EB OR EQUIV.
1/2 WATT ±5% HOT MOLDED COMPOSITION

RESISTANCE (OHMS)	REQUIRED	LOCATION
16	2	R2 R3
330	1	R21

ALLEN–BRADLEY TYPE GB OR EQUIV.
1 WATT ±5% HOT MOLDED COMPOSITION

RESISTANCE (OHMS)	REQUIRED	LOCATION
6800	1	R1

SEMICONDUCTORS

TYPE	REQUIRED	LOCATION
LM305 National	1	IC1
1N957B	1	D15
1N3155	1	D17
1N5222B	1	D11
1N5231B	2	D12 D16
MR810 (Motorola)	6	D1 D2 D3 D4 D9 D10
SR1922A (Motorola)	4	D5 D7 D13 D14
MBD5300 or 1N5823 (Motorola)	2	D6 D8
*MMD–694	1	D18
2N3903	3	Q3 Q6 Q7
2N3904	1	Q5
2N3905	1	Q8
2N4398	1	Q10
2N5086	1	Q4
1714–1402 (Westinghouse)	2	Q1 Q2
MJ3771 (Motorola)	1	Q9

*ORDER FROM NATIONAL CAPACITORS, INC. AS AMPEX 013–694 TYPE DIODE WITH AN ADDITIONAL TEST OF V_F AT 350 ma. EQUAL TO FROM 0.85 TO 0.94 VOLTS.

VARIABLE RESISTORS

RESISTANCE (OHMS)	MANUFACTURE S PART NO.		REQUIRED	LOCATION
	CTS	BOURNS		
200	190PC201A	3009P1201	1	R11
500	190PC501A	3009P1501	2	R17 R18

CHANGE NO.	DATE	DESCRIPTION
1	2–16–73	E.C.O. 0285

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

MACROMODULAR PROJECT

TITLE: PARTS LIST (SHEET 1 OF 2)
MEMORY MODULE POWER SUPPLY BOARD
PART NO. 211.2

APPROVED BY	APPROVED FOR	APPROVED DATE	ENG. TJC	DRAWING NO. 211.2D2
[signature]	MANUF	7-19-72	DRAWN BY MBP	SHEET 1 OF 2
			CHECKED HCL	DATE 6-25-72

POLARIZED CAPACITORS

CAP	MANUFACTURE'S PART NO. SPRAGUE	MALLORY	REQUIRED	LOCATION
25μf	600D256G060DD4		1	C1
580μf	601D587G020FJ4		1	C12
4.7μf	150D475X0050B2	TAS475M050PIC	5	C2 C3 C8 C10 C11
180μf	150D187X0006R2	TAS187K006PIF	2	C4 C5
1μf	150D105X0035A2	TAS105M035PIA	2	C13 C15
47μf	150D476X0006B2	TAS476M006PIC	1	C9
100μf	150D107X0020S2	TAS107M020PIG	1	C16

CERAMIC AND SILVERED-MICA CAPACITORS

CAP.	MANUFACTURE'S PART NO. SPRAGUE	CENTRALAB	ELMENCO	REQUIRED	LOCATION
.01μf	C023B101F103M	DDM-103		1	C19
.47μf	C080A120P474Y	UK10-474		2	C6 C7
.2μf	C069A106P204Z	UK20-204		2	C17 C18
47 pf	C023B102E470M	DD-470	DM-10-470J	1	C14

MAGNETIC COMPONENTS

(SEE PSS SERIES DOCUMENTS FOR MANUFACTURING INFO)

TYPE	REQUIRED	LOCATION.
MMS-T1	1	T1
MMS-T2-0	1	T2
MMS-T3-49	2	T3 T4
MPS-L1	2	L1 L2
MPS-L2	3	L3 L4 L5

PRINTED CIRCUIT BOARD

PTV0129-1
ONE REQUIRED

CONNECTORS

55 REQUIRED
AMPMODU 85863-4

CHANGE NO.	DATE	DESCRIPTION

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

MACROMODULAR PROJECT

TITLE
PARTS LIST (SHEET 2 OF 2)
MEMORY MODULE POWER SUPPLY BOARD
PART NO. 211.2

APPROVED BY	APPROVED FOR	APPROVED DATE	ENG.	DRAWING NO.
	MANUF		TJC	211.2D2A
			DRAWN BY MBP	SHEET 2 OF 2
			CHECKED HCL	DATE 6-25-72

See section 200.5 in Volume II for the description of MPS-L1 and MPS-L2.

PSS-11

COMPUTER SYSTEMS LABORATORY

WASHINGTON UNIVERSITY

TIMING TRANSFORMER DESCRIPTION AND SPECIFICATION

Part Number MMS-T1

211.2D2C

Transformer Description:

The transformer core is a *Magnetics Inc. toroidal tape wound core number MA80558-5D. Windings T1 and T2 of Figure 1 form a 21 turn bifilar winding of number 30 copper wire which is uniformly distributed around core. Windings T3 and T4 form a second bifilar winding of 4 turns of number 28 copper wire which is uniformly distributed around the core. The copper wire insulation will be polyurethane-nylon cover coat (Nyleze or better for 125°C operation).

The wound transformer is installed in a **Epoxy Products Company shell 173-02-10-43A and header 068-02-10-43A. Two of the 9 pins in the header 068-02-10-43A are cut off above and below the header per Figure 2. A piece of number 3 mylar tape or equivalent is placed over the cut pins to protect the transformer windings from scratches. The transformer leads are soldered to the header pins per Figures 1 and 3. The pin numbers used in Figure 3 are the same as the lead numbers of Figure 1. The assembled transformer is filled with Scotcheast number 212 red potting compound.

Finished Transformer Specifications:

I. Identification: The characters "MMS-T1" at least 0.1 inches high will appear on the transformer and shall remain readable after hard rubbing with thumb.

*Magnetics Inc.
Butler, Pennsylvania

**Epoxy Products Company
Div. of Allied Products Corp.
119 Coit Street
Irvington, New Jersey

II. Turns: The number of turns on each winding must be exact:

a. T1 = 21 turns

b. T2 = 21 turns

c. T3 = 4 turns

d. T4 = 4 turns

III. High Voltage Breakdown: Less than 0.1 milliampere shall flow when 200 V_{RMS} AC is applied for one minute across:

a. pins 1, 2 and 3 shorted together and pins 4 and 5 shorted together.

b. pins 1, 2 and 3 shorted together and pins 6 and 7 shorted together.

c. pins 4 and 5 shorted together and pins 6 and 7 shorted together.

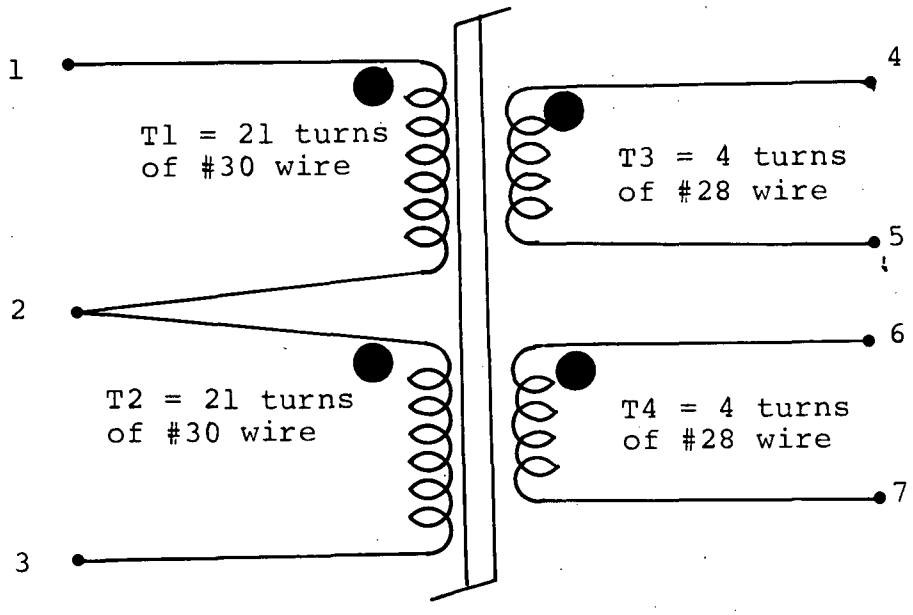


Figure 1

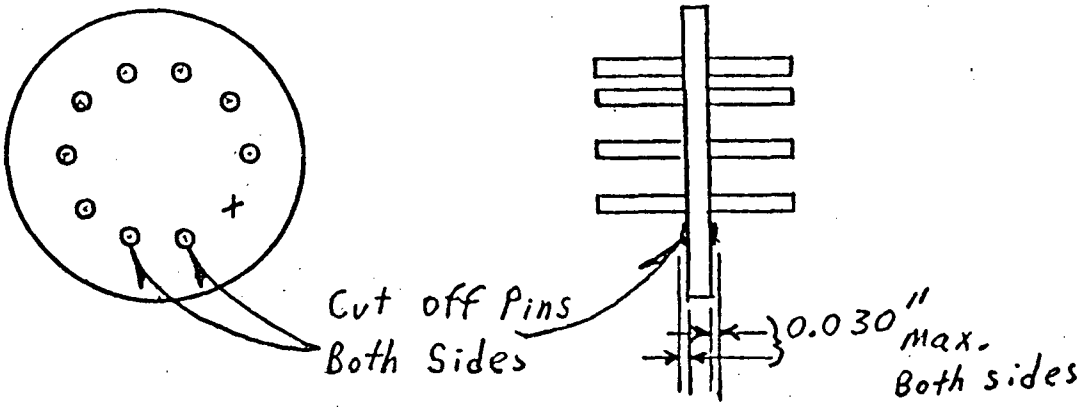


Figure 2

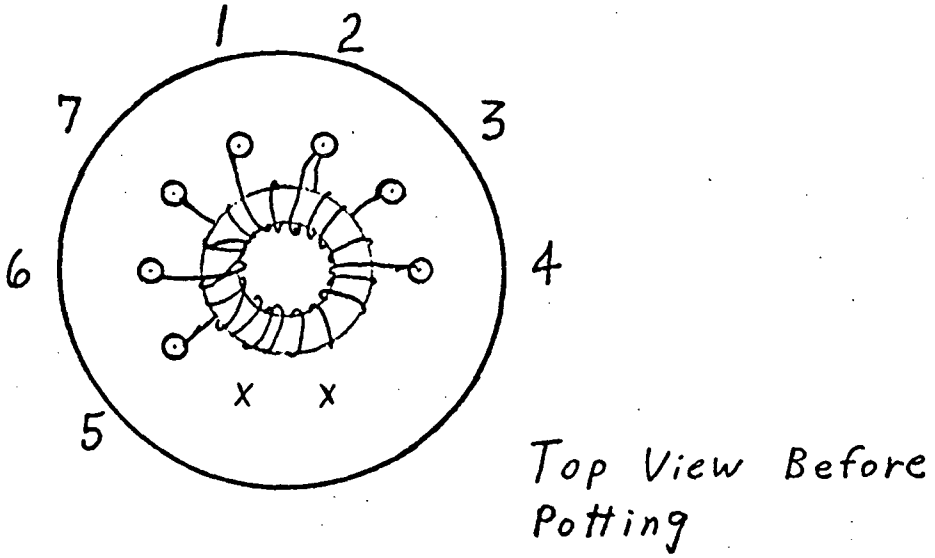


Figure 3

PSS-9

COMPUTER SYSTEMS LABORATORY

WASHINGTON UNIVERSITY

POWER TRANSFORMER DESCRIPTION AND SPECIFICATION

Part Number MMS-T2-0

Written by:

10/4/71

Approved by:

11/1/71

CHG.	E.C.O.	DATE	APPR.
A	0238	12-17-71	

211.2D2G

Transformer Description:

The coil form is a *Ferroxcube type number 2616PCB1 printed circuit bobbin. Windings T3 and T4 are first wound on the bobbin as a 56 turn bifilar winding of number 28 copper wire uniformly covering the length of the bobbin. A single layer of mylar tape 0.003 to 0.007 inch thick is then placed over the windings. Windings T5 and T6 are then wound on the bobbin as a 6 turn bifilar winding of number 20 copper wire. The wire insulation shall be polyurethane nylon overcoat (Nyleze) for 120°C operation.

Windings T3 and T4 are connected to the bobbins' pins as shown in Figures 1 and 2. The ends of windings T5 and T6 extend out the side shown in Figure 2 and are 1.0 to 1.25 inch long. Wires 8A and 8B must be identified together. Wires 7 and 9 need not be individually identified.

The wound bobbin is then placed inside two *Ferroxcube number 2616-L00-3B7 flat ground half-pot cores. The cores are then cemented together, with the center posts of the cores aligned, using Biggs R-312 epoxy cement. The two slits in the side of the transformer are both completely filled with a rigid epoxy such as **Mista Pox 103. The completed transformer is then sprayed with a light coat of clear varnish.

Finished Transformer Specifications:

I. Identification: The characters "MMS-T2-0" at least 0.1 inches high will appear on the transformer and shall remain readable after hard rubbing with thumb.

*Ferroxcube Corporation
Saugerties, New York

**M and R Plastics and Coatings, Inc.
11460 Dorsett Road
Maryland Heights, Mo. 63042

II. Turns: The number of turns on each winding must be exact:

a. T1 = 0 turns

b. T2 = 0 turns

c. T3 = 56 turns

d. T4 = 56 turns

e. T5 = 6 turns

f. T6 = 6 turns

III. Inductance: The inductance between pins 4 and 5 shall be L_p>10mhy and Q>15 with all other windings open circuited when measured on a General Radio type 1650-A impedance bridge. The bridge controls are set to: OSC LEVEL control adjusted for maximum output; the function switch to INT 1 KC; the CRL SELECTOR to L_p; and the CRL MULTIPLIER to 10 mH.

IV. High Voltage Breakdown: Less than 0.1 milliampere shall flow when 500 V_{RMS}AC is applied for one minute across:

a. pins 4,5 and 6 shorted together and wires 7,8A,8B and 9 shorted together.

b. pins 4,5 and 6 with wires 7,8A,8B and 9 all shorted together and the core.

CHG.	E.C.O.	DATE	APPR.
A	0238	12-17-71	

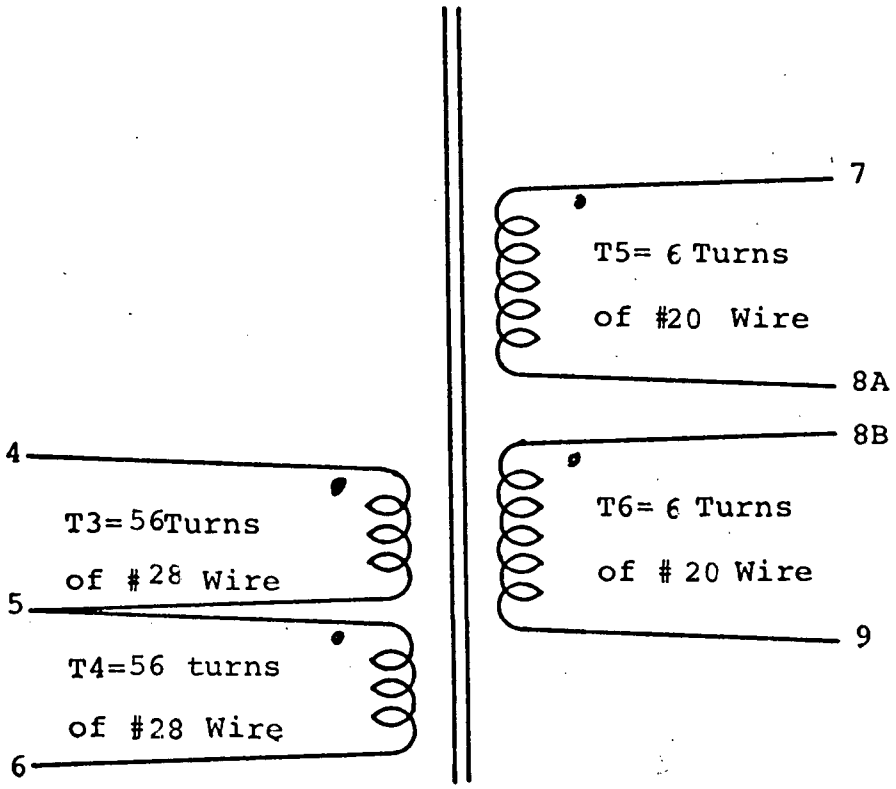
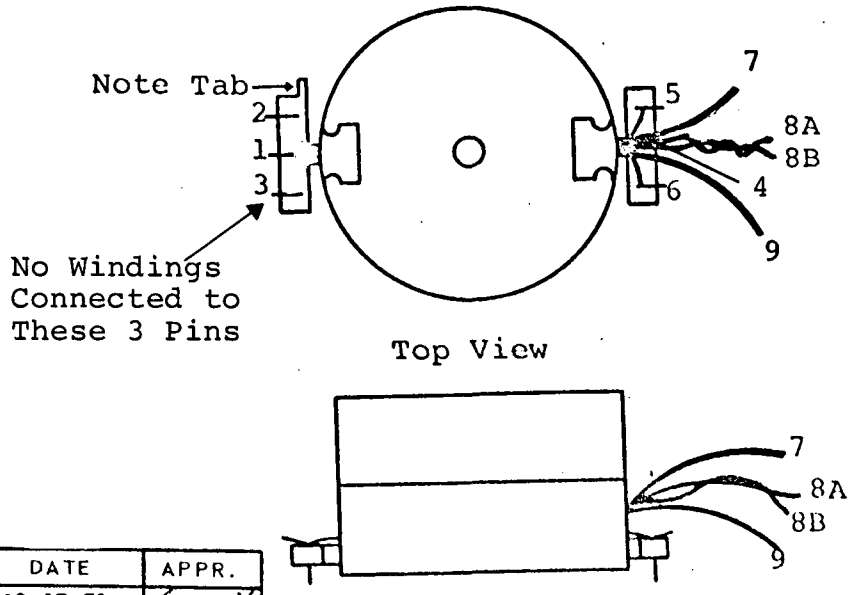


Figure 1



CHG.	E.C.O.	DATE	APPR.
A	0238	12-17-71	

Figure 2

PSS-10

COMPUTER SYSTEMS LABORATORY

WASHINGTON UNIVERSITY

POWER TRANSFORMER DESCRIPTION AND SPECIFICATION

Part Number MMS-T3-49

Written by:

T. J. Chaney

10/4/71

Approved by:

C. E. Molnar

11/1/71

CHG.	E.C.O.	DATE	APPR.
A	0237	12-17-71	

211.2D2K

Transformer Description:

The coil form is a *Ferroxcube type number 2616PCB1 printed circuit bobbin. Windings T1 and T2 are first wound on the bobbin as a 49 turn bifilar winding of number 28 copper wire uniformly covering the length of the bobbin. Next, windings T3 and T4 are wound on the bobbin as a 3 turn bifilar winding of number 28 copper wire. A single layer of mylar tape 0.003 to 0.007 inch thick is then placed over the windings. Windings T5 and T6 are then wound on the bobbin as a 15 turn bifilar winding of number 22 copper wire. The wire insulation shall be polyurethane nylon overcoat (Nyleze) for 120°C operation.

Windings T1, T2, T3 and T4 are connected to the bobbins' pins as shown in Figures 1 and 2. The ends of windings T5 and T6 extend out the side shown in Figure 2 and are 1.5 to 1.75 inch long. Wires 8A and 8B must be identified together. WIRES 7 AND 9 MUST BE INDIVIDUALLY IDENTIFIED.

The wound bobbin is then placed inside two *Ferroxcube number 2616-L00-3B7 flat ground half-pot cores. The cores are then cemented together, with the center posts of the cores aligned, using Biggs R-312 epoxy cement. The two slits in the side of the transformer are both completely filled with a rigid epoxy such as **Mista Pox 103. The completed transformer is then sprayed with a light coat of clear varnish.

*Ferroxcube Corporation
Saugerties, New York

**M and R Plastics and Coatings, Inc.
11460 Dorsett Road
Maryland Heights, Mo. 63042

Finished Transformer Specifications:

I. Identification: the characters "MMS-T3-49" at least 0.1 inches high will appear on the transformer and shall remain readable after hard rubbing with thumb. The style "9" used shall be easily distinguished from an "8".

II. Turns: The number of turns on each winding must be exact:

a. T1 = 49 turns

b. T2 = 49 turns

c. T3 = 3 turns

d. T4 = 3 turns

e. T5 = 15 turns

f. T6 = 15 turns

III. Inductance: The inductance between pins 1 and 2 shall be L_p>10mhy and Q>15 with all other windings open circuited when measured on a General Radio type 1650-A impedance bridge. The bridge controls are set to: OSC LEVEL control adjusted for maximum output; the function switch to INT 1 KC; the CRL SELECTOR to L_p; and the CRL MULTIPLIER to 10 mH.

IV. High Voltage Breakdown: Less than 0.1 milliampere shall flow when 200 V_{RMS} AC is applied for one minute across pins 1, 2 and 3 shorted together and pins 4, 5 and 6 shorted together.

Less than 0.1 milliampere shall flow when 500 V_{RMS} AC is applied for one minute across:

a. pins 1, 2, 3, 4, 5 and 6 shorted together and wires 7, 8A, 8B and 9 shorted together.

b. pins 1, 2, 3, 4, 5 and 6 with wires 7, 8A, 8B and 9 all shorted together and the core.

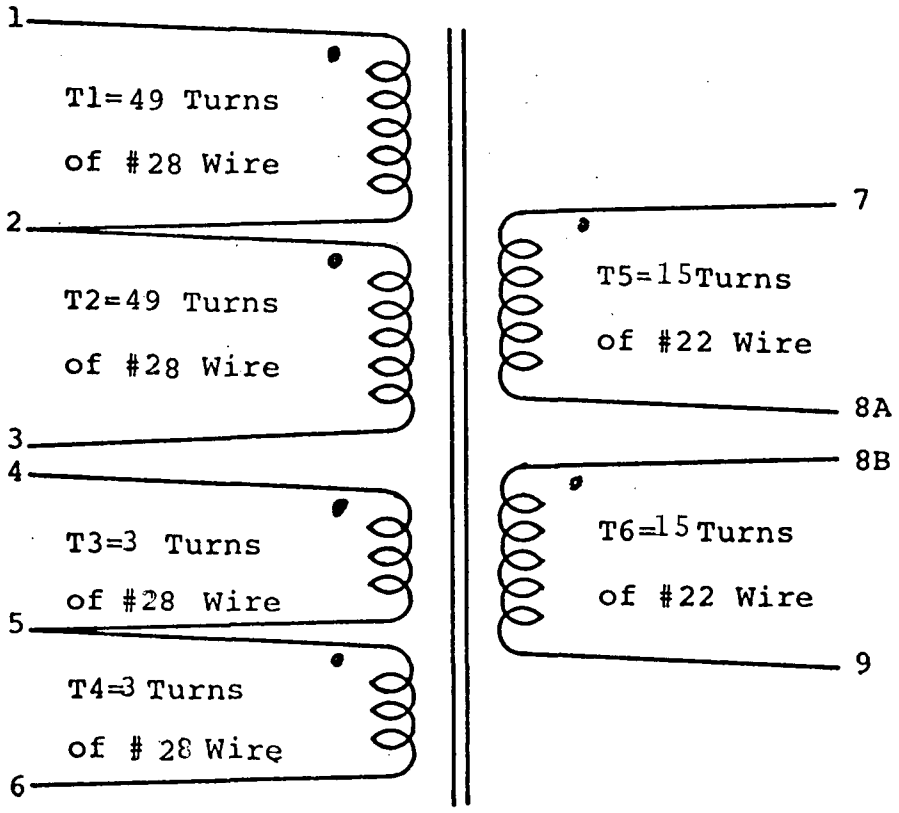
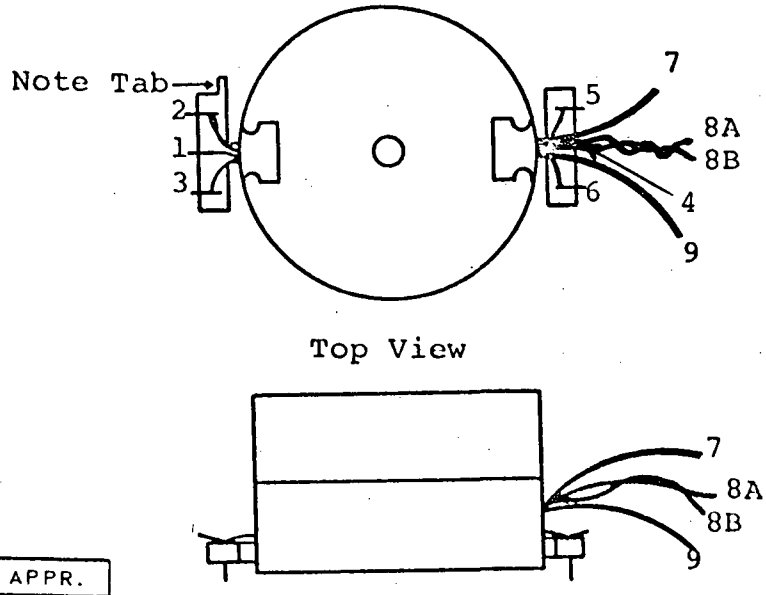


Figure 1

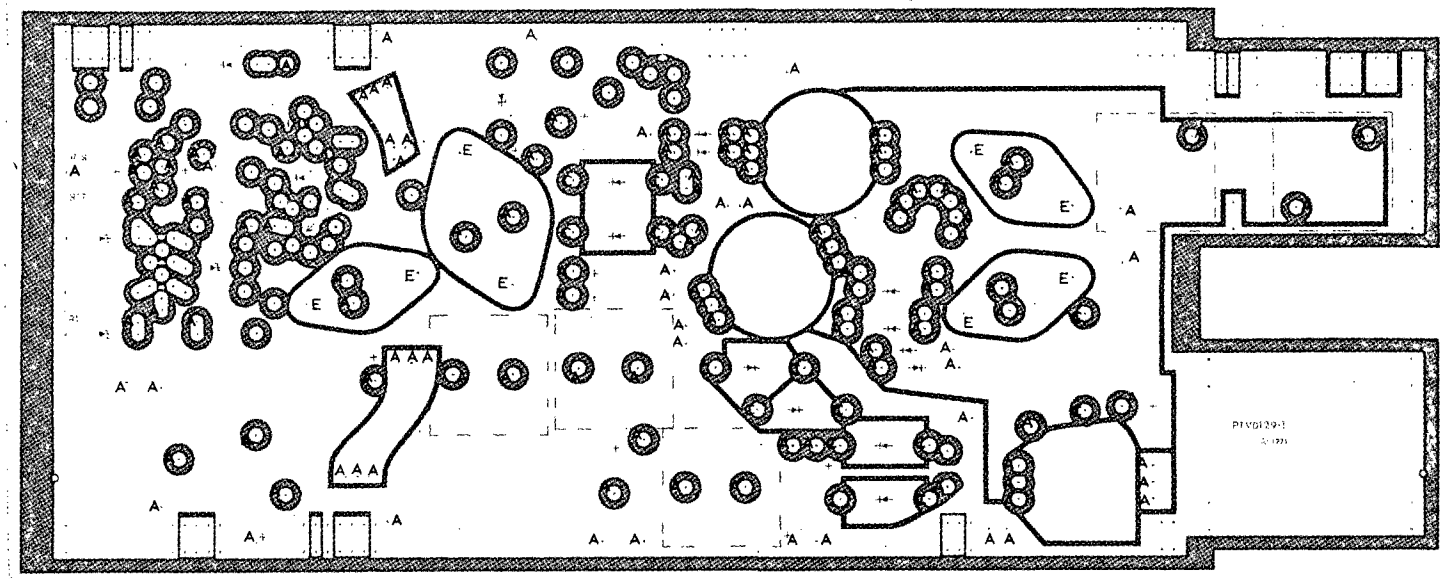


Top View

Figure 2

CHG.	E.C.O.	DATE	APPR.
A	0237	12-17-71	

211.2D2N



TYPE A 131 PLACES
TYPE C 14 PLACES
TYPE E 8 PLACES
TYPE B ALL OTHERS (180 PLACES)

NOTE: SEE CSL DOCUMENT 010 (GENERAL STANDARDS) PAGES 13 AND 14 FOR HOLE SIZES

CHANGE NO.	DATE	DESCRIPTION

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

MACROMODULAR PROJECT

TITLE
MEMORY MODULE: POWER SUPPLY BOARD HOLE SIZES

APPROVED BY	FOR	DATE
	MANUF	7-19-72

ENG. TJC
DRAWN BY PLL
CHECKED HCL
DRAWING NO. 211.2D4
DATE 6-21-72

Delay Specifications For The Memory Macromodule

Introduction:

The memory module has a total of six RC delays which must be verified before the module is assembled.

If discrepancies are found in the delay waveforms they can be tuned to meet specifications by increasing the size of the associated capacitor to extend the delay or conversely, decesasing its value to reduce the delay. Studies have shown that the relationship between time and capacity in the type of delay employed is approximately 1 nanosecond per pf.

Outlined on the following pages are the delay tests. Immediately following each procedure is a figure depicting the expected waveform.

The circuit boards should be inspected carefully to insure that the following procedures have not resulted in damage to the circuit board, particularly in the areas where fresh soldering has taken place. All flux residues should be thoroughly removed.

CHG.	E.C.O.	DATE	APPR.
1	0307	2-25-74	HCK

TEST PROCEDURE

Memory Module Power Supply Board #211.2

This board contains 3 adjustments, two of which must be set before the board is assembled into a Memory Module. These two adjustments are the output voltage sequencing adjustment (R11) and the regulated + 14.5VDC output voltage adjustment (R18).

Procedure

1. Set up: a) Adjust the 3 potientiometers:
   R11 full CCW, R17 full CCW, and R18 full CW;
   b) Connect 2 1N4863 diodes in series, anode to cathode and then connect the open cathode lead of the pair to terminal T88 and the open anode to T89;
   c) Connect a variable voltage power supply capable of 55VDC at 1/2 ampere (set to zero volts out) to the converter input terminals; negative power supply output to LT6 and LT7 and the positive output to LT3 and LT4;
   d) Connect a 5 to 6 ohm 2 watt load between B19 and B18;
   e) Connect a 1.75 to 2 ohm 20 watt load between T92, T93 (connected together) and T87, T90 (connected together);
   f) Connect a 200 ohm 2 watt load from T69 to T68;
   g) Connect a voltmeter from T71 (+) to T72 (-);

CHG.	E.C.O.	DATE	APPR.
1	0307	2-25-74	HCK

h) Connect L16 to T91.

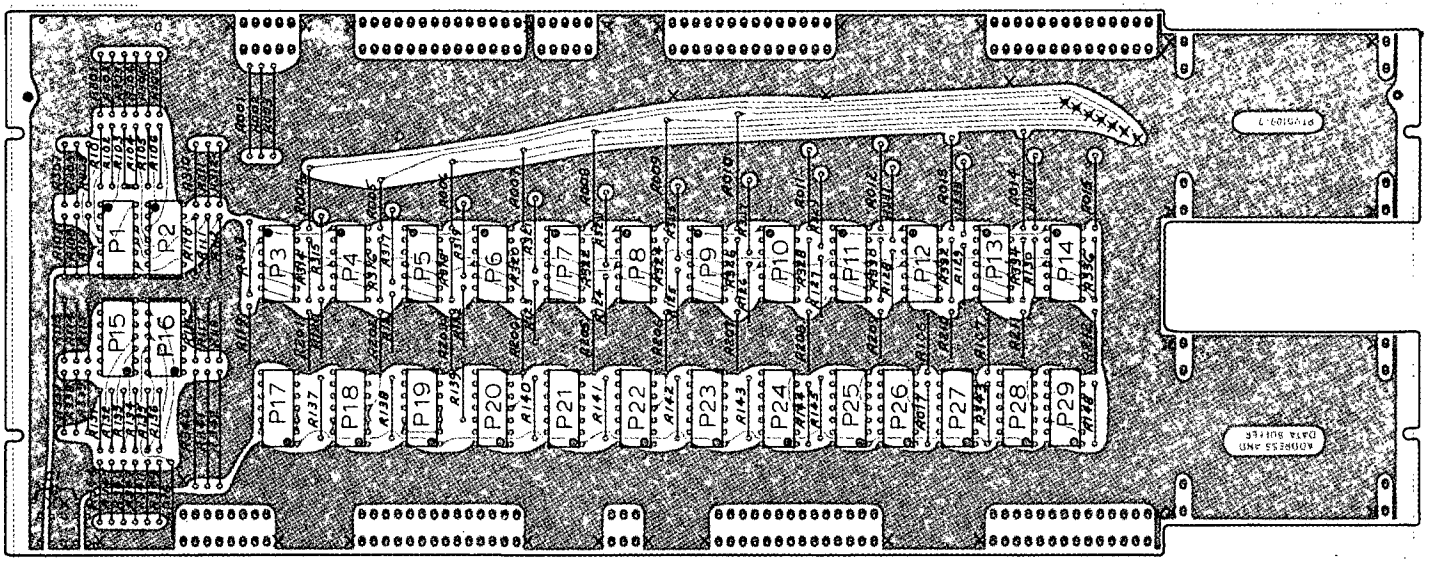
2. Slowly increase the converter input voltage watching the input current. The current should be less than 0.5A when the input voltage reaches 55Vdc.

   The +14.5Vdc output should have "jumped" from about 3 - 4 volts to over 10Vdc when the input voltage was between 30 and 50Vdc.

3. With the input voltage at 54 to 55Vdc, adjust the +14.5V output to 14.45 to 14.55Vdc using R18.

4. Adjust R11 so that the input voltage at which the +14.5V output "jumps" to 14.5V is 50 to 52Vdc.

5. The supply is now adjusted. The circuit board shoud be carefully inspected to insure that the foregoing procedure has not resulted in damage to the circuit board or the connectors.



NOTE:

HOLES MARKED WITH AN X INDICATE PLATED THROUGH HOLES WITH NO COMPONENTS INSTALLED. THESE MUST BE KEPT FREE OF SOLDER.
(40 PLACES)

NOTE:

INSTALL FEMALE AMP MODU CONNECTORS EXACTLY AS SHOWN IN DRAWING 200.50D2.

CHANGE NO.	DATE	DESCRIPTION
1	3-13-73	E.C.O. 0273

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

MACROMODULAR PROJECT

TITLE: COMPONENT IDENTIFICATION
MEMORY MODULE: BIDIRECTIONAL DATA BUSS & ADDRESS BUFFER
PART NO. 211.3

APPROVED BY	FOR	DATE
[signature]	MANUF	7-19-72

ENG. HCL-ADR
DRAWN BY PLL
CHECKED HCL
DRAWING NO. 211.3D1
DATE 6-15-72

INTEGRATED CIRCUITS

TYPE	REQUIRED	LOCATION
M01B	1	P27
M06C	12	P17 thru P26 P28 P29
M29	4	P1 P2 P15 P16
M47B	12	P3 thru P14

CONNECTORS
AMPMODU NO 85863-4
118 REQIURED

CIRCUIT BOARD
PTV0109-2
ONE REQUIRED

CAPACITORS

C01 = .01uf 15V
CERAMIC DISC

RESISTORS

R001 thru R017
JUMPERS 17 EA.

R101 thru R148
1.5K OHM 1/8 W 1% FILM RESISTOR 48 EA.

R201 thru R212
750 OHM 1/8 W 1% FILM RESISTOR 12 EA.

R301 thru R349
121 OHM 1/8 W 1% FILM RESISTOR 49 EA.

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

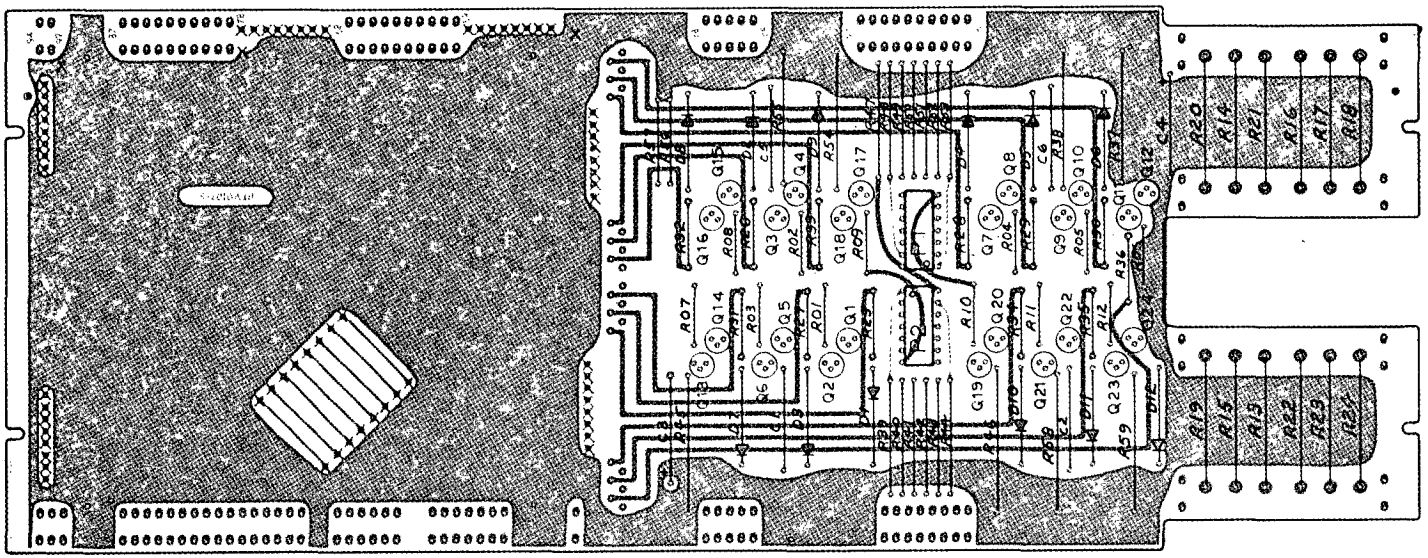
MACROMODULAR PROJECT

TITLE: PARTS LIST
MEM. BI-DIRECTIONAL DATA BUS & ADDRESS BUFFER PART NO. 211.3

CHANGE NO.	DATE	DESCRIPTION
1	10-16-72	E.C.O. 0273 cem

APPROVED BY	APPROVED FOR	APPROVED DATE
Clem	MANUF	7-19-72

ENG HCL/ADR
DRAWN BY CAH
CHECKED HCL
DRAWING NO. 211.3D2
DATE 6-24-72



NOTE: INSTALL FEMALE AMP MODU CONNECTORS EXACTLY AS SHOWN IN DRAWING 200.50D2

NOTE: TRANSISTORS MUST BE INSTALLED ON TRANSISTOR PADS.

NOTE: HOLES MARKED WITH AN X INDICATE PLATED THROUGH HOLES WITH NO COMPONENTS INSTALLED. THESE MUST BE KEPT FREE OF SOLDER. (67 PLACES)

CHANGE NO.	DATE	DESCRIPTION

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

MACROMODULAR PROJECT

TITLE: COMPONENT IDENTIFICATION
MEMORY MODULE: INHIBIT DRIVERS BOARD
PART NO. 211.4

APPROVED BY	FOR	DATE
Cam	MANUF	7-19-72

ENG. HCL-ADR
DRAWN BY PLL
CHECKED HCL

DRAWING NO. 211.4 D1
DATE 6-15-72

DIODES

TYPE	REQUIRED	LOCATION
MMD-694	12	D1 thru D12

CAPACITORS

TYPE	REQUIRED	LOCATION
.01 uf 25V	4	C1 C2 C5 C6
4.7 uf 25V	2	C3 C4

RESISTORS

TYPE	REQUIRED	LOCATION
R0	23	R37 thru R59
R3	12	R01 thru R12
* 22.2 OHM 3W NON-INDUCTIVE	12	R13 thru R24
*100 OHM ¼W 5% CARBON COMP.	12	R25 thru R36

TRANSISTORS

TYPE	REQUIRED	LOCATION
2N3648	24	Q1 thru Q24

CONNECTORS

AMPMODU NO.85863-4
NINETY-TWO REQUIRED

CIRCUIT BOARD

PTV0107-5
ONE REQUIRED

INTEGRATED CIRCUITS

TYPE	REQUIRED	LOCATION
MC837P	2	P1 P2

NOTE:

R0 = JUMPERS
R3 = 121 OHM 1% FILM RESISTOR
*R9= SPECIAL RESISTORS

TRANSISTOR PADS

TYPE	REQUIRED	LOCATION
TRANSIPAD NO. 10268	24	Q1 thru Q24

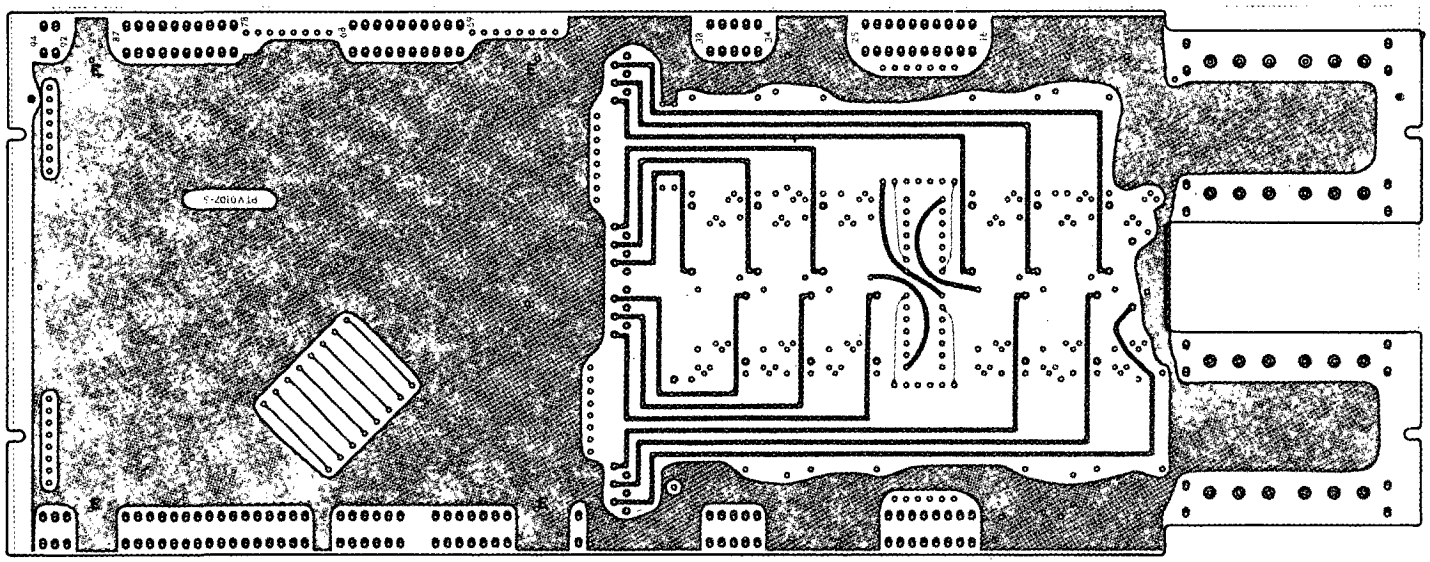
COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

MACROMODULAR PROJECT

TITLE: PARTS LIST
MEMORY MODULE INHIBIT DRIVERS BOARD
PART NO. 211.4

APPROVED BY	FOR	DATE	ENG	DRAWING NO.
	MANUF	7-19-72	HCL/ADR	211.4D2
			DRAWN BY CAH	
			CHECKED HCL	DATE 6-23-72

CHANGE NO.	DATE	DESCRIPTION



TYPE E HOLES (4 PLACES)
SEE CSL DOCUMENT 010
(GENERAL STANDARDS) FOR
HOLE SIZES

CHANGE NO.	DATE	DESCRIPTION

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

MACROMODULAR PROJECT

TITLE
HOLE SIZES
MEMORY MODULE: INHIBIT DRIVERS BOARD
PART NO. 211.4

APPROVED BY	FOR	DATE
[signature]	MANUF	7-19-72

ENG. HCL
DRAWN BY PLL
CHECKED HCL

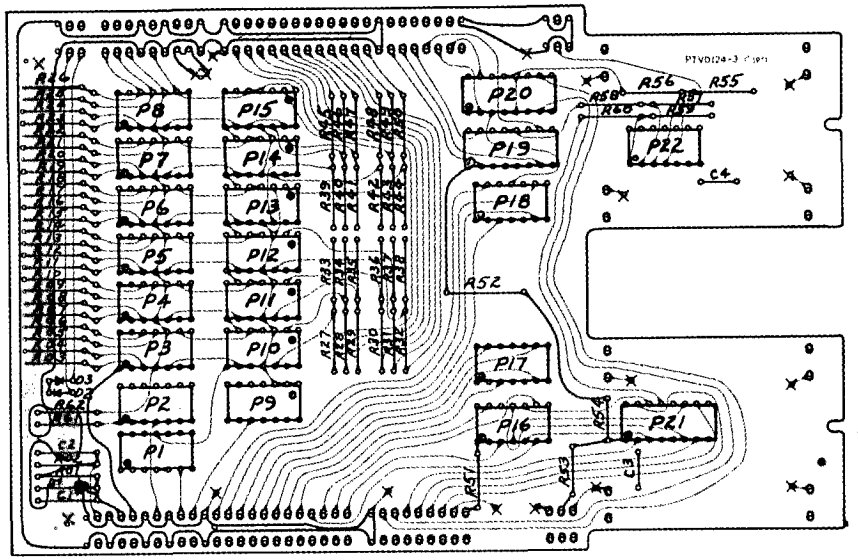
DRAWING NO. 211.4D4
DATE 7-5-72

NOTE:

INSTALL FEMALE AMP MODU CONNECTORS
ON REVERSE SIDE OF BOARD.

NOTE:

HOLES MARKED WITH AN X INDICATE PLATED THROUGH HOLES WITH NO COMPONENTS INSTALLED.
THESE MUST BE KEPT FREE OF SOLDER. (18 PLACES)



CHANGE NO.	DATE	DESCRIPTION
1	10-16-72	E.C.O. 0272 cmw

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

MACROMODULAR PROJECT

TITLE: COMPONENT IDENTIFICATION
MEMORY MODULE: SENSE AMP AND DATA REGISTER
PART NO. 211.5

APPROVED BY	FOR	DATE
cmw	MANUF	7-19-72

ENG. HCL
DRAWN BY PLL
CHECKED HCL

DRAWING NO. 211.5D1
DATE 7-5-72

INTEGRATED CIRCUITS

TYPE	REQUIRED	LOCATION
M01B	3	P1 P9 P22
M03B	1	P2
M39	3	P19 P20 P21
M40	3	P16 P17 P18
MC1543	6	P3 P4 P5 P6 P7 P8
M47	6	P10 P11 P12 P13 P14 P15

DIODES

TYPE	REQUIRED	LOCATION
IN821 6.2 ZENER	1	D1
GE1N4863	2	D2 D3

RESISTORS

TYPE	REQUIRED	LOCATION
R0	4	R51 R52 R53 R54
R1	15	R33 R34 R35 R36 R37 R38 R39 R40 R41 R42 R43 R44 R55 R57 R59
R2	1	R62
R3	15	R27 R28 R29 R30 R31 R32 R45 R46 R47 R48 R49 R50 R56 R58 R60
*100 OHMS ±5% OHMS ¼W CARBON COMP.	24	R03 thru R26
*22 OHMS ±1% 1/8 W FILM RESISTOR	1	R61

RESISTORS (cont)

TYPE	REQUIRED	LOCATION
*325 OHMS 1% 1/8W FILM RESISTOR	1	R01
*272 OHMS 1% 1/8W FILM RESISTOR	1	R02

CAPACITORS

TYPE	REQUIRED	LOCATION
10,000pf (SPRAGUE TYPE CK-103 CERAMIC DISC) 25V	4	C1 C2 C3 C4

CONNECTORS

AMPMODU FEMALE NO. 85863-4
79 REQUIRED

CIRCUIT BOARD
PTV0124-3
ONE REQUIRED

NOTE:

R0 = JUMPERS
R1 = 1.5K OHM 1% FILM RESISTOR 1/8 WATT
R2 = 750 OHMS 1% FILM RESISTOR 1/8 WATT
R3 = 121 1% FILM RESISTOR 1/8 WATT
*R9 = SPECIAL RESISTORS

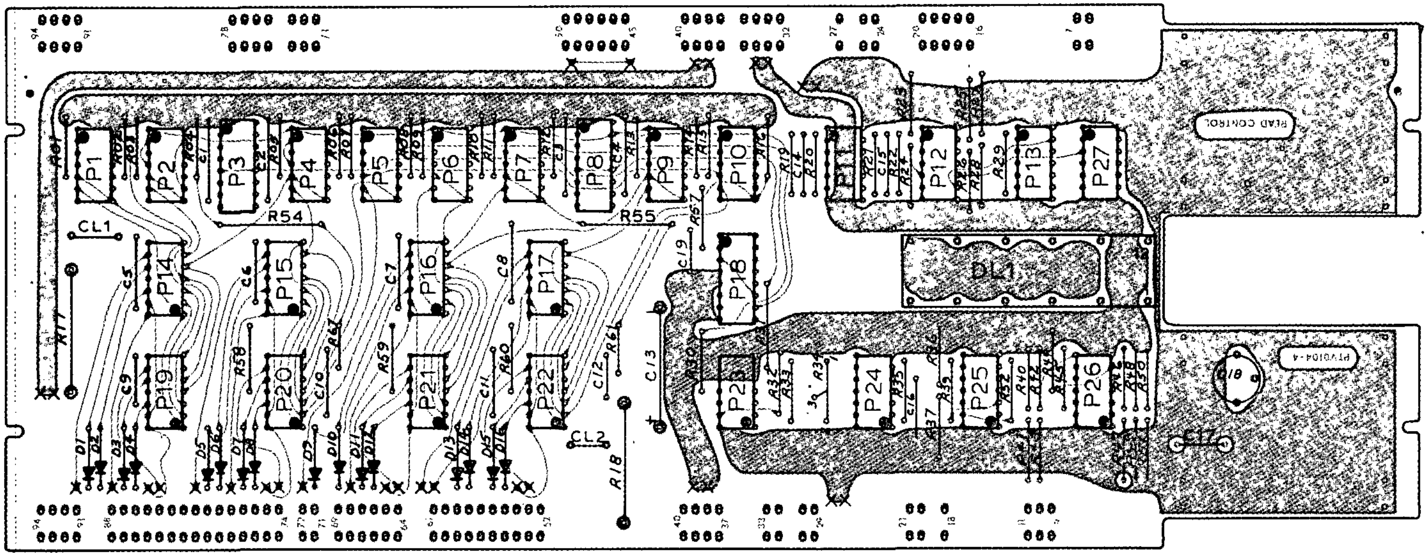
CHANGE NO.	DATE	DESCRIPTION
2	1-28-74	E.C.O. 0304 HCL
1	10-16-72	E.C.O. 0273 cem

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

MACROMODULAR PROJECT

TITLE
PARTS LIST
MEMORY SENSE AMP & DATA REGISTER BOARD
PART NO. 211.5

APPROVED BY	APPROVED FOR	APPROVED DATE	ENG.	DRAWING NO.
CDA	MANUF	7-19-72	HCL/ADR	211.5D2
			DRAWN BY CAH	
			CHECKED HCL	DATE 6-9-72



NOTE:

HOLES MARKED WITH AN X INDICATE PLATED THROUGH HOLES WITH NO COMPONENTS INSTALLED. THESE MUST BE KEPT FREE OF SOLDER. (30 PLACES)

NOTE:

INSTALL FEMALE AMP MODU CONNECTORS EXACTLY AS SHOWN IN DRAWING 200.50D2.

CHANGE NO.	DATE	DESCRIPTION
1	3-13-73	E.C.O. 0273

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

MACROMODULAR PROJECT

TITLE: COMPONENT IDENTIFICATION
MEMORY MODULE: X&Y CURRENT DRIVERS–READ TIMING & CONTROL
PART NO. 211.6

APPROVED BY	FOR	DATE
[signature]	MANUF	7-19-72

ENG.: HCL
DRAWN BY: PLL
CHECKED: HCL
DRAWING NO.: 211.6D1
DATE: 7-3-72

INTEGRATED CIRCUITS

TYPE	REQUIRED	LOCATION
M01B	2	P23 P27
M31	2	P12 P13
M35	4	P11 P24 P25 P26
M39	3	P3 P8 P18
SN7440	8	P1 P2 P4 P5 P6 P7 P9 P10
SN75324A	8	P14 P15 P16 P17 P19 P20 P21 P22

DIODES

TYPE	REQUIRED	LOCATION
MMD-694 (CSL DIODE)	16	D1 thru D16

DELAY LINE

TYPE	REQUIRED	LOCATION
PE-7118	1	DL1

RESISTORS

TYPE	REQUIRED	LOCATION
R1	7	R24 R26 R28 R40 R42 R44 R46
R2	7	R19 R20 R21 R22 R35 R39 R52
R3	7	R23 R25 R27 R29 R41 R43 R45
R6	3	R37 R49 R51
* 470 OHMS ¼W 16 ±5% CARBON COMP.		R01 thru R16
* 29.2 OHMS 3W 2 NON-INDUCTIVE 1% WIRE WOUND		R17 R18
* 430 OHMS ¼W 3 ±5% CARBON COMP.		R36 R48 R50
* 390 OHMS ¼W 1 ±5% CARBON COMP		R33
* 2,000 OHMS ¼W 1 ±5% CARBON COMP.		R47
* 2,000 OHMS TRIMPOT	1	R34

CAPACITORS

TYPE	REQUIRED	LOCATION
.01ufd 15 V DISC	5	C1 thru C4 C19
.01 ufd 25V DISC	8	C5 thru C12
4.7 ufd ELECTROLYTIC (SPRAGUE 150D475X0050B2)	1	C13
30pf DIPPED SILVER MICA	1	C15
150pf DIPPED SILVER MICA	1	C16
4 5-50pf VARIABLE	1	C18
27pf dipped silver mica	1	C14
(OMIT)	1	C17

CONNECTORS

AMP MODU FEMALE NO. 85863-4
94 REQUIRED

PRINTED CIRCUIT BOARD

PTV0104-5
1 REQUIRED

CURRENT LOOPS

TYPE	REQUIRED	LOCATION
NO.22 STRANDED WIRE TEFLON INSULATED 2 IN LONG	2	CL1 CL2

NOTE:

R1 = 1500 OHMS 1/8W 1% FILM RESISTOR
R2 = 750 OHMS 1/8W 1% FILM RESISTOR
R3 = 121 OHMS 1/8W 1% FILM RESISTOR
R6 = 130 OHMS 1/8W 1% FILM RESISTOR
*R9 = SPECIAL RESISTORS

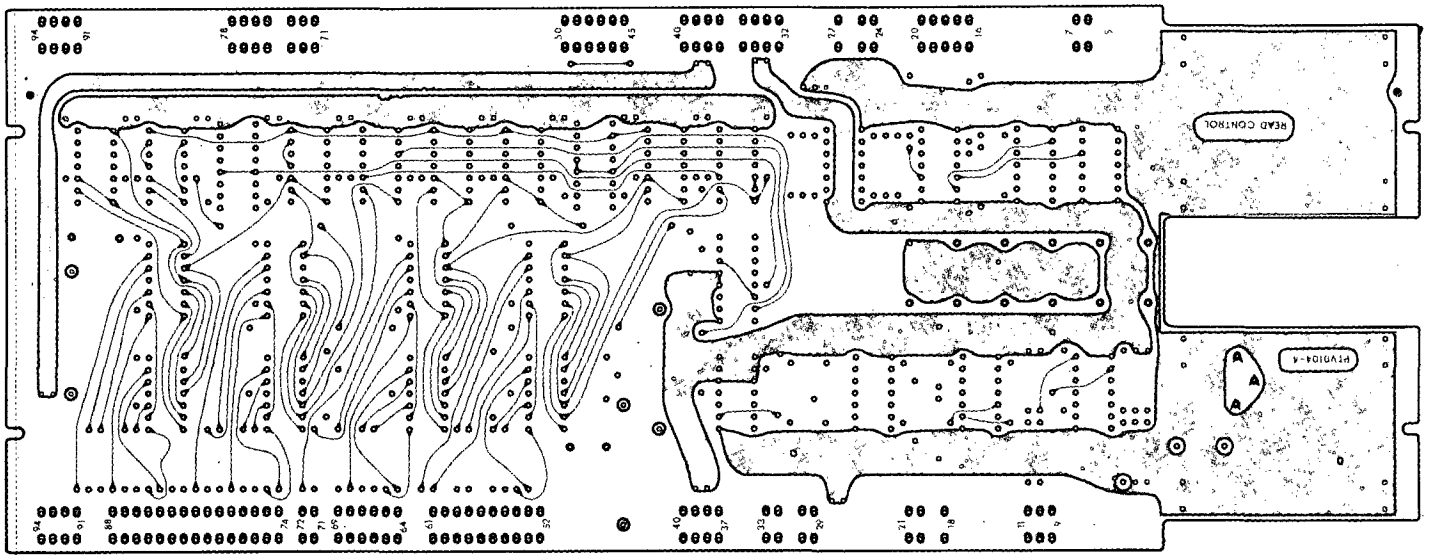
CHANGE NO.	DATE	DESCRIPTION
1.	1-28-74	E.C.O. 0304 HCL

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

MACROMODULAR PROJECT

TITLE PARTS LIST
MEMORY MODULE: X AND Y CURRENT DRIVERS
READ TIMING AND CONTROL
PART NO. 211.6

APPROVED BY	FOR	DATE	ENG.	DRAWING NO.
CAH	MANF	7-19-72	HCL	211.6D2
			DRAWN BY CAH	
			CHECKED HCL	DATE 6-24-72



TYPE A

3 PLACES

SEE CSL DOCUMENT 010 (GENERAL STANDARDS)
PAGE 13 FOR HOLE SIZE.

CHANGE NO.	DATE	DESCRIPTION

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

MACROMODULAR PROJECT

TITLE
HOLE SIZES
MEMORY MODULE: X AND Y DRIVERS , READ CONTROL
PART NO. 211.6

APPROVED BY	FOR	DATE
CMM	MANUF	7-19-72

ENG. HCL
DRAWN BY PLL
CHECKED HCL

DRAWING NO. 211.6D6
DATE 7-5-72

Delay Test

Memory Module Read Timing And Control Board #211.6

I. Preparation For Test Procedures 1 and 2.

A. Apply -5.2 VDC to T38 and T39

B. Apply Ground to T37

C. Apply a square wave with the following parameters to B7

a) Period: 2 usec

b) Amplitude: -0.75 and -1.55 Volts

c) Rise time: 10 nsec or less

d) Fall time: 10 nsec or less

D. Connect pulse generator ground to B6

II. Test Procedure 1.

A. Connect channel 1 input of 454 oscilloscope to B17

B. Connect channel 2 input of scope to B19

C. Synchronize on channel 1

D. Use the delayed sweep to measure the time between the leading edge of waveform on channel 1 with respect to the leading edge of the waveform displayed on channel 2. Record the measurement.

E. Turn the Delay Time Multiplier on the 454 CW until the next pulses come into view and repeat steps outlined in step D. Both measurements must fall within 33 to 39 nanoseconds, inclusive. If tuning is required change capacitor C14.

F. Using the 90% points check pulse width of the waveform on channel 2. The pulse should be 40 to 50 nsec wide. Pulse width can be varied by changing capacitor C15.

CHG.	E.C.O.	DATE	APPR.
1	0307	2-26-74	[illegible]

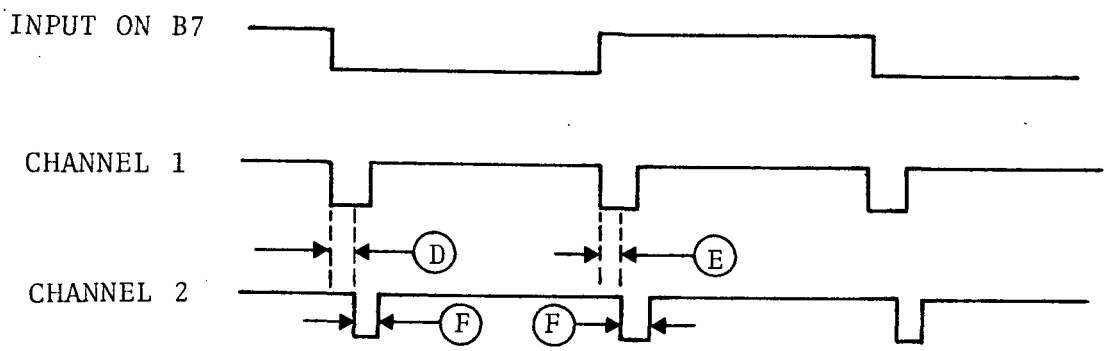


Fig. 4

III. Test Procedure 2.

A. Connect channel 1 of scope to B17

B. Connect channel 2 of scope to B18

C. Trigger on channel 1

D. Use the delayed sweep to measure the time between the leading edge of the waveform on channel 1 versus the trailing edge of the waveform on channel 2. By varying the potientiometer R933, set the time to 135 nsec. If unable to do so, select a new capacitor value for C16.

E. Turn the Delay Time Multiplier of the 454 CW until the next pulse appears on channel 1. Compare the time again between the leading edge of channel 1 versus the trailing edge of channel 2. The time should be between 128 to 141 nanoseconds, inclusive. If it is necessary to readjust R933 repeat the test of step D and confirm that measurement also falls within 128 to 141 nsec, inclusive.

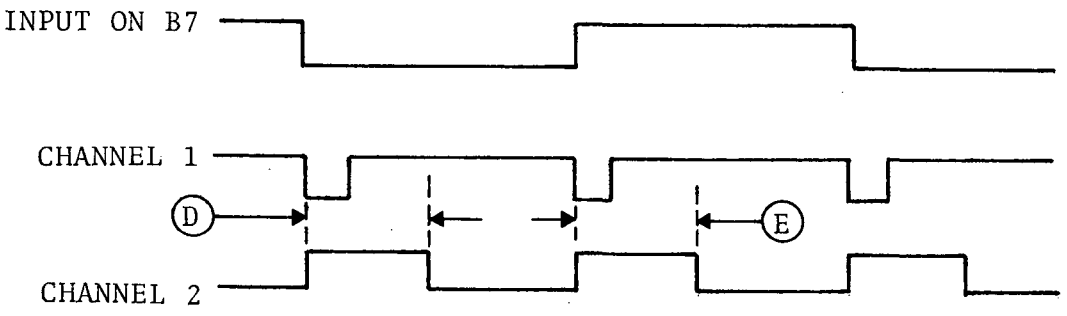
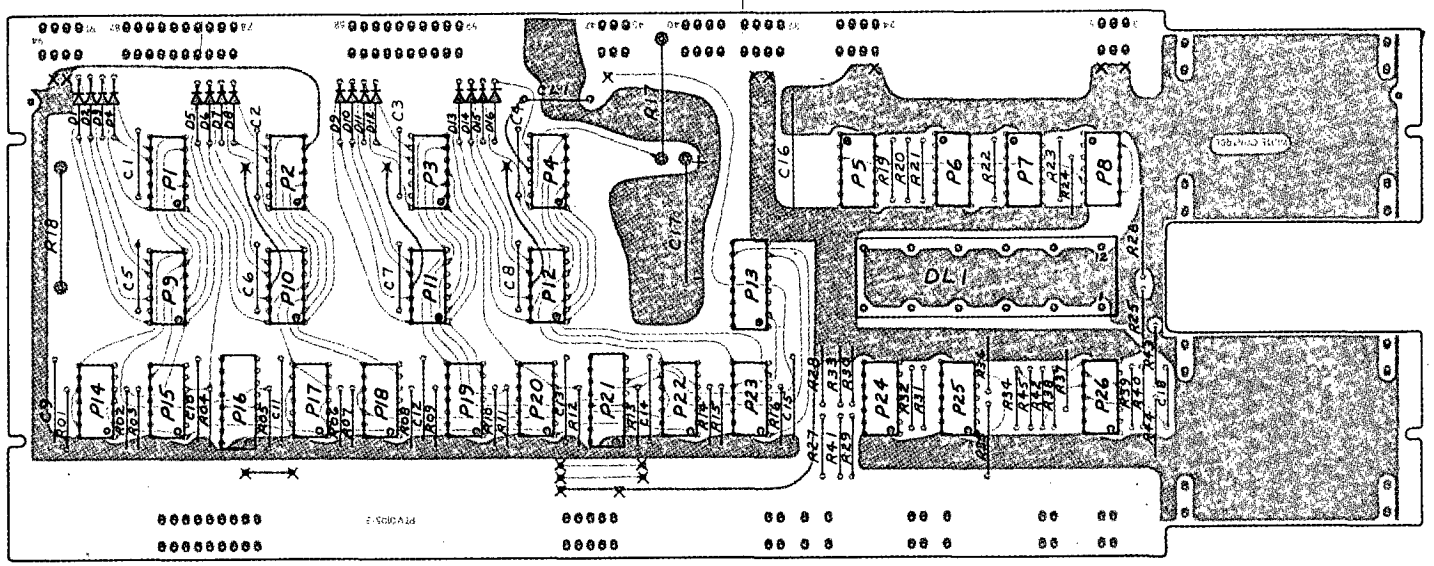


Fig. 5



NOTE: HOLES MARKED WITH AN X INDICATE PLATED THROUGH HOLES WITH NO COMPONENTS INSTALLED. THESE MUST BE KEPT FREE OF SOLDER. (19 PLACES)

NOTE: INSTALL FEMALE AMP MODU CONNECTORS EXACTLY AS SHOWN IN DRAWING 200.50D2

CHANGE NO.	DATE	DESCRIPTION
1	3-13-73	E.C.O. 0273

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

MACROMODULAR PROJECT

TITLE: COMPONENT IDENTIFICATION
MEMORY MODULE X & Y RETURN LINE DRIVERS WRITE TIMING & CONTROL PART NO. 211.7

APPROVED BY	FOR	DATE
Chun	MANUF	7-19-72

ENG. HCL
DRAWN BY PLL
CHECKED HCL
DRAWING NO. 211.7D1
DATE 6-28-72

INTEGRATED CIRCUITS

TYPE	REQUIRED	LOCATION
M01B	1	P7
M10	2	P5 P24
M11	1	P8
M31	2	P6 P25
M35	1	P26
M39	3	P13 P16 P21
SN7440	8	P14 P15 P17 P18 P19 P20 P22 P23
SN75324A	8	P1 P2 P3 P4 P9 P10 P11 P12

DIODES

TYPE	REQUIRED	LOCATION
MMD-694 (CSL DIODE)	16	D1 thru D16

CONNECTORS

AMP MODU FEMALE NO. 85863-4
75 REQUIRED

RESISTORS

TYPE	REQUIRED	LOCATION
R1	8	R21 R28 R30 R32 R33 R36 R37 R40
R2	2	R24 R34
R3	10	R19 R20 R22 R23 R27 R29 R31 R35 R38 R41
R6	2	R26 R44
*470 OHMS ± 5% 1/4 W CARBON COMP.	16	R01 thru R16
*29.2 OHMS ± 1% 3 W NON-INDUCTIVE WIRE WOUND	2	R17 R18
*430 OHMS ± 5% 1/4 W CARBON COMP.	2	R25 R43
*2,000 OHMS ± 5% 1/4 W CARBON COMP	1	R39
*1,000 OHMS ± 5% 1/4 W CARBON COMP.	1	R42

RESISTORS (cont)

TYPE	REQUIRED	LOCATION
*3,000 OHMS ± 5% 1/4 W CARBON COMP.	1	R45

CURRENT LOOP

TYPE	REQUIRED	LOCATION
NO. 22 STRANDED WIRE TEFLON INSULATED 2 INCHES LONG	1	CL1

DELAY LINE

TYPE	REQUIRED	LOCATION
PE-7118	1	DL1

PRINTED CIRCUIT BOARD

PTV0105-4 1 REQUIRED

CAPACITORS

TYPE	REQUIRED	LOCATION
.01 ufd 25V DISC	8	C1 thru C8
.01 ufd 15V DISC	8	C9 thru C16
4.7 ufd ELECTROLYTIC	1	C17
200 pf Dipped silver mica	1	C18

NOTE:

R1 = 1500 OHMS ±1% 1/8 W FILM RESISTOR
R2 = 750 OHMS ±1% 1/8 W FILM RESISTOR
R3 = 121 OHMS ±1% 1/8 W FILM RESISTOR
R6 = 130 OHMS ±1% 1/8 W FILM RESISTOR
*R9 = SPECIAL RESISTORS

CHANGE NO.	DATE	DESCRIPTION
1	1-28-74	E.C.O. 0304 HCL

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

MACROMODULAR PROJECT

TITLE
PARTS LIST
MEMORY: X & Y RETURN LINE DRIVERS
WRITE TIMING AND CONTROL
PART NO. 211.7

APPROVED BY	FOR	DATE	ENG.	DRAWING NO.
CW	MANUF	7-19-72	HCL	
			DRAWN BY CAH	211.7D2
			CHECKED HCL	DATE 6-23-72

Delay Test

Memory Module Write Timing And Control Board #211.7

I. Preparation For Test Procedure.

A. Apply -5.2 VDC to B33 and B34

B. Apply Ground to B32

C. Apply a source of high to B26

a) High = -0.75 VDC

D. Apply a square wave with the following parameters to B4

a) Period: 2 usec

b) Amplitude: -0.75 and -1.55 Volts

c) Rise time: 10 nsec or less

d) Fall time: 10 nsec or less

E. Connect pulse generator ground to B5

II. Test Procedure.

A. Connect channel 1 input of scope to B4

B. Connect channel 2 input of scope to pin 12 of package 26

C. Synchronize scope on channel 1

D. Record the time duration from the leading edge of channel 1 waveform to the leading edge of the waveform on channel 2.

E. Record the time relationship between the trailing edge of each.

F. The minimum time of either measurement in steps E and F must be equal to or greater than 600 nanoseconds. If the delay is too short, increase the value of C18.

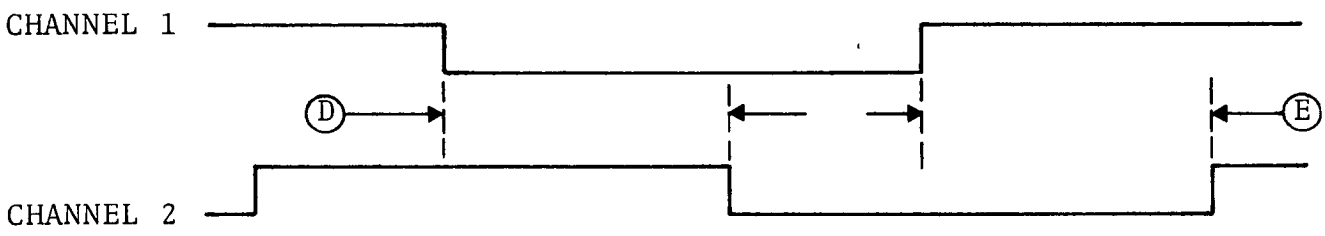
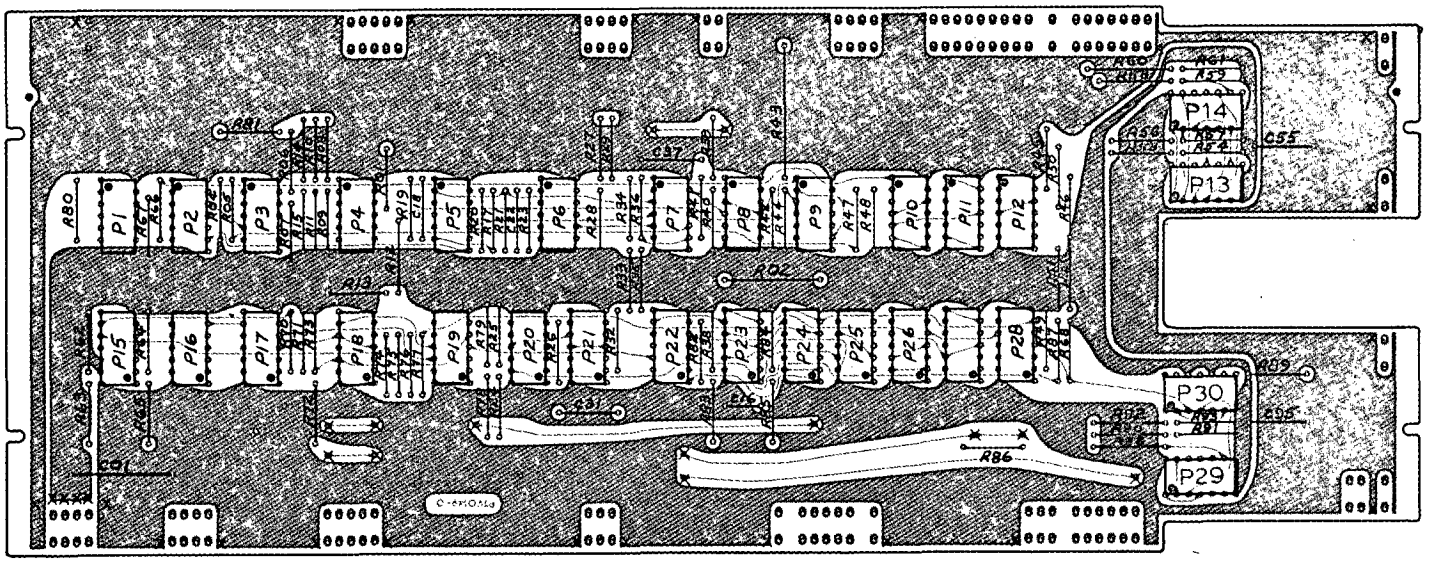


Fig. 3



NOTE: HOLES MARKED WITH AN X INDICATE PLATED THROUGH HOLES WITH NO COMPONENTS INSTALLED. THESE MUST BE KEPT FREE OF SOLDER.
(40 PLACES)

NOTE: INSTALL FEMALE AMP MODU CONNECTORS EXACTLY AS SHOWN IN DRAWING 200.50D2

CHANGE NO.	DATE	DESCRIPTION

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

MACROMODULAR PROJECT

TITLE: COMPONENT IDENTIFICATION
MEMORY MODULE: MACROMODULAR CONTROL
PART NO. 211.8

APPROVED BY	FOR	DATE
Cam	MANUF	7-19-72

ENG. HCL
DRAWN BY PLL
CHECKED HCL

DRAWING NO. 211.8D1
DATE 6-28-72

INTEGRATED CIRCUITS

TYPE	REQUIRED	LOCATION
M01	2	P1
		P6
M07	1	P19
M10	9	P2
		P9
		P10
		P12
		P15
		P22
		P24
		P26
		P27
M12	1	P30
M16	2	P17
		P18
M29	1	P4
M30	7	P7
		P11
		P14
		P23
		P25
		P28
		P29
M31	2	P16
		P20
M35	2	P5
		P21
M47	2	P8
		P13
M48	1	P3

CONNECTORS

AMP MODU FEMALE NO. 85863-4
74 REQUIRED

PRINTED CIRCUIT BOARD

PTV0149-1 1 REQUIRED

RESISTORS

TYPE	REQUIRED	LOCATION
R0	2	R01
		R02
R1	34	R04
		R07
		R09
		R11
		R13
		R15
		R25
		R28
		R34
		R36
		R38
		R40
		R44
		R46
		R48
		R49
		R51
		R52
		R54
		R57
		R59
		R61
		R62
		R64
		R67
		R68
		R71
		R73
		R75
		R76
		R79
		R84
		R89
		R93
R2	9	R17
		R19
		R20
		R21
		R26
		R32
		R41
		R86
		R91

RESISTORS (cont)

TYPE	REQUIRED	LOCATION
R3	38	R05
		R06
		R08
		R10
		R12
		R14
		R23
		R24
		R27
		R29
		R33
		R35
		R39
		R43
		R45
		R47
		R50
		R53
		R56
		R58
		R60
		R63
		R65
		R66
		R70
		R72
		R74
		R77
		R78
		R80
		R81
		R82
		R83
		R85
		R87
		R88
		R90
		R92
R4	1	R42

CAPACITORS

TYPE	REQUIRED	LOCATION
.01 ufd 15 WVDC	3	C01
		C55
		C95
27 pf	2	C22
		C31
47 pf	1	C18
10 pf	1	C37
DETERMINED AT TIME OF TEST	1	C16

NOTE: R0 = JUMPER
R1 = 1,500 OHMS ± 1% 1/8 W FILM RESISTOR
R2 = 750 OHMS ± 1% 1/8 W FILM RESISTOR
R3 = 121 OHMS ± 1% 1/8 W FILM RESISTOR
R4 = 15,000 OHMS ± 5% 1/4 W FILM RESISTOR

CHANGE NO.	DATE	DESCRIPTION
1	1-28-74	E.C.O. 0304 HCL

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

MACROMODULAR PROJECT

TITLE
PARTS LIST
MEMORY MODULE: MACROMODULAR CONTROL
PART NO. 211.8

APPROVED BY	FOR	DATE	ENG.	DRAWING NO.
	MANUF	7-19-72	HCL	211.8D2
			DRAWN BY CAH	
			CHECKED HCL	DATE 6-23-72

Delay Test

Memory Module Macromodular Control Board #211.8

I. Preparation for Test Procedure 1.

A. Apply -5.2 VDC to T90, T91, T92, T93

B. Apply Ground to T89, T94

C. Apply a source of high to B14

a) High = -0.75 VDC

D. Apply a square wave with the following parameters to B16

a) Period: 2 usec.

b) Amplitude: -0.75 and -1.55 Volts

c) Rise time: 10 nsec or less

d) Fall time: 10 nsec or less

E. Connect pulse generator ground to B19

II. Test Procedure 1.

A. Connect channel 1 input of 454 oscilloscope to B16

B. Connect channel 2 input to T29

C. Synchronize display on channel 1

D. Use the delayed sweep feature of the 454 to observe the timing relationship between the leading edge of the waveform displayed on channel 1 versus the leading edge of the waveform on channel 2. Similarly note the relationship between the trailing edges of the signals. The minimum time of either must be greater than or equal to 18 nanoseconds.

E. If tuning is required change capacitor C37. (For each additional nanosecond required add 1 pf to the present value of C37.)

CHG.	E.C.O.	DATE	APPR.
1	0307	2-26-74	HCL

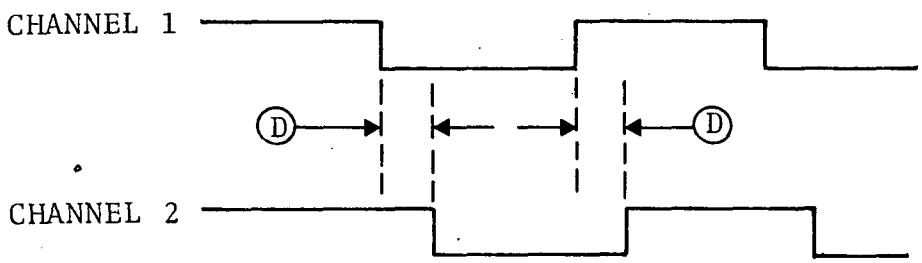


Fig. 1

III. Preparation For Test Procedure 2.

A. Retain -5.2 VDC and Ground connections described in IA and IB

B. Apply a source of high to T2, T3, T4, T5, T6, T7, T67

C. Connect T10 to B11

D. Connect T9 to B9

E. Apply the square wave described in ID to T27

IV. Test Procedure 2.

A. Connect channel 1 input of 454 to B46

B. Connect channel 2 input to T30

C. Synchronize on channel 1

D. The specification for each waveform is:

a) Minimum width: 37 nsec

b) Maximum width: 50 nsec (Measurements are taken at the 90% points)

E. If tuning is required the associated capacitors are:

a) Channel 1: C31

b) Channel 2: C22

F. Use the delayed sweep to measure the time between the trailing edge of waveform on channel 1 to the trailing edge of the waveform on channel 2. Record the time.

G. Turn the Delay Time Multiplier on the 454 CW until the next pulses come into view and record the measurements as in step F. If either measurement is less than 37 nanoseconds, increase proportionately the value of C18.

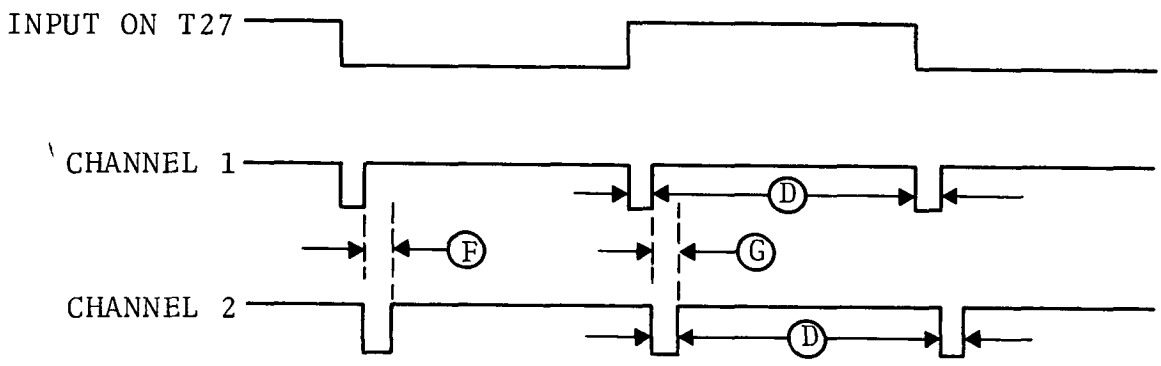
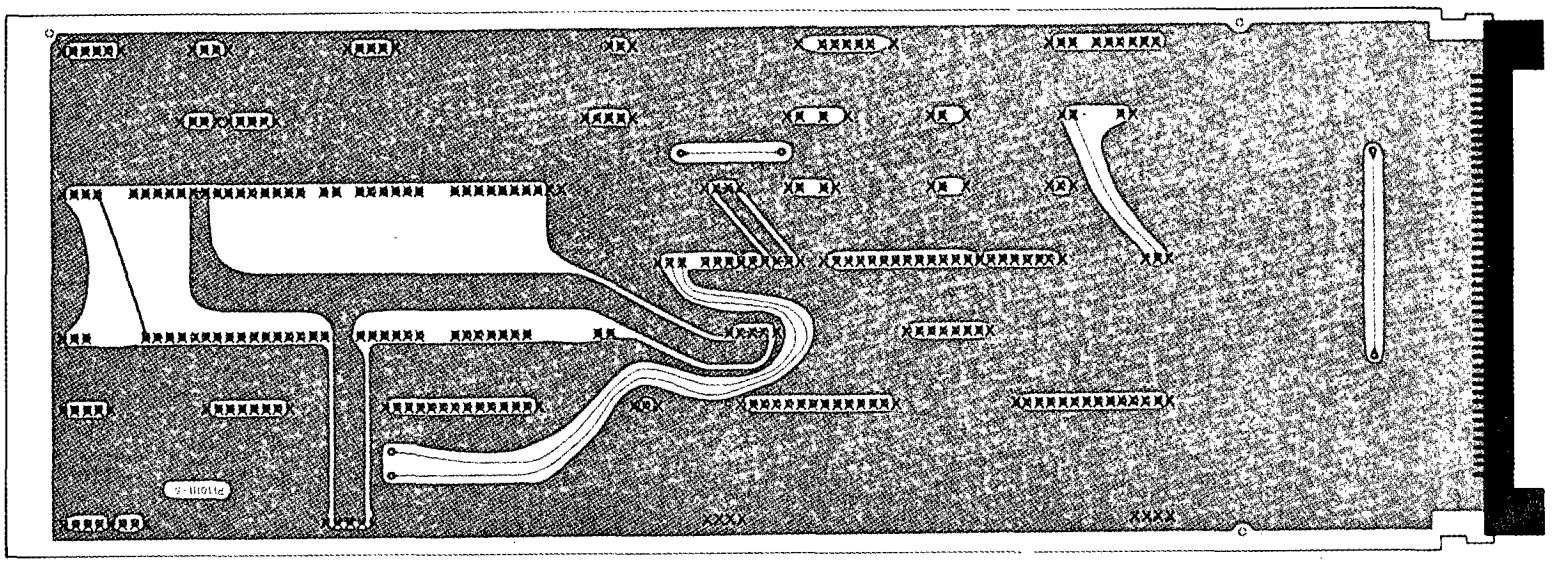


Fig. 2



NOTE 1:

SEE DRAWING NO. 200.50D26 FOR CONNECTOR ORIENTATION.

NOTE 2:

MALE AMP MODU PINS MUST BE INSTALLED FROM THIS SIDE IN LOCATIONS MARKED X PRECISELY AS SHOWN IN DRAWINGS 200.50D1 AND 200.50D2. (272 PINS)

CHANGE NO.	DATE	DESCRIPTION
1	3-13-73	E.C.O. 0273

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

MACROMODULAR PROJECT

TITLE: COMPONENT IDENTIFICATION
MEMORY MODULE: TOP MOTHER BOARD
PART NO. 211.9

APPROVED BY	FOR	DATE
	MANUF	7-19-72

ENG. HCL
DRAWN BY PLL
CHECKED HCL
DRAWING NO. 211.9D1
DATE 7-5-72

CONNECTORS

AMP MODU NO. 85931-5
272 REQUIRED

AMP CONNECTOR NO. 1-202 845-5
1 REQUIRED

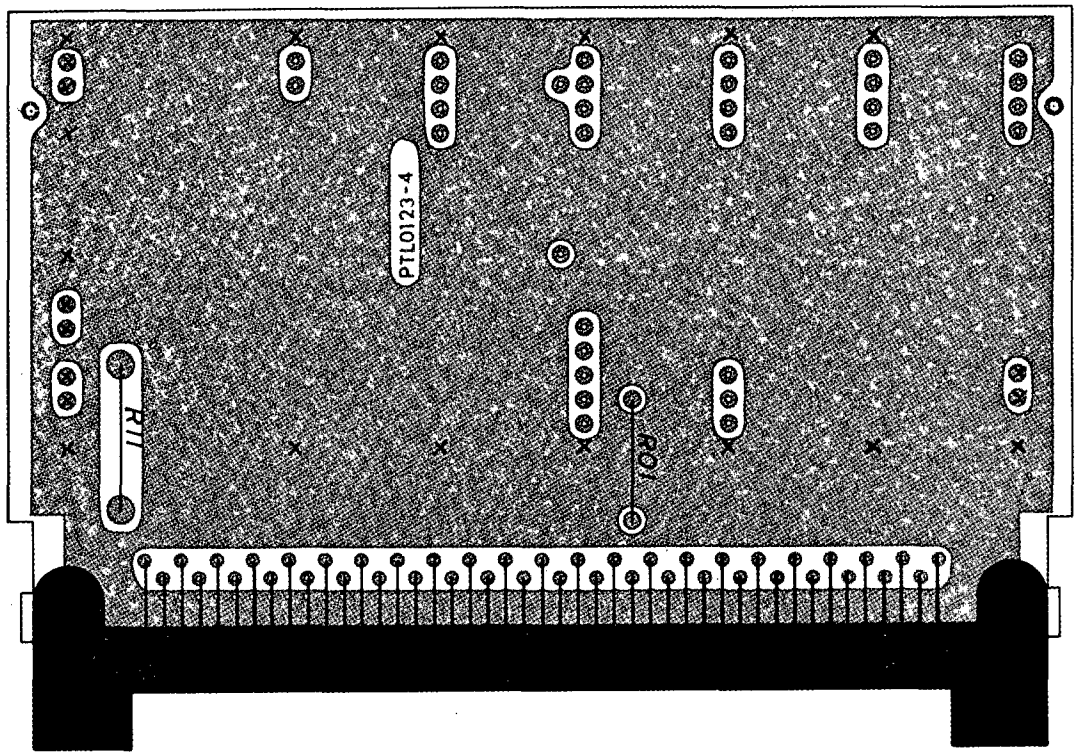
PRINTED CIRCUIT BOARD

PTT 0111-5
1 REQUIRED

COMPUTER SYSTEMS LABORATORY WASHINGTON UNIVERSITY ST. LOUIS, MISSOURI			MACROMODULAR PROJECT		
			TITLE PARTS LIST MEMORY MODULE: TOP MOTHERBOARD PART NO. 211.9		
			APPROVED BY: Chas	FOR: MANUF	DATE: 7-19-72
			ENG HCL	DRAWING NO. 2119D2	
			DRAWN BY CAH		
CHANGE NO.	DATE	DESCRIPTION	CHECKED HCL	DATE 7-5-72	

NOTE:
AMPMODU PINS MUST BE INSTALLED FROM THIS SIDE IN LOCATIONS MARKED X PRECISELY AS SHOWN IN DWG. 200.50D2 AND 200.50D3.
(23 PINS)

NOTE:
SEE DRAWING NUMBER 200.50D28 FOR CONNECTOR MOUNTING ORIENTATION.



CHANGE NO.	DATE	DESCRIPTION
2	1-28-74	E.C.O. 0304 HCL
1	3-13-73	E.C.O. 0273

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

MACROMODULAR PROJECT

TITLE: COMPONENT IDENTIFICATION
MEMORY MODULE: LATERAL MOTHERBOARD
PART NO. 211.10

APPROVED BY	FOR	DATE
[signature]	MANUF	7-19-72

ENG. HCL-ADR
DRAWN BY PLL
CHECKED HCL
DRAWING NO. 211.10D1
DATE 6-21-72

RESISTOR 7.56K OHM 1% FILM
R01

FUSE BUSSMAN GFA 2 AMP
ONE REQUIRED
R11

AMP CONNECTOR
583 464-1
ONE REQUIRED

CONNECTORS
AMPMODU NO. 85931-5
TWENTY THREE REQUIRED

CIRCUIT BOARD
PTL0123-4
ONE REQUIRED

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

MACROMODULAR PROJECT

TITLE: PARTS LIST
MEMORY MODULE LATERAL MOTHERBOARD
PART NO. 211.10

CHANGE NO.	DATE	DESCRIPTION
1	1-28-74	E.C.O. 0304 HCL

APPROVED BY	APPROVED FOR	APPROVED DATE
	MANUF	7-19-72

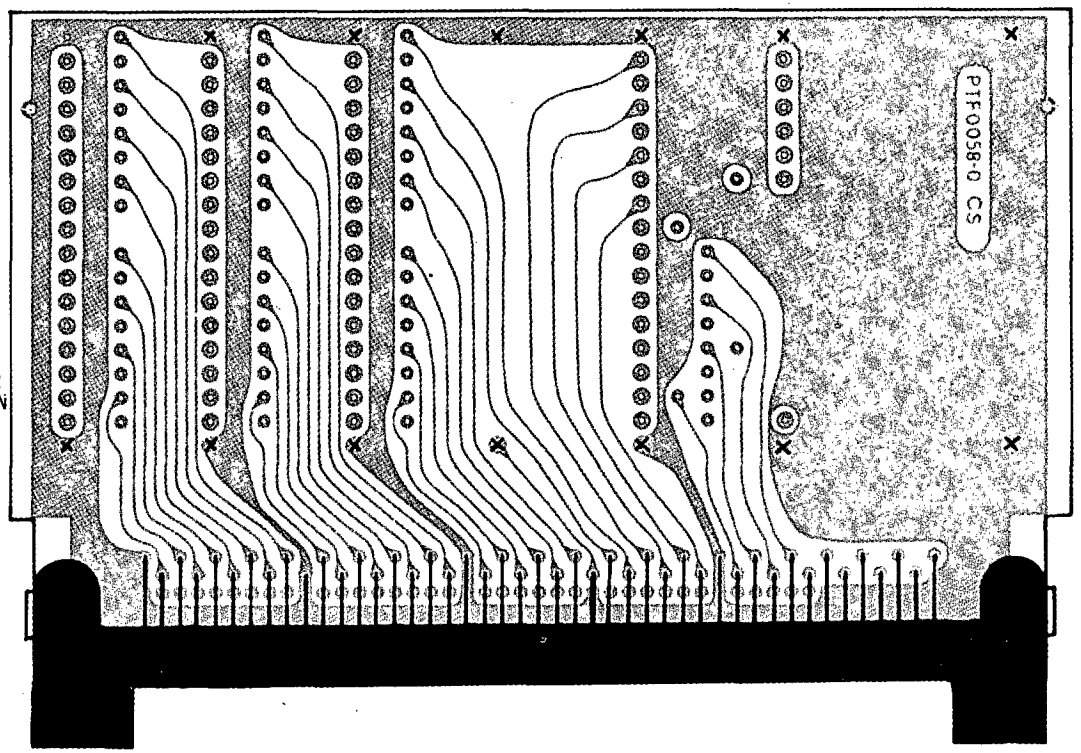
ENG: HCL/ADR
DRAWN BY: CAH
CHECKED: HCL
DRAWING NO.: 211.10D2
DATE: 6-23-72

NOTE:

AMP MODU PINS MUST BE INSTALLED FROM THIS SIDE IN LOCATIONS MARKED X PRECISELY AS SHOWN IN DWG. 200.50D2 and 200.50D3. (13 PINS)

NOTE:

SEE DRAWING NUMBER 200.50D29 FOR CONNECTOR MOUNTING ORIENTATION



CHANGE NO.	DATE	DESCRIPTION
1	3-13-73	E.C.O. 0273

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

MACROMODULAR PROJECT

TITLE: COMPONENT IDENTIFICATION
MEMORY MODULE FACEPLATE MOTHERBOARD
PART NO. 211.11

APPROVED BY	FOR	DATE
	MANUF	7-19-72

ENG. HCL/ADR
DRAWN BY DHO
CHECKED HCL

DRAWING NO. 211.11D1
DATE 3-8-71

AMP CONNECTOR
583-464-1
ONE REQUIRED

CONNECTOR
AMPMODU NO 85931-5
THIRTEEN REQUIRED

CIRCUIT BOARD
PTF0058-1
ONE REQUIRED

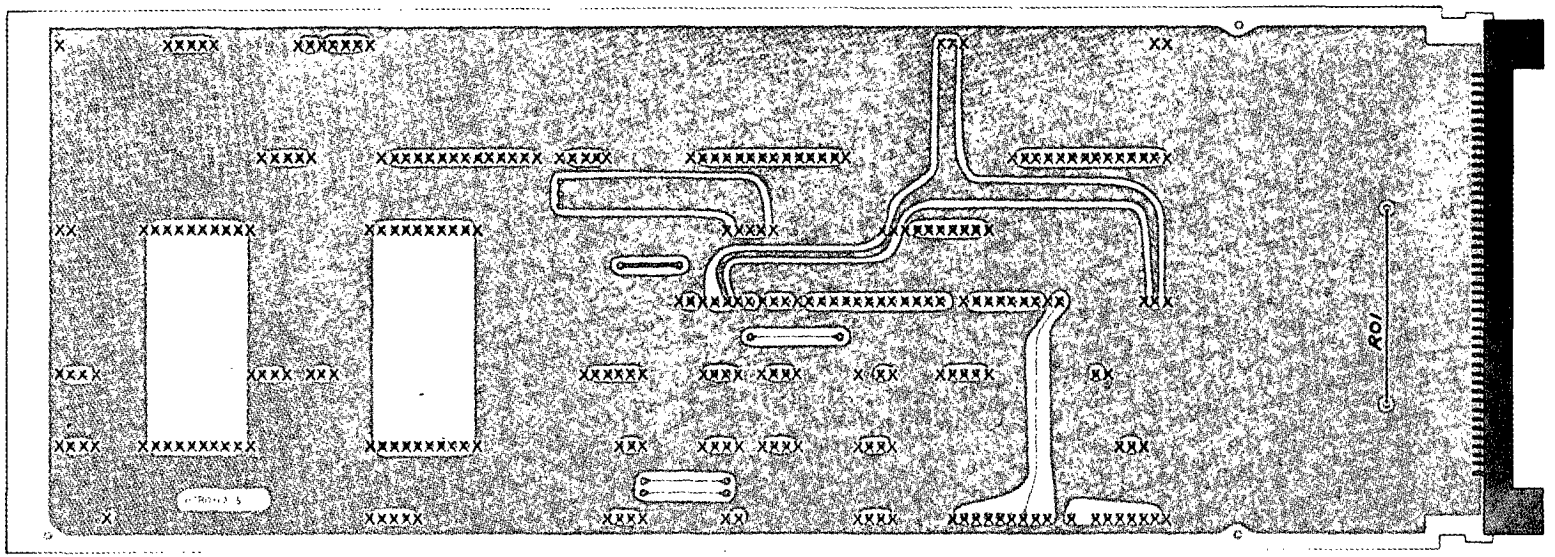
COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

MACROMODULAR PROJECT

TITLE
PARTS LIST
MEMORY MODULE FACEPLATE MOTHER BOARD
PART NO. 211.11

APPROVED			ENG	DRAWING NO.
BY	FOR	DATE	HCL /ADR	211 11D2
CAH	MANUF	7-19-72	DRAWN BY CAH	
			CHECKED HCL	DATE 6-23-72

CHANGE NO.	DATE	DESCRIPTION



NOTE 1:

SEE DRAWING NO. 200.50D27 FOR CONNECTOR ORIENTATION.

NOTE 2:

MALE AMP MODU PINS MUST BE INSTALLED FROM THIS SIDE IN LOCATIONS MARKED X PRECISELY AS SHOWN IN DRAWINGS 200.50D2 AND 200.50D3 (252 PINS)

CHANGE NO	DATE	DESCRIPTION
1	3-13-73	E.C.O. 0273

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

MACROMODULAR PROJECT

TITLE: COMPONENT IDENTIFICATION
MEMORY MODULE: BOTTOM MOTHERBOARD
PART NO. 211.12

APPROVED BY	FOR	DATE
	MANUF	7-19-72

ENG. HCL
DRAWN BY PLL
CHECKED HCL

DRAWING NO. 211.12D1
DATE 7-5-72

RESISTOR

R01 = ZERO OHMS (JUMPER)

CONNECTORS

AMP MODU NO. 85931–5
252 REQUIRED

AMP CONNECTOR 1–202 845–5
1 REQUIRED

PRINTED CIRCUIT BOARD

PTB0112–5
1 REQUIRED

COMPUTER SYSTEMS LABORATORY WASHINGTON UNIVERSITY ST. LOUIS, MISSOURI	**MACROMODULAR PROJECT**	
	TITLE PARTS LIST MEMORY MODULE: BOTTOM MOTHERBOARD PART NO. 211.12	
	APPROVED BY / FOR / DATE: [illegible] / MANUF / 7-19-72	ENG HCL; DRAWN BY CAH; CHECKED HCL
		DRAWING NO. 211.12D2; DATE 7-5-72
CHANGE NO. / DATE / DESCRIPTION		

DYNAMIC MEMORY WAVEFORMS

To obtain the waveforms described in this post assembly procedure, one must have at his disposal either a test panel of data switches with a controlling interface (including Preset, Shield, and Power) or a complement of data processing modules configured to provide the parameters required by the memory. The latter method used at CSL is the test described.

The memory selection and function codes are provided by the Unit Memory Controller (UMC). This module has explicit Read and Write terminals and controls a single memory module directly below it. A count and compare routine comprised of a Load, Register, Arithmetic, and Compare modules provide the data input as well as the address data.

Due to the physical difficulty of testing and probing while the module is in the frame, two special cables were fabricated to extend the module out of the frame and onto a work surface. One cable connected the bottom motherboard of the UMC to the top motherboard of the memory. The other cable connected into the lateral channel of the frame to provide Preset, Shield, and +55 VDC.

The bottom motherboard of the memory is replaced with a specially prepared motherboard. The special preparation (See Photo 1) of the motherboard involves the cutting or opening up of the 16 return lines and replacing them with current loops to facillitate the use of a current probe. Prior to reassembly with the modified motherboard the stack assembly was prepared by lifting the collector end of one of the inhibit load resistors (22.2 ohms, 3 watt),

and adding a current loop in series with the inhibit line. See Photo 2.

After reassembly and supplying the necessary control input, which consisted of a continuous Write loop, the following waveforms,(Fig 1) are obtained on each of the current loops on the motherboard. The 454 oscilloscope should be synchronized externally on T30 of the Macromodular Control Board, (labeled LD ADD) located on the top motherboard. Figure 1 is a tracing of an actual waveform.

Amplitude: 370 ma.

Time: 1 usec.

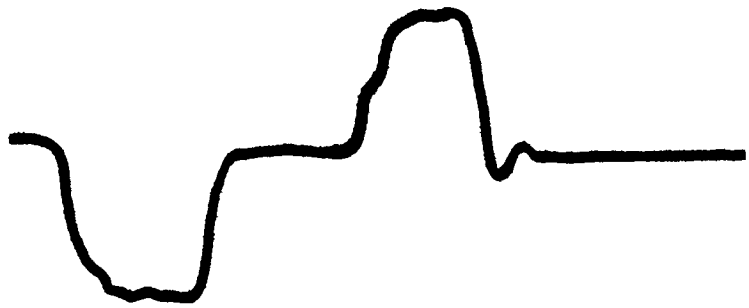


Fig 1

The inhibit current waveform is seen by placing the current probe on the loop added to the inhibit load resistor. Maintain the scope trigger on LD ADD. The waveform below is typical. (Fig 2).

Amplitude: 370 ma.

Time: 400 nsec.

Fig 2

NOTE: To scrutinize all inhibit waveforms it is of course necessary to add current loops to each of the 12 inhibit resistors. One can however, by use of a voltage probe, examine the voltage waveform accross the remaining load resistors to verify their activity.

The remaining waveform of extreme importance is the sense line output. Test points are provided on the top motherboard for the following procedure:

1. Connect channel 1 of the 454 oscilloscope to T38 (labeled STRBTST).

2. Using a differential probe connect channel 2 of the scope to T39 and T40 (labeled SA IN $\pm$).

3. Synchronize externally on T30 (labeled LD ADD).

The waveform obtained on channel 2 is dependent upon the data pattern being written. The waveform below in Fig 3 was obtained by writing alternate ones and zeroes throughout memory.

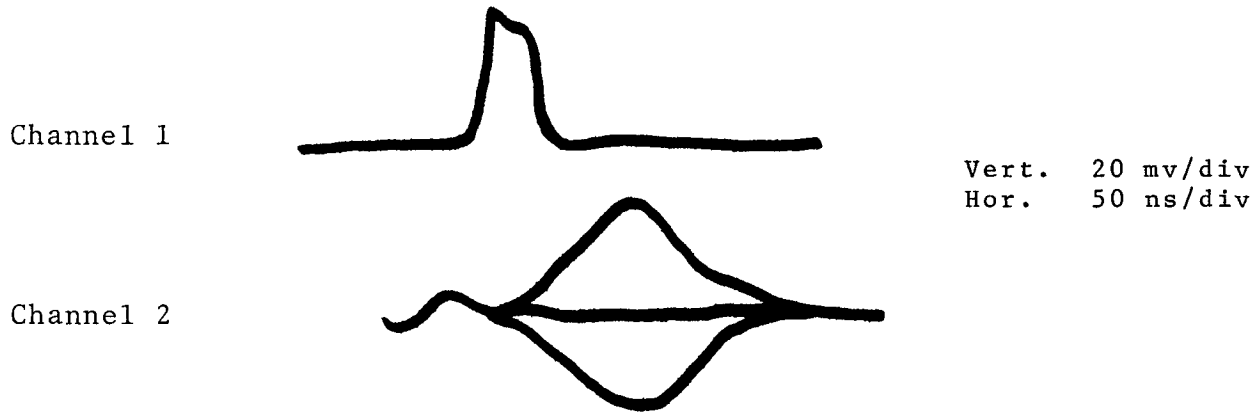


Fig 3

Position the base line of channel 1 directly over the base

line of channel 2. By varying the variable capacitor (C18) located on the panhandle end of the Read Control Board (See Photo 3), adjust the position of the strobe pulse on channel 1 so that its 90% point on the leading edge occurs at the peak of the sense signal on channel 2. Use the Time Delay Multiplier of the scope to verify the same condition on an adjacent pulse. When this is accomplished as indicated by Fig 4, the memory module is tuned.

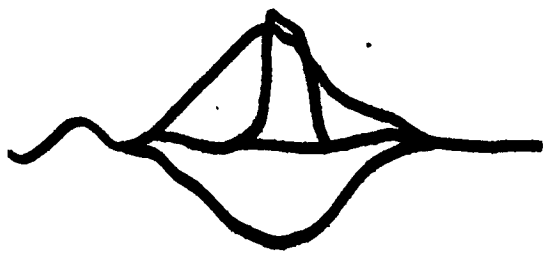


Fig 4

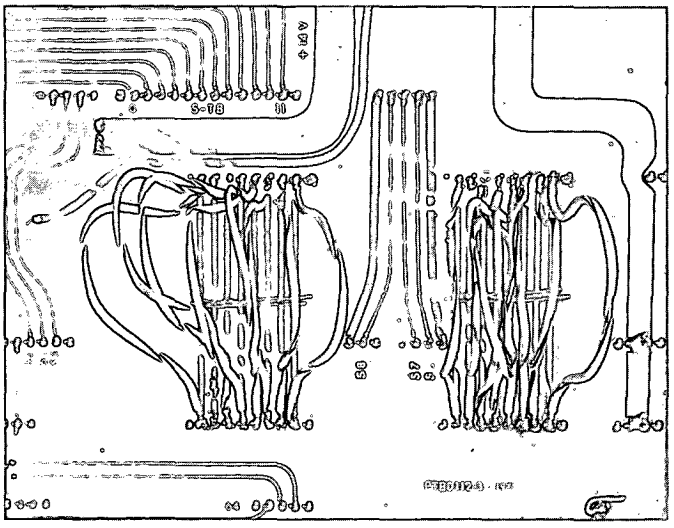


Photo 1

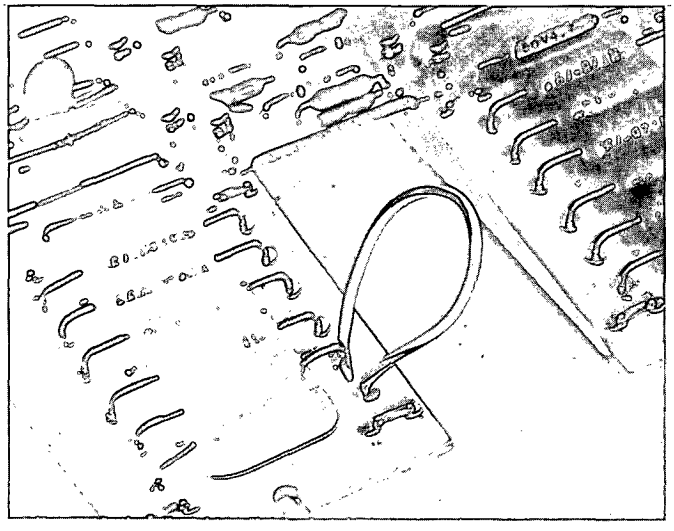


Photo 2

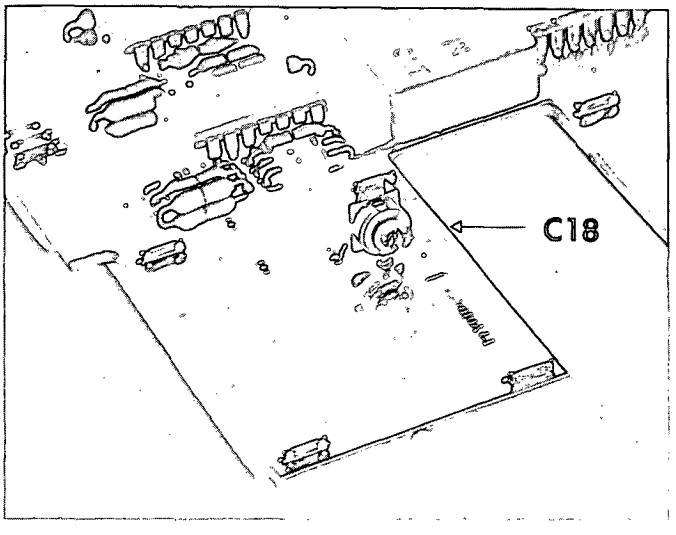
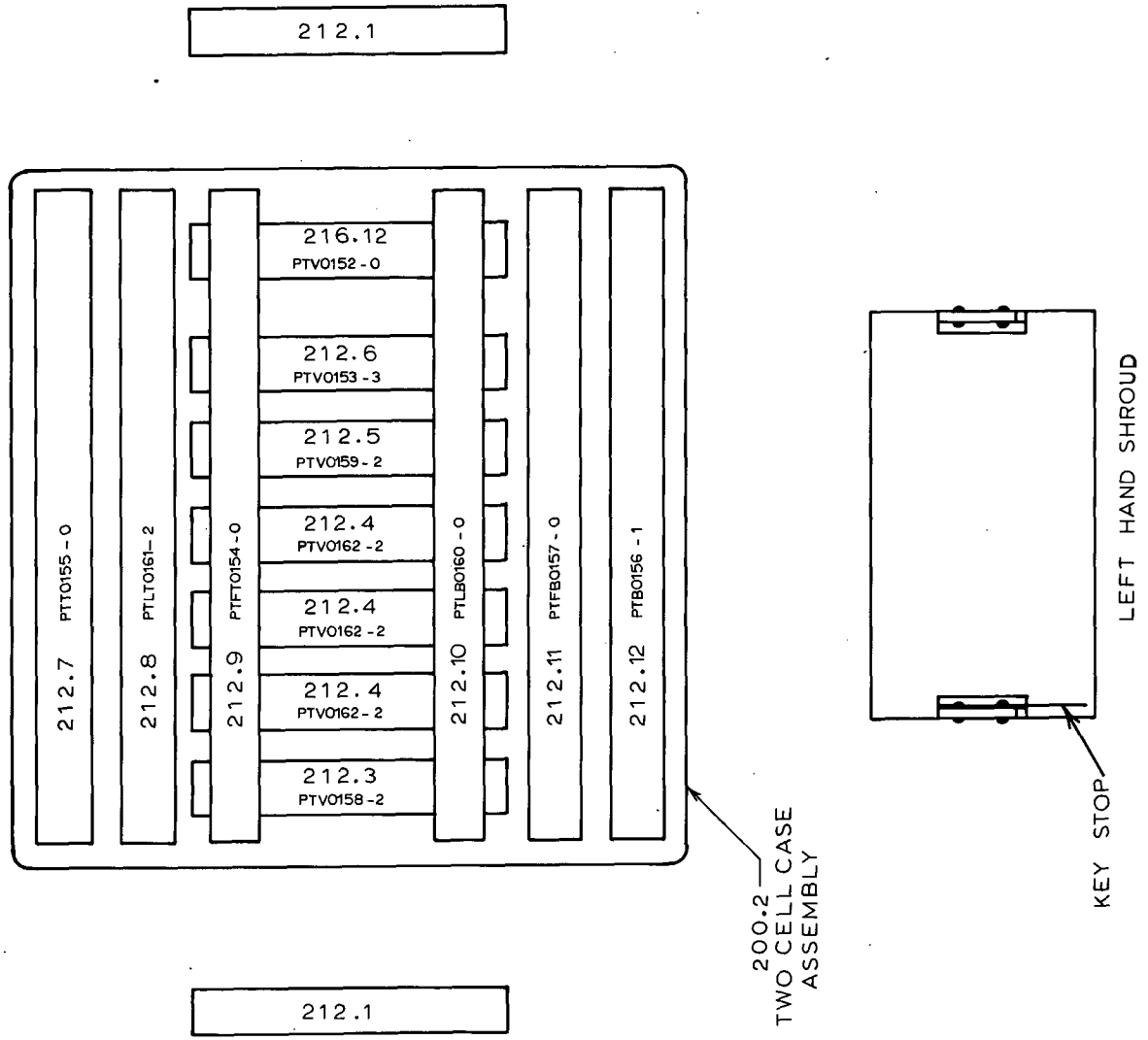


Photo 3



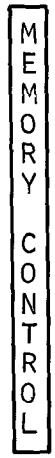
CHANGE NO.	DATE	DESCRIPTION

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

MACROMODULAR PROJECT

TITLE
ASSEMBLY SCHEMATIC & PARTS LIST
GENERAL MEMORY CONTROLLER
PART NO. 212

APPROVED BY	FOR	DATE	ENG. HCL-ADR	DRAWING NO. 212.0D
			DRAWN BY PLL	
			CHECKED a.d.r.	DATE 12-4-72

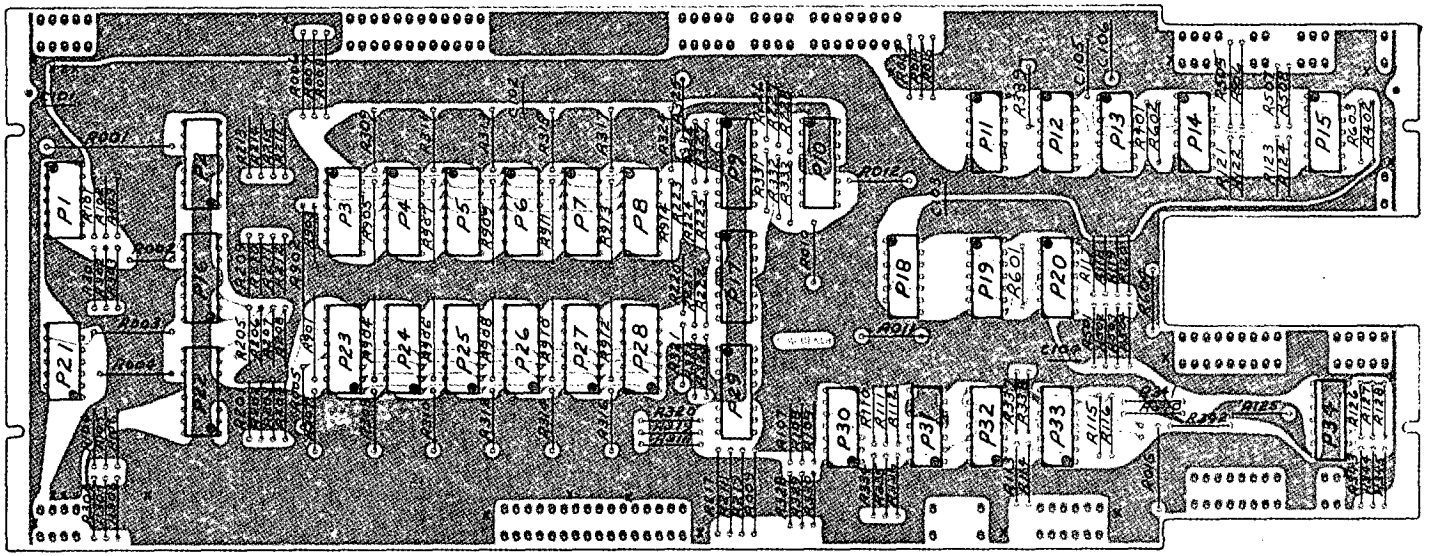


NOT TO SCALE

METALCRAFT "AUTOGRAPH" OR EQUIVALENT:
BLANK SIZE: ¼" x 2" SHEARED WITH SQUARE
CORNERS. BLACK LETTERS, VOGUE BOLD
12 POINT BOLD FACE TYPE CENTERED TOP,
BOTTOM AND SIDES WITH 6 POINT SPACING
ON GREY PMS 428 BACKING, MANUFACTURED
FROM .016 THICK ALUMINUM WITH SOLVENT ACT
ACTIVATED PERMANENT ADHESIVE BACKING.

NOTE: PANTONE MATCHING SYSTEM (PMS)

COMPUTER SYSTEMS LABORATORY WASHINGTON UNIVERSITY ST. LOUIS, MISSOURI			MACROMODULAR PROJECT	
			TITLE: IDENTIFICATION LABEL MEMOPY CONTROL MODULE PART NO. 212.1	
			APPROVED: BY NTK. / FOR PROD. / DATE 8/26	ENG NTK; DRAWN BY MBP; CHECKED [illegible]
				DRAWING NO. 212.1D; DATE 7-25-71
CHANGE NO.	DATE	DESCRIPTION		



NOTES:

1. FEMALE AMP MODU CONNECTORS MUST BE INSTALLED FROM THIS SIDE PRECISELY AS SHOWN ON DRAWING NO. 200.50D2.

2. HOLES MARKED WITH AN "X" ARE FEED-THROUGH HOLES WITH NO COMPONENTS INSTALLED. (26 PLACES).

CHANGE NO.	DATE	DESCRIPTION

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

MACROMODULAR PROJECT

TITLE: COMPONENT IDENTIFICATION
GMC: INTEGRATED CIRCUIT MEMORY
PART NO. 212.3

APPROVED BY	FOR	DATE
Cerm	PROD	5/24/73

ENG. HCL-ADR
DRAWN BY PLL
CHECKED a.d.k.

DRAWING NO. 212.3D1
DATE 5-9-73

INTEGRATED CIRCUIT IDENTIFICATION

TYPE	REQUIRED	LOCATION
M10	4	P19
		P31
		P32
		P33
M30	1	P13
M35	8	P1
		P11
		P14
		P15
		P18
		P20
		P21
		P30
M40	1	P34
M47	1	P12
F9582	7	P2
		P9
		P10
		P16
		P17
		P22
		P29
F95410	12	P3
		P4
		P5
		P6
		P7
		P8
		P23
		P24
		P25
		P26
		P27
		P28

CONNECTORS

TYPE	REQUIRED
Amp modu female No. 85863-4	97

PRINTED CIRCUIT BOARD

PTV0158-2 — 1 required

RESISTORS

TYPE	REQUIRED	LOCATION
R0	16	R001 thru R016
R1	28	R101 thru R128
R2	28	R201 thru R228
R3	45	R301 thru R345
R4	2	R401, R402
R5	8	R501 thru R508
R6	4	R601 thru R604
470 ohms	12	R901
		R904 thru R914
100 ohms	1	R902
150 ohms	1	R903

CAPACITORS

TYPE	REQUIRED	LOCATION
C1XX .01 ufd ceramic disk	6	C101
		C102
		C103
		C104
		C105
		C106

NOTE:

R0 = zero ohms (jumper)
R1 = 1500 ohms ±1% 1/8W film resistor
R2 = 750 ohms ±1% 1/8W film resistor
R3 = 121 ohms ±1% 1/8W film resistor
R4 = 15000 ohms ±5% 1/4W film resistor
R5 = 57.6 ohms ±1% 1/8W film resistor
R6 = 130 ohms ±1% 1/8W film resistor
470 ohms = ±5% 1/4W carbon composition
100 ohms = ±5% 1/4W carbon composition
150 ohms = ±5% 1/4W carbon composition

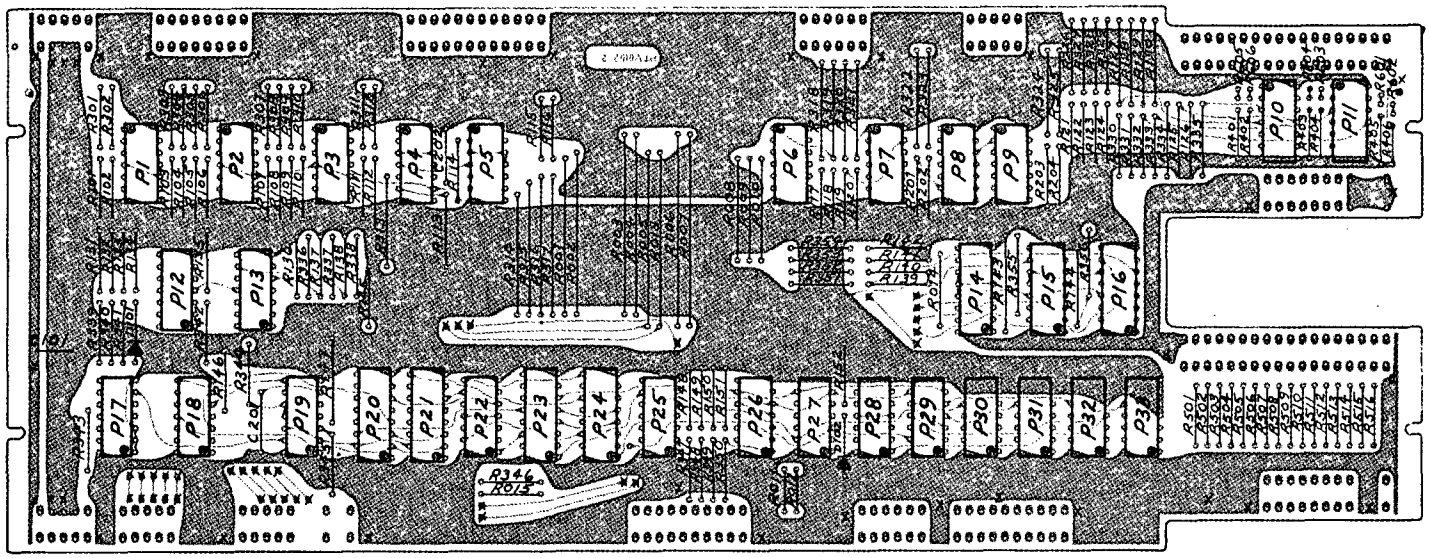
CHANGE NO.	DATE	DESCRIPTION

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

MACROMODULAR PROJECT

TITLE: PARTS LIST
GMC: INTEGRATED CIRCUIT
MEMORY PART NO. 212.3

APPROVED BY	FOR	DATE	ENG.	DRAWING NO.
	PROD	5/21/73	HCL-ADR	212.3D2
			DRAWN BY: CAH	
			CHECKED: ADR.	DATE: 5-16-73



NOTES:

1. FEMALE AMP MODU CONNECTORS MUST BE INSTALLED FROM THIS SIDE PRECISELY AS SHOWN ON DRAWING NO. 200.50D2.
2. HOLES MARKED WITH AN "X" ARE FEED-THROUGH HOLES WITH NO COMPONENTS INSTALLED. (67 PLACES)
3. R601 THROUGH R606 MUST BE INSTALLED IN A VERTICAL POSITION.

CHANGE NO.	DATE	DESCRIPTION

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

MACROMODULAR PROJECT

TITLE: COMPONENT IDENTIFICATION
GMC: DATA BOARD
PART NO. 212.4

APPROVED BY	FOR	DATE
cerw	PROD	5/21/73

ENG. HCL-ADR
DRAWN BY PLL
CHECKED a.o.r.
DRAWING NO. 212.4D1
DATE 5-9-73

INTEGRATED CIRCUIT IDENTIFICATION

TYPE	REQUIRED	LOCATION
M01B	4	P30
		P31
		P32
		P33
M04	1	P17
M06	1	P5
M06B	1	P4
M10	2	P18
		P19
M10A	2	P8
		P9
M16	7	P1
		P2
		P3
		P6
		P7
		P25
		P26
M20	2	P10
		P11
M28	5	P14
		P15
		P16
		P20
		P21
M28A	2	P23
		P24
M30	1	P28
M40	~~4~~ p27	P29
M47	3	P12
		P13
		P22

RESISTORS

TYPE	REQUIRED	LOCATION
R0	15	R001 thru R015
R1	52	R101 thru R152
R2	4	R201 thru R204
R3	56	R301 thru R356
R4	6	R401 thru R406
R5	16	R501 thru R516
R6	6	R601 thru R606

DIODE

TYPE	REQUIRED	LOCATION
GE IN3604	2	D101
		D102

CONNECTOR

TYPE	REQUIRED
Amp modu female #85863-4	135

PRINTED CIRCUIT BOARD

PTV0162-2 — 1 required

CAPACITORS

TYPE	REQUIRED	LOCATION
62 pfd	1	C202
Not required	1	C201
.01 ufd Ceramic disc	1	C101

NOTE:

R0 = zero ohms (jumper)
R1 = 1500 ohms ±1% 1/8W film resistor
R2 = 750 ohms ±1% 1/8W film resistor
R3 = 121 ohms ±1% 1/8W film resistor
R4 = 15000 ohms ±5% 1/4W carbon composition
R5 = 57.6 ohms ±1% 1/8W film resistor
R6 = 130 ohms ±1% 1/8W film resistor

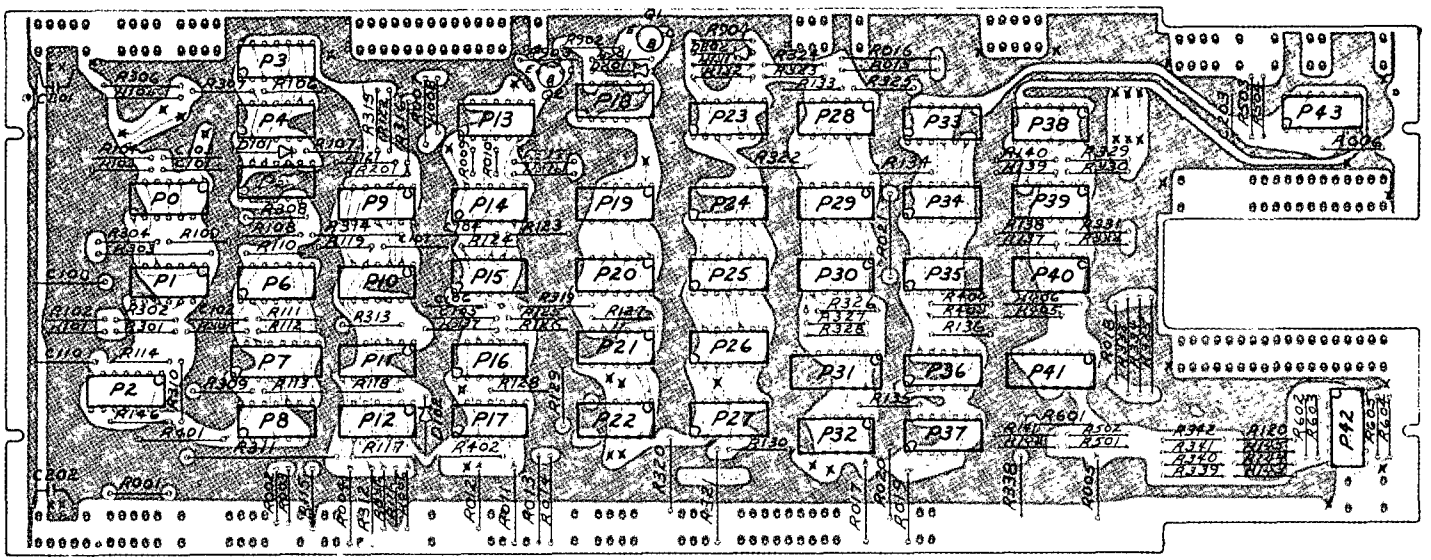
CHANGE NO.	DATE	DESCRIPTION

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

MACROMODULAR PROJECT

TITLE: PARTS LIST
GMC: DATA BOARD
PART NO. 212.4

APPROVED BY	APPROVED FOR	APPROVED DATE	ENG.	DRAWING NO.
	PROD	5/24/73	HCL-ADR	212.4 D2
			DRAWN BY CAH	
			CHECKED adr.	DATE 5-16-73



NOTES:

1. FEMALE AMP MODU CONNECTORS MUST BE INSTALLED FROM THIS SIDE PRECISELY AS SHOWN ON DRAWING NO. 200.50D2.

2. HOLES MARKED WITH AN "X" ARE FEED-THROUGH HOLES WITH NO COMPONENTS INSTALLED. (42 PLACES).

CHANGE NO.	DATE	DESCRIPTION

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

MACROMODULAR PROJECT

TITLE: COMPONENT IDENTIFICATION
GMC: CONTROL BOARD NO. 2
PART NO. 212.5

APPROVED BY	FOR	DATE
clm	PROD	5/21/73

ENG. HCL-ADR
DRAWN BY PLL
CHECKED adr.
DRAWING NO. 212.5D1
DATE 5-9-73

INTEGRATED CIRCUITS

TYPE	REQUIRED	LOCATION
M01	7	P19 P24 P30 P34 P35 P39 P40
M02	1	P29
M03	1	P15
M04	9	P5 P8 P14 P20 P23 P25 P26 P27 P28
M06	1	P13
M10	8	P1 P3 P18 P21 P22 P32 P33 P36
M11	5	P2 P6 P9 P16 P0
M16	1	P4
M20	1	P42
M28	2	P31 P41
M07	1	P10

INTEGRATED CIRCUITS (cont.)

TYPE	REQUIRED	LOCATION
M30	1	P11
M31	1	P12
M32B	1	P7
M35	2	P37 P43
M47	2	P17 P38

DIODES

TYPE	REQUIRED	LOCATION
IN3604	2	D101 D102
HP82-2900	2	D201 D202

CONNECTORS

TYPE	REQUIRED
Amp modu female #85863-4	122

RESISTORS

TYPE	REQUIRED	LOCATION
R0	21	R001 thru R021
R1	46	R101 thru R146
R2	1	R201
R3	42	R301 thru R342
R4	6	R601 thru R606
R5	4	R501 thru R504
R6	6	R601 thru R606
510 ohms	2	R901, R904
5.1K ohms	2	R902, R903

TRANSISTORS

TYPE	REQUIRED	LOCATION
MPS3640	2	Q1 Q2

CAPACITORS

TYPE	REQUIRED	LOCATION
250 pfd	1	C101
240 pfd	1	C102
100 pfd	1	C103
300 pfd	1	C104
120 pfd	1	C105
39 pfd	1	C108
180 pfd	1	C110
Not required	2	C106 C107
.01 ufd ceramic disc	3	C201 C202 C203

PRINTED CIRCUIT BOARD

PTV0159-2 — 1 required

NOTE:

R0 = zero ohms (jumper)
R1 = 1500 ohms ±1% 1/8W film resistor
R2 = 750 ohms ±1% 1/8W film resistor
R3 = 121 ohms ±1% 1/8W film resistor
R4 = 15000 ohms ±5% 1/4W carbon composition
R5 = 57.6 ohms ±1% 1/8W film resistor
R6 = 130 ohms ±1% 1/8W film resistor
R901, R904 = 510 ohms carbon composition 5%
R902, R903 = 5.1K ohms carbon composition 5%

CHANGE NO.	DATE	DESCRIPTION

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

MACROMODULAR PROJECT

TITLE
PARTS LIST
GMC: CONTROL BOARD NO. 2
PART NO. 212.5

APPROVED BY	APPROVED FOR	APPROVED DATE	ENG.	DRAWING NO.
	PROD		HCL-ADR	212.5D2
			DRAWN BY CAH	
			CHECKED a.d.r.	DATE 5-16-73

Test Procedure

General Memory Controller Board #212.5

This board contains six critical delays whose proper value must be checked on each board prior to assembly into a Memory Controller.

If the delay value is excessively large, the operation of the module will be needlessly slowed down. If the delay value is excessively short, the module may perform incorrectly under certain conditions.

Procedure

Test 1:

Tie pins BL2 and T45 high. Apply a square wave signal with a period of 200 nanoseconds or greater to pin T44. The signal should have a rise and fall time not greater than 10 nanoseconds. Remove high on BL2 and make the following measurements:

1. A minimum 35 nanosecond positive pulse with a maximum of 40 nanoseconds on pin T67. The value of Capacitor C110 must be increased should the pulse be too short or decreased if too wide.

2. Minimum delay from a transition on pin T30 until pin 11 of package 6 goes high is 26 nanoseconds. The delay should be observed for both positive and negative going transitions of T30 and is measured from midpoint to midpoint. If the smaller of the two delays is less than 26 nanoseconds the value of capacitor C102 should be increased.

3. A minimum 15 nanosecond positive pulse and a maximum of 20 nanoseconds on pin B86. The value of capacitor C103 must be increased should the pulse be too short or decreased if too wide.

Test 2: Tie pins BL2, BFP16, T47, and T44 high. Apply a square wave signal with a period of 200 nanoseconds or greater to pin B85. The signal should have a rise and fall time not greater than 10 nanoseconds. Observe the waveform on pin B85 with channel one of a 454 oscilloscope. Observe the waveform on pin 2 of package 14 with the second channel. The delay between pin B85 going high and pin 2 of package 14 going low, measured from midpoint to midpoint should be a minimum of 48 nanoseconds. Should the delay be too short the value of capacitor C101 should be increased.

Test 3:

Tie pins BL2, T47, T45, T44, and T55 high. Apply a square wave signal with a period of 200 nanoseconds or greater to pin B85. The signal

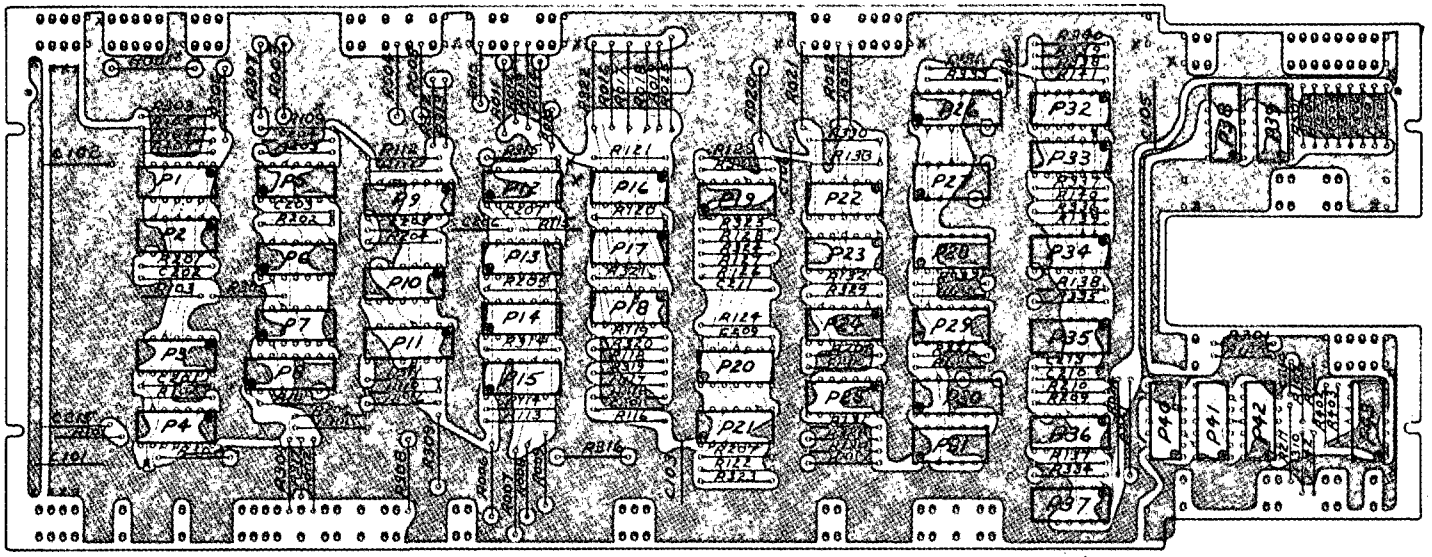
should have a rise and fall time not greater than 10 nanoseconds. Make the following measurements:

1. A minimum 49 nanosecond positive pulse at pin B55 measured from midpoint to midpoint. Should the pulse be too short increase the value of C105.

2. A minimum delay of 24 nanoseconds from pin B55 going low until pin B84 goes high measured from midpoint to midpoint. Should the delay be too short increase the value of C105.

The final capacitor values and the measured delays for each board should be recorded on the test sheet provided for that board, along with the serial number of the board.

CHG.	E.C.O.	DATE	APPR.
1	0307	2-15-74	ADR



NOTES:

1. FEMALE AMP MODU CONNECTORS MUST BE INSTALLED FROM THIS SIDE PRECISELY AS SHOWN ON DRAWING NO. 200.50D2.

2. HOLES MARKED WITH AN "X" ARE FEED-THROUGH HOLES WITH NO COMPONENTS INSTALLED. (27 PLACES).

CHANGE NO.	DATE	DESCRIPTION

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

MACROMODULAR PROJECT

TITLE: COMPONENT IDENTIFICATION
GMC: CONTROL BOARD NO. 1
PART NO. 212.6

APPROVED BY	FOR	DATE
Cem	PROD	5/21/73

ENG. HCL-ADR
DRAWN BY PLL
CHECKED ADR

DRAWING NO. 212.6D1
DATE 5-9-73

INTEGRATED CIRCUITS

TYPE	REQUIRED	LOCATION
M01	3	P34
		P38
		P39
M01B	3	P14
		P35
		P37
M03	1	P13
M04	6	P12
		P15
		P17
		P18
		P23
		P31
M06	1	P21
M07	2	P19
		P22
M10	9	P5
		P6
		P10
		P16
		P24
		P27
		P33
		P36
		P40
M11	2	P4
		P32
M12	1	P20
M16	3	P3
		P25
		P28
M20	1	P43
M30	3	P2
		P7
		P41
M32B	5	P8
		P9
		P11
		P26
		P30
M35	2	P29
		P42
M47	1	P1

RESISTORS

TYPE	REQUIRED	LOCATION
R0	26	R001 thru R026
R1	41	R101 thru R141
R2	11	R201 thru R211
R3	42	R301 thru R342
R4	3	R401 thru R403
R5	8	R501 thru R508

CONNECTOR REQUIREMENT

TYPE	REQUIRED
Amp Modu Female #85863-4	95

PRINTED CIRCUIT BOARD

PTV0153-4 — 1 Required

CAPACITORS

TYPE	REQUIRED	LOCATION
.01 ufd ceramic disc	6	C101 thru C106
220 pfd	1	C201
30 pfd	2	C204
		C205
300 pfd	1	C206
130 pfd	1	C209
33 pfd	2	C210
		C213
12 pfd	1	C212
250 pfd	1	C211
18 pfd	1	C214
200 pfd	1	C215
Not required	4	C202
		C203
		C207
		C208

NOTE:

R0 = zero ohms (jumper)
R1 = 1500 ohms ±1% 1/8W film resistor
R2 = 750 ohms ±1% 1/8W film resistor
R3 = 121 ohms ±1% 1/8W film resistor
R4 = 15000 ohms ±5% 1/4W carbon composition
R5 = 57.6 ohms ±1% 1/8W film resistor

CHANGE NO.	DATE	DESCRIPTION

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

MACROMODULAR PROJECT

TITLE: PARTS LIST
GMC: CONTROL BOARD NO. 1
PART NO. 212.6

APPROVED BY	APPROVED FOR	APPROVED DATE	ENG.	DRAWING NO.
	PROD	5/16/73	HCL-ADR	212.6 D 2
			DRAWN BY CAH	
			CHECKED a.d.r.	DATE 5-16-73

Test Procedure

General Memory Controller Board #212.6

This board contains ten critical delays whose proper value must be checked on each board prior to assembly into a Controller Module.

If the delay value is excessively large, the operation of the module will be needlessly slowed down. If the delay value is excessively short, the module may perform incorrectly under certain conditions.

Procedure

Test 1:

Tie pins B68 and TL2 high. Apply a square wave signal with a period of 200 nanoseconds or greater to pin B79. The signal should have a rise and fall time not greater than 10 nanoseconds. Observe the waveform at pin B79 with channel one of a 454 oscilloscope. Remove high on TL2, and observe the waveform at pin B65 with the second channel. The minimum delay between the two waveforms, measured from midpoint of each transition should be 57 nanoseconds. The waveforms should appear as in figure 1 and should be observed for both T_1 and T_2. If the smaller of the two delays is less than 57 nanoseconds the value of capacitors C204 and C205 should be increased. If the value of the smaller of the delays is greater than 70 nanoseconds the value of C204 and C205 should be reduced.

Test 2:

Tie pins B88, TL2, B68, B86, TL10 and B87 high. Apply a square wave signal with a period of 200 nanoseconds or greater to pin B61. The signal should have a rise and fall time not greater than 10 nanoseconds. Remove high on TL2 and make the following measurements. Measurements are made from midpoint to midpoint.

1. A minimum of 45 nanoseconds and a maximum of 50 nanoseconds negative pulse at T77. The value of Capacitor C206 should be reduced to decrease pulse width.

2. A minimum of 45 nanoseconds and a maximum of 55 nanoseconds negative pulse at pin T76. The value of capacitor C211 should be reduced to decrease pulse width.

3. Observe the waveform at pin B61 with channel one. Observe the waveform at pin T77 with the second channel. The minimum delay from pin B61 going positive to pin T77 going positive should be 80 nanoseconds. The waveforms should appear as in figure 2. If the delay is less than 80 nanoseconds the value of capacitor C202 and C203 should be increased.

CHG.	E.C.O.	DATE	APPR
1	0307	2-25-74	ADR

4. A minimum of 21 nanoseconds from pin T77 high to pin B67 high. The value of Capacitor C209 should be increased if the delay is less than 21 nanoseconds.

Test 3:

Tie pins T45, TL2, TFP17 high and pins TFP3, TFP2, to -5.2 volts. Apply a differential square wave with a period of 200 nanoseconds to pins TFP4 and TFP5. The signal should have a rise and fall time not greater than 10 nanoseconds. The following measurements are made from midpoint to midpoint.

1. A minimum of 47 nanoseconds and a maximum of 51 nanoseconds delay from pin T28 going low to pin B55 going low. Capacitor C201 must be increased in value should the delay be too short, or decreased should the delay be too long.

2. A minimum of 12 nanoseconds and maximum of 24 nanoseconds high pulse pin TL18. The pulse should be observed for both positive and negative going transitions of the input clock. The value of capacitor C214 should be reduced if the pulse is too long, or increase if the pulse is too short.

3. A minimum of 34 nanoseconds delay from pin TL18 going low until pins B56 goes high. See figure 3. The delay should be observed for both positive and negative going transitions of the clock. The value of capacitors C210 and C213 should be increased if the delay is too short.

4. A minimum of 37 nanoseconds delay from pin TL18 going low until TL5 transitions. The signal on TL5 must be observed for both positive and negative transitions, and T_1 and T_2 must be a minimum of 37 nanoseconds. See figure 4. The value of capacitors C10 and C213 must be increased should the delay be too short.

Test 4:

Tie pins T82, BFB16, and TL2 high. Apply a square wave signal with a period of 200 nanoseconds or greater to pin B84. The signal should have a rise and fall time not greater than 10 nanoseconds. Observe the waveform at pin B84 with channel one of a 454 oscilloscope. Remove high on TL2 and observe the waveform at pin 8 of package 24 with channel 2. A minimum 12 nanosecond pulse will occur for each negative transition of clock. The value of capacitor C212 must be increased should the delay be too short.

The final capacitor values and the measured delays for each board should be recorded on the test sheet provided for that board, along with the serial number of the board.

TUNING WAVEFORMS

GENERAL MEMORY CONTROLLER BOARD #212.6

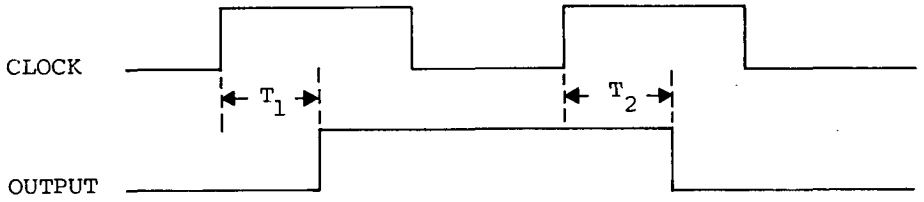


Figure 1

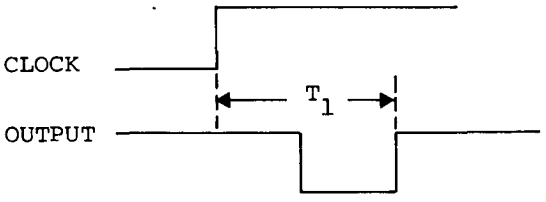


Figure 2

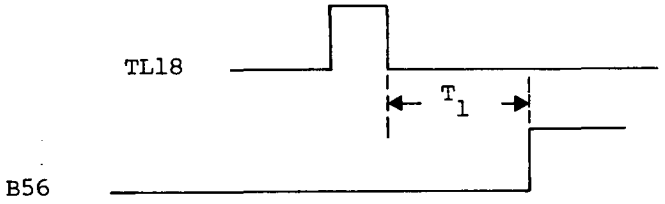


Figure 3

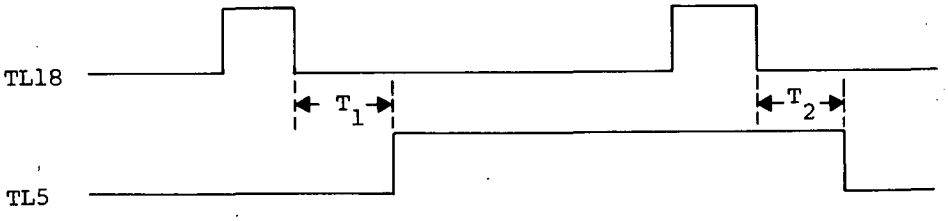
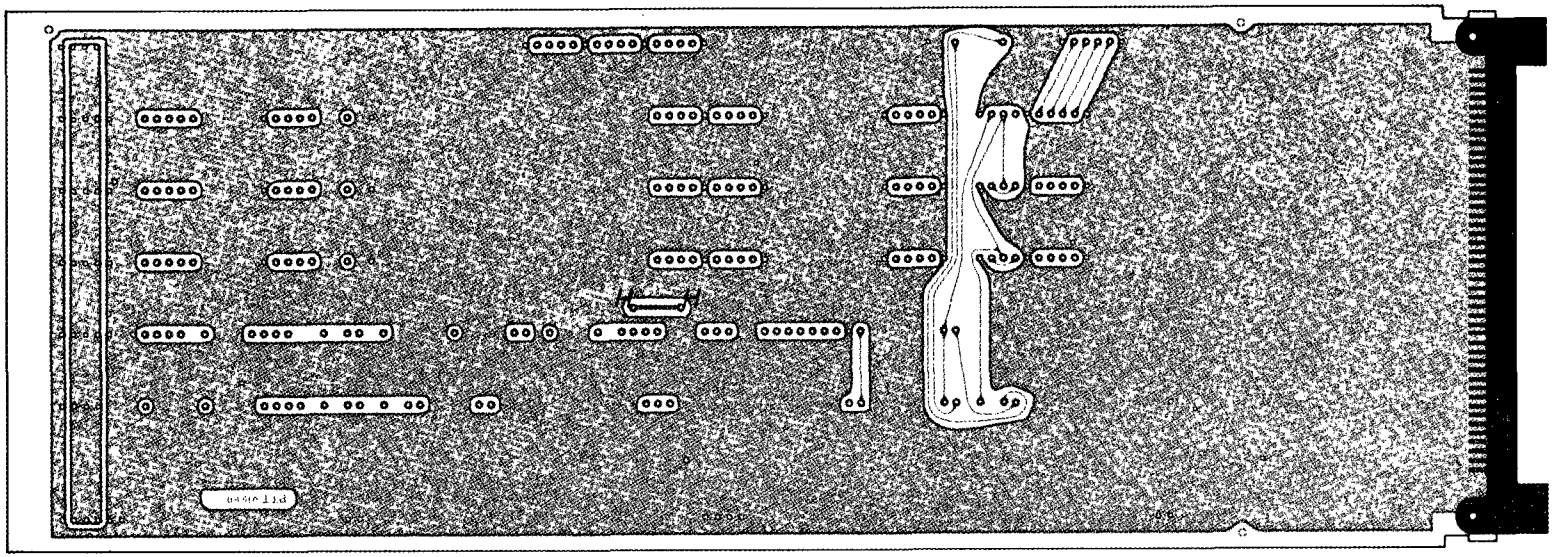


Figure 4



NOTES:

1. HOLES MARKED WITH AN "H" ARE FEED-THROUGH HOLES WITH NO COMPONENTS INSTALLED. (2 PLACES)

2. MALE AMP MODU CONNECTORS MUST BE INSTALLED IN ALL OTHER LOCATIONS PRECISELY AS SHOWN IN DRAWINGS 200.50D2 AND 200.50D3 (242 PLACES)

CHANGE NO.	DATE	DESCRIPTION

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

MACROMODULAR PROJECT

TITLE: COMPONENT IDENTIFICATION
GMC: TOP MOTHERBOARD
PART NO. 212.7

APPROVED BY	FOR	DATE
Cum	PROD	5/21/73

ENG. HCL/ADR
DRAWN BY CAH
CHECKED ADR

DRAWING NO. 212.7D1
DATE 2-27-73

CONNECTORS

Male Amp Modu No. 85931-5

242 Required

Amp No. 1-202 845-5

1 Required

PRINTED CIRCUIT BOARD

PTT0155-0 1 Required

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

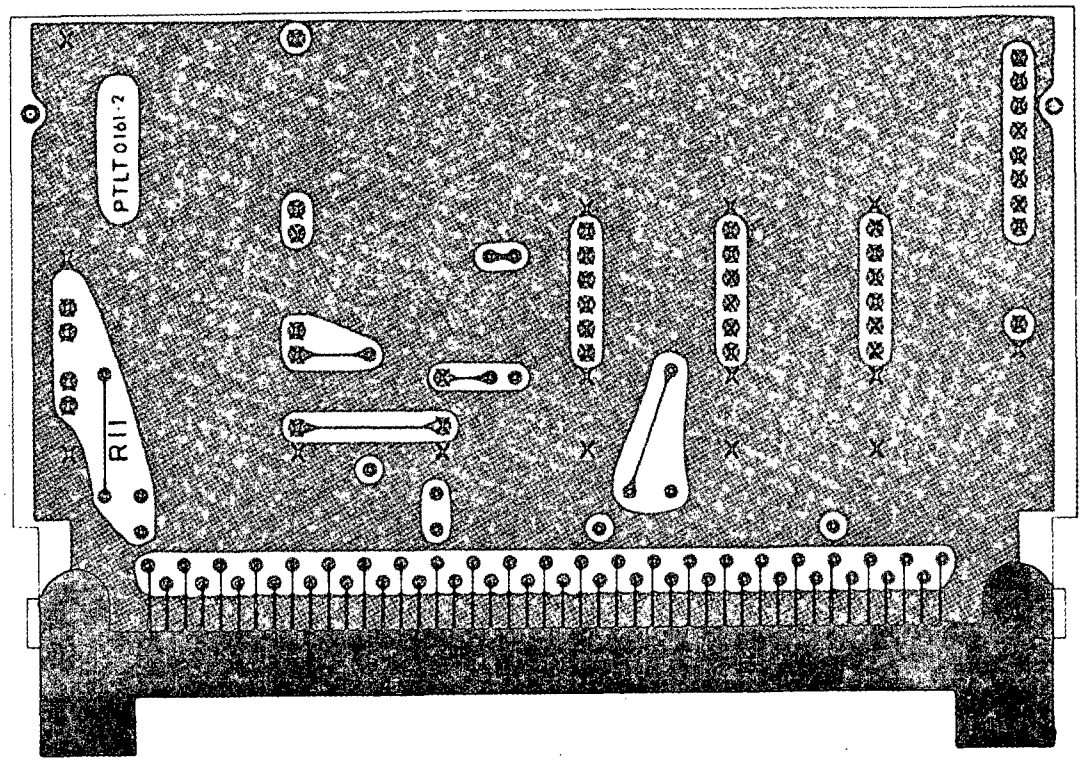
MACROMODULAR PROJECT

TITLE: Parts List
GMC: Top Motherboard
Part No. 212.7

CHANGE NO.	DATE	DESCRIPTION

APPROVED BY	FOR	DATE
	PROD	2-27-73

ENG. HCL/ADR
DRAWN BY CAH
CHECKED A.D.R.
DRAWING NO. 212.7D2
DATE 2-27-73



NOTES:

1. MALE AMP MODU PINS MUST BE INSTALLED FROM THIS SIDE IN ALL LOCATIONS MARKED "X" PRECISELY AS SHOWN IN DRAWINGS 200.50D2 AND 200.50D3. (54 PLACES)

2. SEE DRAWING NO. 200.50D28 FOR CONNECTOR MOUNTING ORIENTATION.

CHANGE NO.	DATE	DESCRIPTION

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

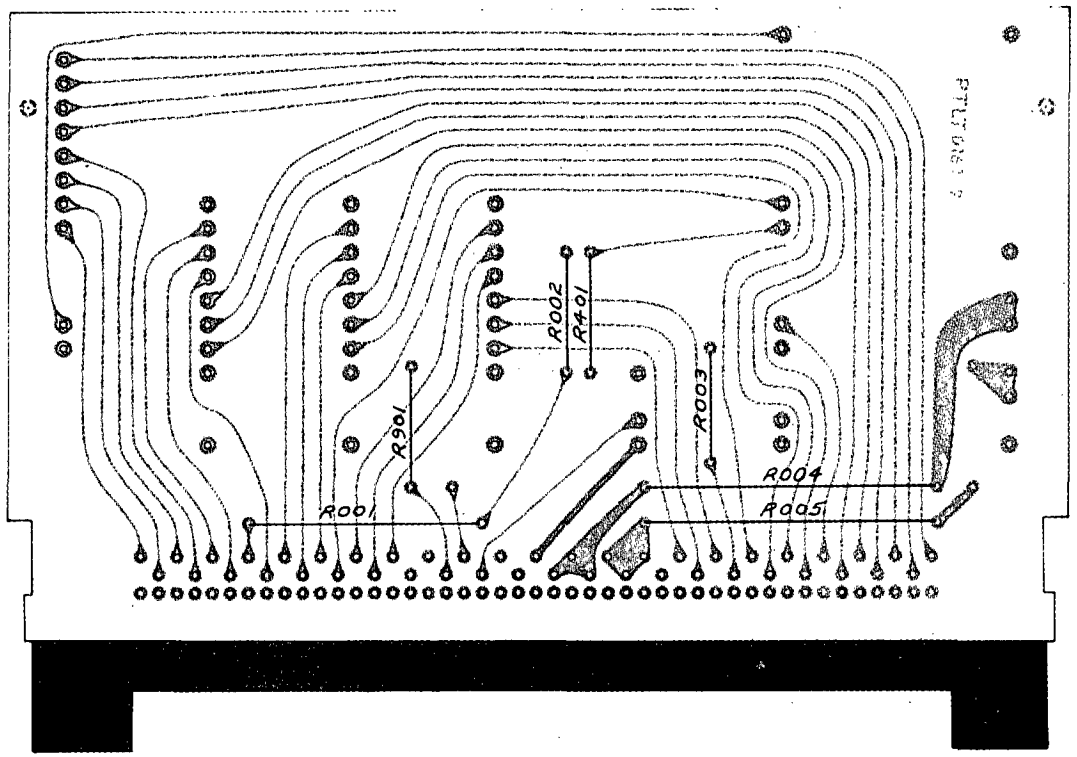
MACROMODULAR PROJECT

TITLE: COMPONENT IDENTIFICATION
GMC: TOP LATERAL MOTHERBOARD COMP. SIDE
PART NO. 212.8

APPROVED BY	FOR	DATE
Chm	PROD	5/21/73

ENG. HCL/ADR
DRAWN BY PLL
CHECKED a.d.r.

DRAWING NO. 212.8D1
DATE 5-17-73



CHANGE NO.	DATE	DESCRIPTION

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

MACROMODULAR PROJECT

TITLE COMPONENT IDENTIFICATION
GMC: TOP LATERAL MOTHERBOARD
SIGNAL SIDE PART NO. 212.8

APPROVED BY	FOR	DATE
	PROD	

ENG. HCL-ADR
DRAWN BY PLL
CHECKED adl

DRAWING NO. 212.8D2
DATE 5-17-73

RESISTORS

TYPE	REQUIRED	LOCATION
Zero ohms (jumper)	5	R001 thru R005
15000 ohms ±5% 1/4W carbon	1	R401
39000 ohms ±5% 1/4W carbon	1	R901

FUSE

R11 = Bussman GFA 2 amp

CONNECTORS

Male amp modu No. 85931-5	54 required
Amp No. 583464-1	1 required

PRINTED CIRCUIT BOARD

PTLT0161-2	1 required

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

MACROMODULAR PROJECT

TITLE: Parts List
GMC: Top Lateral Motherboard
Part No. 212.8

APPROVED BY	APPROVED FOR	APPROVED DATE	ENG	DRAWING NO.
COLA	PROD	[illegible]	ADR	212.8D3
			DRAWN BY: CAH	
			CHECKED: A.D.R.	DATE: 5-17-73

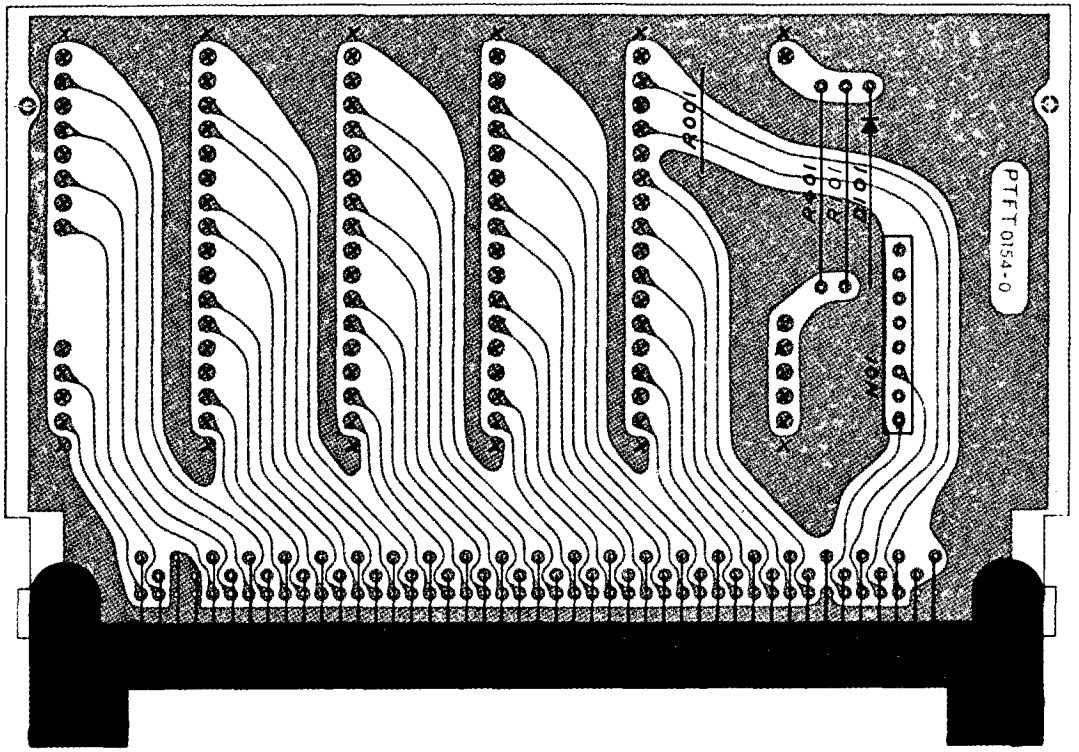
CHANGE NO.	DATE	DESCRIPTION

NOTE 1:

Male amp modu pins must be installed from this side in all locations marked "X" precisely as shown in drawings 200.50D2 and 200.50D3. (94 pins)

NOTE 2:

See drawing number 200.50D29 for connector mounting orientation



CHANGE NO.	DATE	DESCRIPTION

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

MACROMODULAR PROJECT

TITLE: COMPONENT IDENTIFICATION
GMC TOP FACEPLATE MOTHER BOARD
PART NO. 212.9

APPROVED BY	FOR	DATE
Cam	PROD	6/21/73

ENG. HCL-ADR
DRAWN BY PLL
CHECKED A.D.R

DRAWING NO. 212.9D1
DATE 2-27-73

RESISTORS

TYPE	REQUIRED	LOCATION
Zero ohms (Jumper)	1	R001
R1 (1500 ohms ±1% 1/8W film)	1	R101
R4 (15K ohms ±5% 1/4W carbon	1	R401
LTN-2	1	N01

DIODES

TYPE	REQUIRED	LOCATION
IN3604	1	D101

CONNECTORS

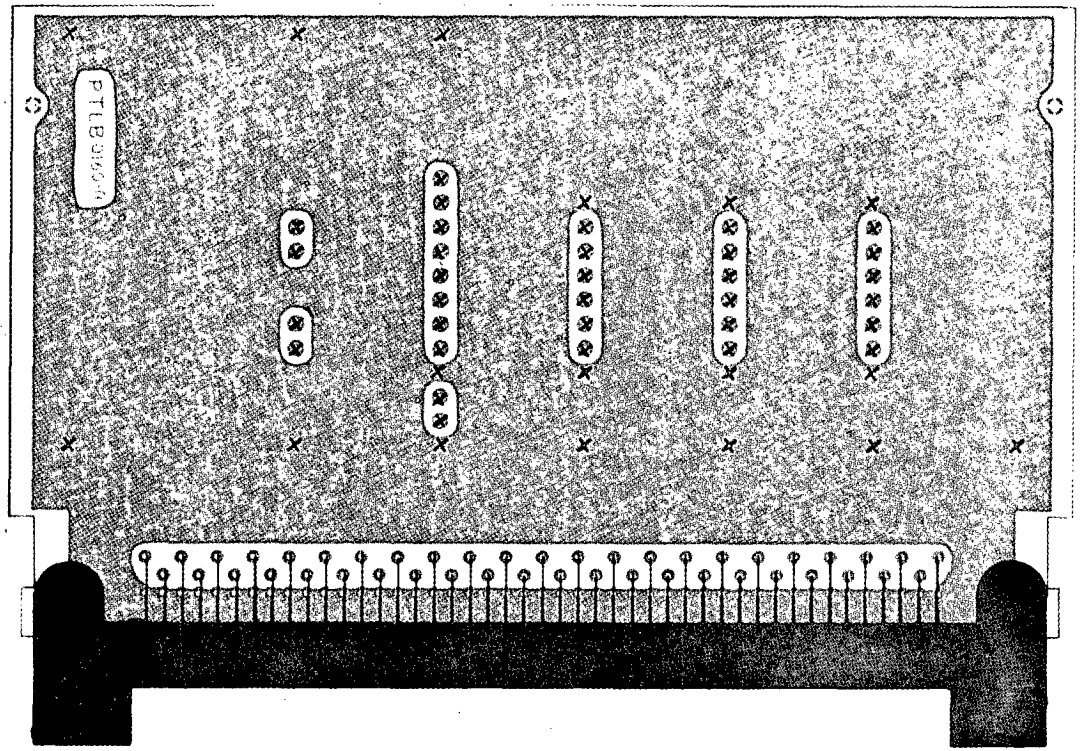
Male amp modu No. 85931-5
91 required

Amp No. 583464-1
1 required

PRINTED CIRCUIT BOARD

PTFT0154-0
1 required

COMPUTER SYSTEMS LABORATORY WASHINGTON UNIVERSITY ST. LOUIS, MISSOURI			MACROMODULAR PROJECT		
			TITLE: Parts List GMC: Top Faceplate Motherboard Part No. 212.9		
			APPROVED BY	FOR	DATE
				PROD	
CHANGE NO.	DATE	DESCRIPTION			
			ENG: ADR/HCL	DRAWING NO.: 212.9D2	
			DRAWN BY: CAH		
			CHECKED: ADR	DATE: 2-27-73	



NOTE 1.

Male amp modu pins must be installed from this side in all locations marked "X" precisely as shown in drawings 200.50D2 and 200.50D3 (49 pins)

NOTE 2.

See drawing No. 200.50D28 for connector mounting orientation.

CHANGE NO	DATE	DESCRIPTION

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

MACROMODULAR PROJECT

TITLE: COMPONENT IDENTIFICATION
GMC: BOTTOM LATERAL MOTHER BOARD
PART NO. 212.10

APPROVED BY	FOR	DATE
[illegible]	PROD	5/14/73

ENG. HCL-ADR
DRAWN BY PLL
CHECKED A.D.R.
DRAWING NO. 212.10D1
DATE 2-27-73

CONNECTORS

Male amp modu No. 85931-5
49 Required

Amp No. 583 464-1
1 Required

PRINTED CIRCUIT BOARD

PTLB0160-0
1 Required

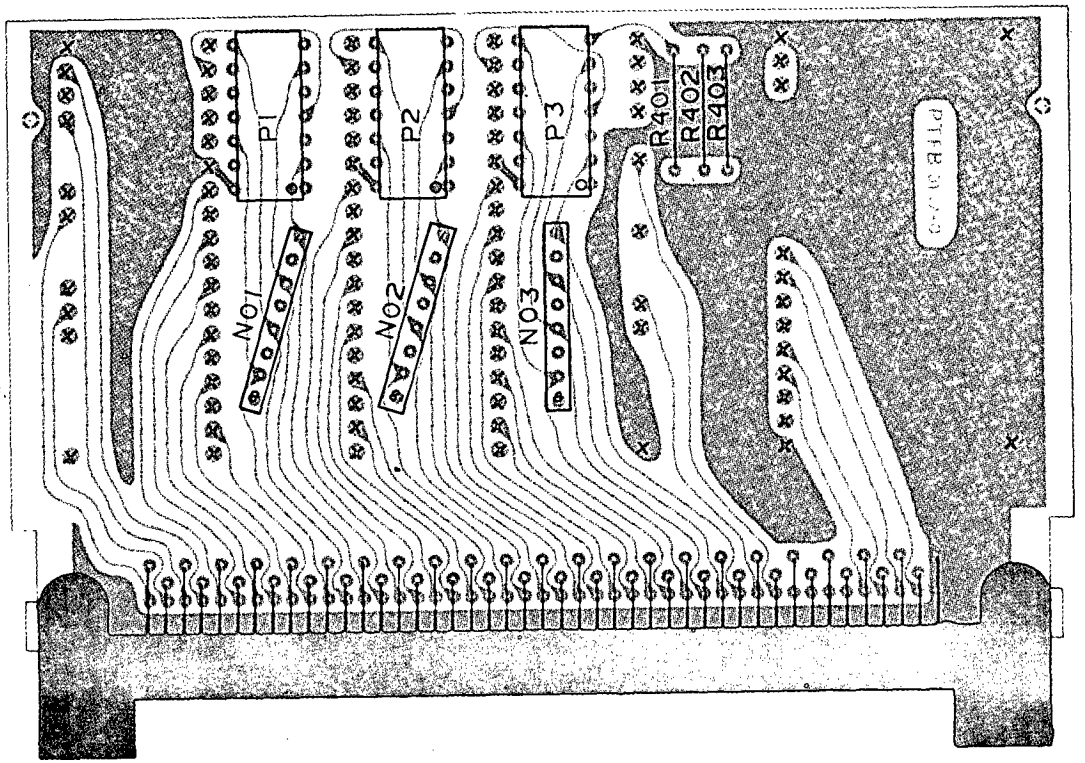
COMPUTER SYSTEMS LABORATORY WASHINGTON UNIVERSITY ST. LOUIS, MISSOURI	**MACROMODULAR PROJECT**	
	TITLE: Parts List GMC: Bottom Lateral Motherboard Part No. 212.10	
	APPROVED BY: [illegible] FOR: PROD DATE: 2[illegible]/73	ENG: HCL/ADR DRAWN BY: CAH CHECKED: M.D.R.
		DRAWING NO.: 212.10D2 DATE: 2-27-73

CHANGE NO.	DATE	DESCRIPTION

NOTES:

1. MALE AMP MODU PINS MUST BE INSTALLED FROM THIS SIDE IN ALL LOCATIONS MARKED "X" PRECISELY AS SHOWN IN DRAWINGS 200.50D2 AND 200.50D3 (87 PINS)

2. SEE DRAWING 200.50D29 FOR CONNECTOR MOUNTING ORIENTATION.



CHANGE NO.	DATE	DESCRIPTION

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

MACROMODULAR PROJECT

TITLE: COMPONENT IDENTIFICATION
GMC: BOTTOM FACEPLATE MOTHERBOARD
PART NO. 212.11

APPROVED BY	FOR	DATE
Cam	PROD	8/21/73

ENG. HCL-ADR
DRAWN BY CAH
CHECKED a.d.k.
DRAWING NO. 212.11D1
DATE 5-16-73

INTEGRATED CIRCUITS

TYPE	REQUIRED	LOCATION
M20	3	P1 P2 P3

RESISTORS

TYPE	REQUIRED	LOCATION
LTN-2	3	NO1 NO2 NO3
15000 ohms ±5% 1/4W carbon comp.	3	R401 R402 R403

CONNECTORS

Male amp modu No. 85931-5 87 required
Amp No. 583464-1 1 required

PRINTED CIRCUIT BOARD

PTFB0157-0 1 required

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

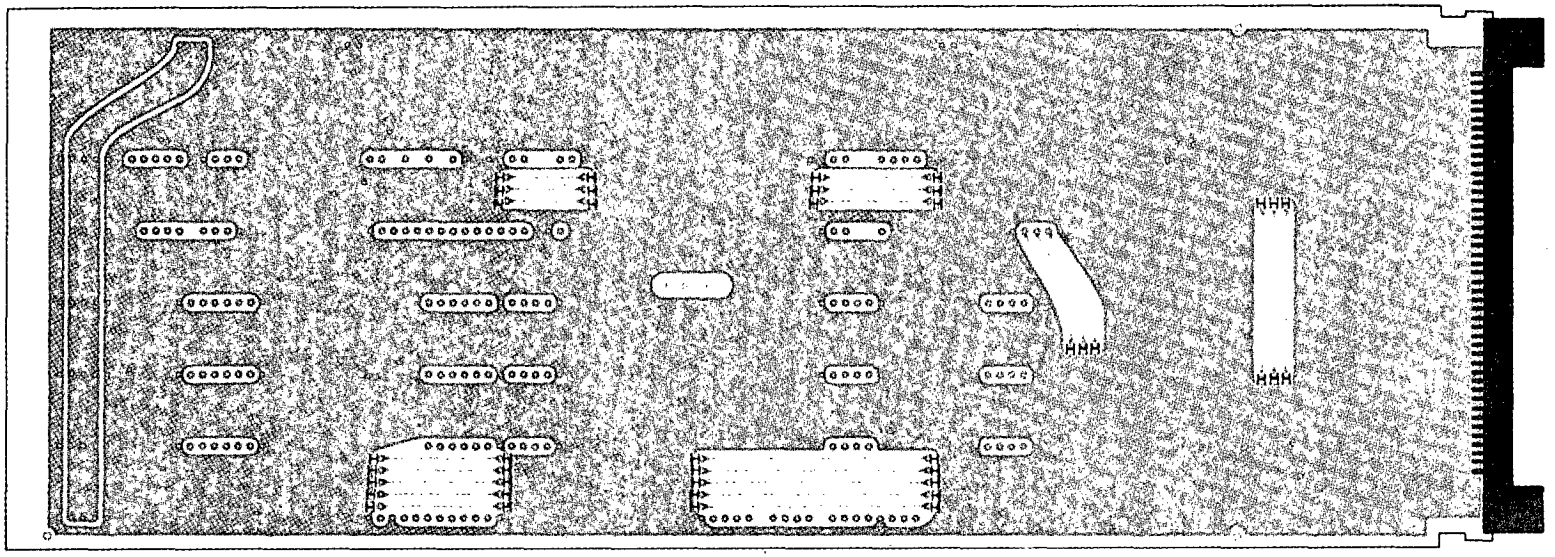
MACROMODULAR PROJECT

TITLE: Parts List
GMC: Top Faceplate motherboard
Part No. 212.11

APPROVED BY	FOR	DATE
	PROD	

ENG: ADR
DRAWN BY: CAH
CHECKED: a.D.R.
DRAWING NO.: 212.11D2
DATE: 5-17-73

CHANGE NO.	DATE	DESCRIPTION



NOTES:

1. HOLES MARKED WITH AN "H" ARE FEED-THROUGH HOLES WITH NO COMPONENTS INSTALLED. (41 PLACES)
2. MALE AMP MODU CONNECTORS MUST BE INSTALLED IN ALL OTHER LOCATIONS PRECISELY AS SHOWN IN DRAWINGS 200.59D2 AND 200.50D3. (227 PLACES)

CHANGE NO.	DATE	DESCRIPTION

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

MACROMODULAR PROJECT

TITLE: COMPONENT IDENTIFICATION
GMC: BOTTOM MOTHERBOARD
PART NO. 212.12

APPROVED BY	FOR	DATE
	PROD	5/20/73

ENG. HCL/ADR
DRAWN BY PLL
CHECKED ADR.
DRAWING NO. 212.12D1
DATE 2-27-73

CONNECTORS

Male amp modu No. 85931-5

227 Required

Amp No. 1-202 845-5

1 Required

PRINTED CIRCUIT BOARD

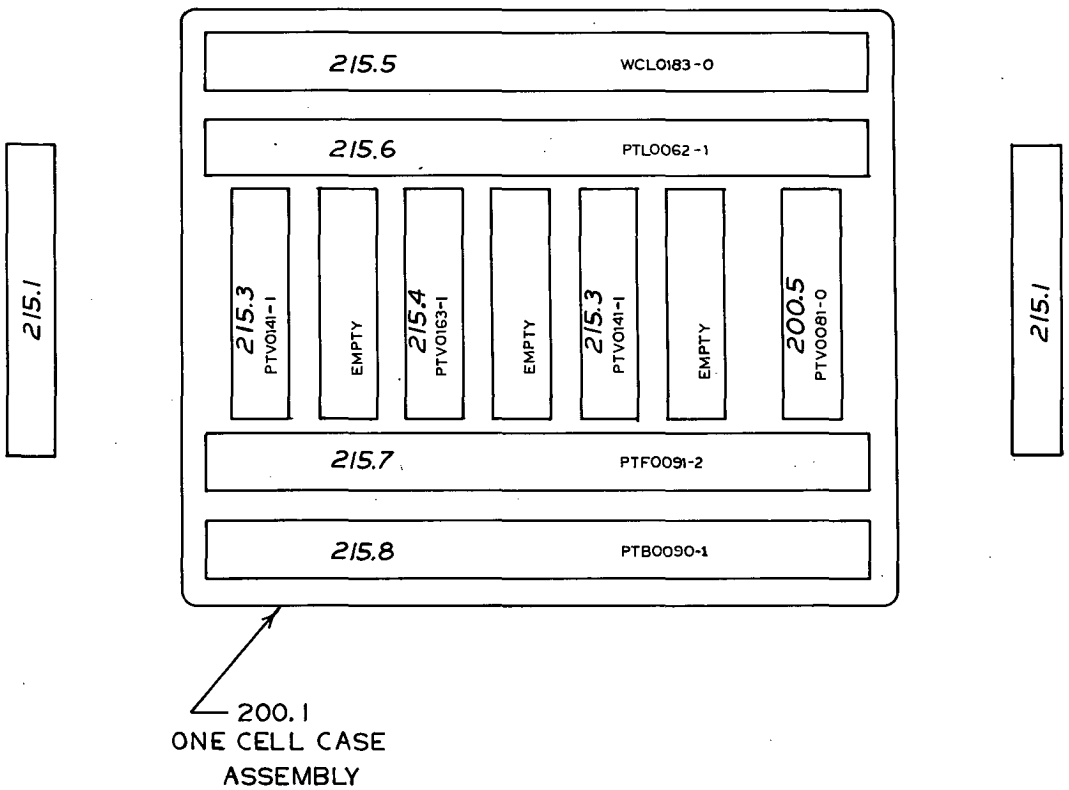
PTB0156-1

1 Required

COMPUTER SYSTEMS LABORATORY WASHINGTON UNIVERSITY ST. LOUIS, MISSOURI	MACROMODULAR PROJECT
	TITLE Parts List GMG: Bottom Motherboard Part No. 212.12

APPROVED BY	FOR	DATE	ENG	DRAWING NO.
CO...	PROD	11 May 73	HCL/ADR	212.12D2
			DRAWN BY CAH	
			CHECKED A.D.L.	DATE 2-27-73

CHANGE NO.	DATE	DESCRIPTION



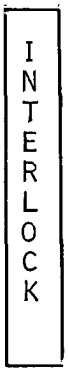
CHANGE NO.	DATE	

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

MACROMODULAR PROJECT

TITLE ASSEMBLY SCHEMATIC & PARTS LIST
INTERLOCK MODULE
PART NO. 215

APPROVED			ENG	DRAWING NO.
BY	FOR	DATE	MLP	215.0D
	PROD	4-23-73	DRAWN BY PLL	
			CHECKED NTK	DATE 3-28-70



METALCRAFT "AUTOGRAPH" OR EQUIVALENT"
BLANK SIZE: ¼" X 2" SHEARED WITH SQUARE
CORNERS. WHITE LETTERS, VOGUE BOLD
12 POINT BOLD FACE TYPE CENTERED TOP,
BOTTOM AND SIDES WITH 6 POINT SPACING ON
DEEP PURPLE PMS 260 BACKING. MANUFACTURED
FROM .016 THICK ALUMINUM WITH SOLVENT
ACTIVATED PERMANENT ADHESIVE BACKING.

NOTE: PANTONE MATCHING SYSTEM (PMS)

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

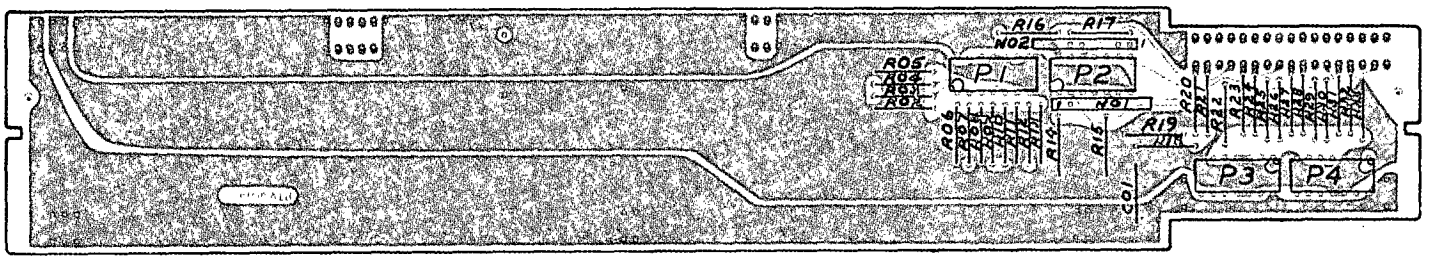
MACROMODULAR PROJECT

TITLE: IDENTIFICATION LABEL
INTERLOCK MODULE
PART #215.1

CHANGE NO.	DATE	DESCRIPTION

APPROVED BY	FOR	DATE
NTK	PROD.	1-4-72

ENG: NTK
DRAWN BY: MBP
CHECKED: D.H.O.
DRAWING NO.: 215.1D
DATE: 1-3-72



NOTE:

FEMALE AMP MODU CONNECTORS MUST BE INSTALLED PRECISELY
AS SHOWN IN DRAWING 200.50D2

CHANGE NO	DATE	DESCRIPTION

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST LOUIS MISSOURI

MACROMODULAR PROJECT

TITLE: COMPONENT IDENTIFICATION
INTERLOCK RETURN BOARD
PART NO. 215.3

APPROVED BY	FOR	DATE
Cerr	PROD	4-23-73

ENG: MLP
DRAWN BY: MAC
CHECKED: MLP
DRAWING NO: 215.3D1
DATE: 3-7-73

INTEGRATED CIRCUITS

TYPE	REQUIRED	LOCATION
M06	2	P3 P4
M20	1	P2
M31	1	P1

RESISTORS

TYPE	REQUIRED	LOCATION
R1	6	R02 R05 R06 R08 R11 R13
R2	8	R18 R19 R22 R25 R26 R29 R30 R33
R3	6	R03 R04 R07 R09 R10 R12
R4	4	R14 R15 R16 R17
R5	8	R20 R21 R23

RESISTORS (cont.)

TYPE	REQUIRED	LOCATION
R5 (cont.)		R24 R27 R28 R31 R32
LTN-2	2	N01
(Cut pins 3,4,7 & 8)		N02

CAPACITORS

TYPE	REQUIRED	LOCATION
.01µfd (Ceramic Disc)	1	C01

CONNECTORS

TYPE	REQUIRED
Amp Modu Female #85863-4	41

PRINTED CIRCUIT BOARD

PTV 0141-1 — 1 Required

NOTE:

R1XX = 1,500 Ohms ±1% 1/8W Film
R2XX = 750 Ohms ±1% 1/8W Film
R3XX = 121 Ohms ±1% 1/8W Film
R4XX = 15,000 Ohms ±5% 1/4W Carbon
R5XX = 57.6 Ohms ±1% 1/8W Film

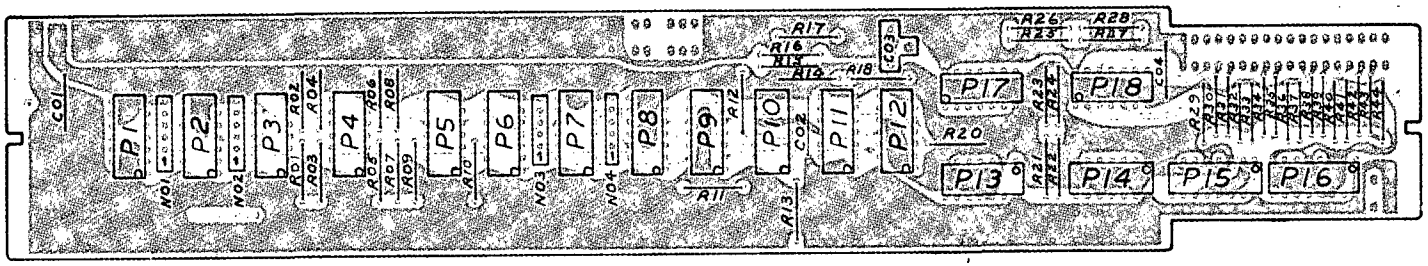
COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

MACROMODULAR PROJECT

TITLE: PARTS LIST
INTERLOCK RETURN BOARD
PART NO. 215.3

APPROVED BY	APPROVED FOR	APPROVED DATE	ENG	DRAWING NO.
	PROD	4-23-73	MLP	215.3D2
			DRAWN BY CAH	
			CHECKED MLP	DATE 1-18-73

CHANGE NO.	DATE	DESCRIPTION



NOTE:

FEMALE AMP MODU CONNECTORS MUST BE INSTALLED
PRECISELY AS SHOWN IN DRAWING 200.50D2

CHANGE NO	DATE	DESCRIPTION

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST LOUIS MISSOURI

MACROMODULAR PROJECT

TITLE: COMPONENT IDENTIFICATION
INTERLOCK CONTRCL BOARD
PART NO 215.4

APPROVED		
BY	FOR	DATE
[illegible]	PROD	1-23-73

ENG: MLP
DRAWN BY: MAC
CHECKED: MLP

DRAWING NO: 215.4D1
DATE: 1-25-73

INTEGRATED CIRCUITS

TYPE	REQUIRED	LOCATION
M01B	1	P10
M04	1	P11
M05	3	P13 P17 P12
M10	2	P5 P14
M16A	2	P2 P7
M20	1	P18
M30	2	P4 P9
M32B	2	P15 P16
M35	4	P1 P3 P6 P8

CAPACITORS

TYPE	REQUIRED	LOCATION
.01 µfd (Ceramic Disc)	3	C01 C02 C04
Variable (Johanson 9334)	1	C03

CONNECTORS

TYPE	REQUIRED
Amp Modu Female #85863-4	37

PRINTED CIRCUIT BOARD

PTV 0163-1 1 Required

RESISTORS

TYPE	REQUIRED	LOCATION
R0	1	R13
R1	18	R02 R04 R06 R08 R14 R15 R23 R24 R27 R28 R29 R32 R33 R36 R37 R40 R41 R44
R8	1	R20
R3	15	R01 R03 R05 R07 R09 R10 R11 R12 R16 R17 R18 R21 R22 R25 R26
R5	8	R30 R31 R34 R35 R38 R39 R42 R43
GC1	4	N01 N02 N03 N04

NOTE:

R0XX = Zero Ohms (Jumper)
R1XX = 1,500 Ohms ±1% 1/8W Film
R2XX = 750 Ohms ±1% 1/8W Film
R3XX = 121 Ohms ±1% 1/8W Film
R5XX = 57.6 Ohms ±1% 1/8W Film
GC-1 = CTS Resistor Network
R8XX = 6.8K Ohms ±1% 1/8W Film

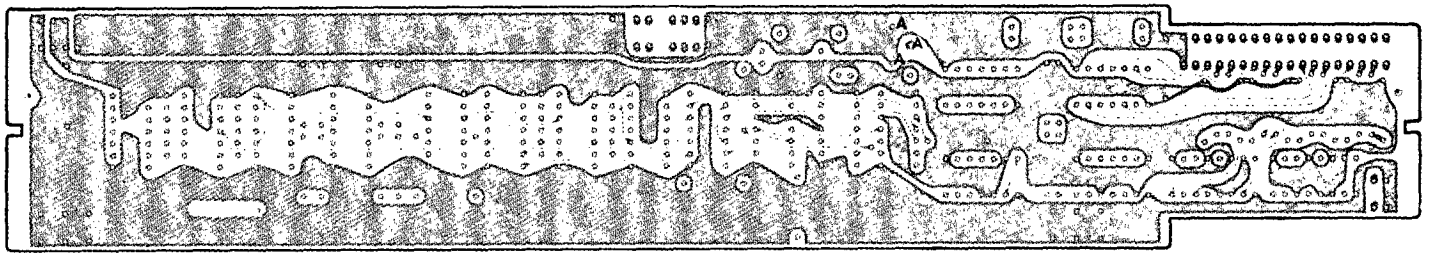
CHANGE NO.	DATE	DESCRIPTION

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

MACROMODULAR PROJECT

TITLE
PARTS LIST
INTERLOCK: CONTROL BOARD
PART NO. 215.4

APPROVED BY	APPROVED FOR	APPROVED DATE	ENG.	DRAWING NO.
	PROD	4-23-73	MLP	215.4D2
			DRAWN BY PLL	
			CHECKED MMX P	DATE 1-18-73



NOTE 1 :
TYPE "A" HOLES
3 PLACES
SEE CSL DOCUMENT 010 (GENERAL STANDARDS)
PAGES 13 AND 14 FOR HOLE SIZES.

CHANGE NO	DATE	DESCRIPTION

COMPUTER SYSTEMS LABORATORY.
WASHINGTON UNIVERSITY
ST. LOUIS MISSOURI

MACROMODULAR PROJECT

TITLE: HOLE IDENTIFICATION
INTERLOCK MODULE: CONTROL BOARD
PART NO. 215.4

APPROVED BY	FOR	DATE
Chen	PROD	4-23-73

ENG MLP
DRAWN CAH
CHECKED MLP
DRAWING NO 215.404
DATE 2-9-73

TEST PROCEDURE

INTERLOCK CONTROL BOARD #215.4

This board has a variable delay which compensates for the glitch detector setup time. If the delay is too short, the Interlock can fail in a disastrous manner. If the delay is too long, time is wasted; but the Interlock will function properly. The procedure given here not only sets the delay properly, but also tests certain circuits which are vital to the operation of the glitch detecting circuit.

EQUIPMENT

Pulse generator, 250 KHz.

Power supply, 5.2V $\pm$ 1% @ 750 ma.

Oscilloscope with resolution to 5-10ns/cm.

Variable delay for pulse generator output:min: 0-10ns, max:40-50ns.

Two switches for delayed and undelayed pulses to select one of four gates with MECL II defferential outputs.

IC test clip, 14 pin.

TERMS

$\bar{D}$ = The switch for the undelayed pulse.

D = The switch for the delayed pulse.

PD = The Pulse Delay in the test circuit.

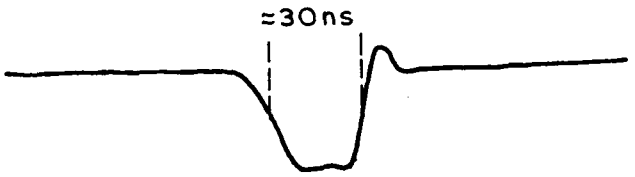
ID = The Interlock Delay which is on the Control Board.

Note: ID is controlled by turning a variable capacitor.

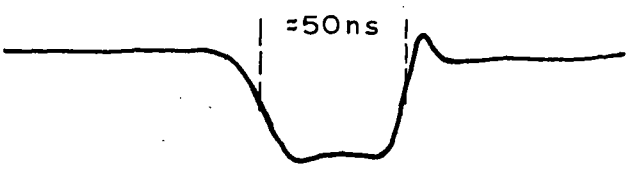
CHG.	E.C.O.	DATE	APPR.
1	0306	2-18-74	MKVP

PROCEDURE

1. Using a circuit like the one in Figure 1, connect it to the Control Board. Note that the four 15K bias resistors are used to keep the inactive inputs at the preset state.
2. A. Put IC test clip on package 11.
   B. Put scope channel 2 on pin 6 of test clip.
   C. Put scope channel 1 on undelayed pulse (TP1).
   D. Set scope trigger to channel 1, AC-coupled. Adjust the trigger so that either the positive or negative edge of the pulse can be detected simply by changing the polarity switch between + and -.
3. If any of the waveforms called for in the following steps fail to appear, momentarily ground the Preset input. If that doesn't help, check the connections to the Control Board, especially the jumpers to B40 - B44. Try Preset again, and if the Board continues to fail, it is probably in need of repair.
4. A. Set PD to minimum delay.
   B. Set ID to maximum delay. (See fig. 2a)
   C. Set D and $\bar{D}$ to 1. Observe the following wave form on channel 2.

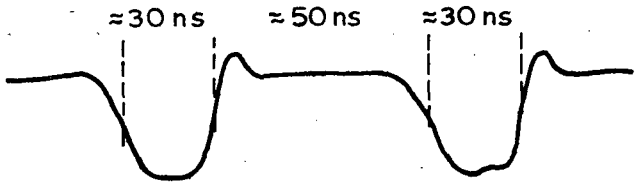


   D. Change the trigger polarity, and the waveform should remain the same.
   E. Repeat steps C and D for D and $\bar{D}$ set to 2, 3 and 4.
5. A. Set $\bar{D}$ to 1 and D to 2. Observe the following waveform.

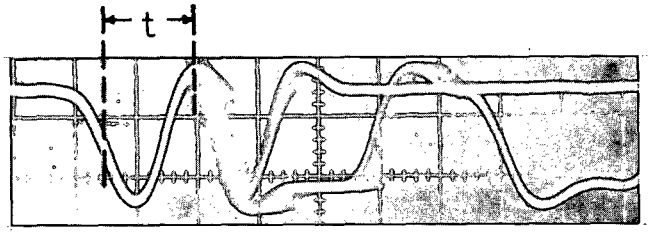


B. Repeat step A with the following values for $\bar{D}$ and D.
1-3, 1-4, 2-3, 2-4, 3-4.

6. Set PD to maximum delay (40-50ns). Observe the following waveform.



7. A. Set ID to minimum delay. (See fig. 2b).
B. Set $\bar{D}$ to 1 and D to 2.
C. Tune PD to obtain the glitch waveform as below.



D. For each setting of $\bar{D}$ and D in the table below, adjust PD to obtain the largest t possible while glitching.

$\bar{D}$	1	1	1	2	2	2	3	3	3	4	4	4
D	2	3	4	3	4	1	4	1	2	1	2	3

Record the largest value of t for the twelve measurements.

E. Repeat step D with the trigger polarity reversed.
F. Record the largest value of all twenty-four measurements as t-max. A variation of more than 5ns between t-max and any other value of t may indicate trouble with the Control Board.

8. A. Set $\bar{D}$ and D to 1.
B. Increase ID by t-max + 4ns as below.

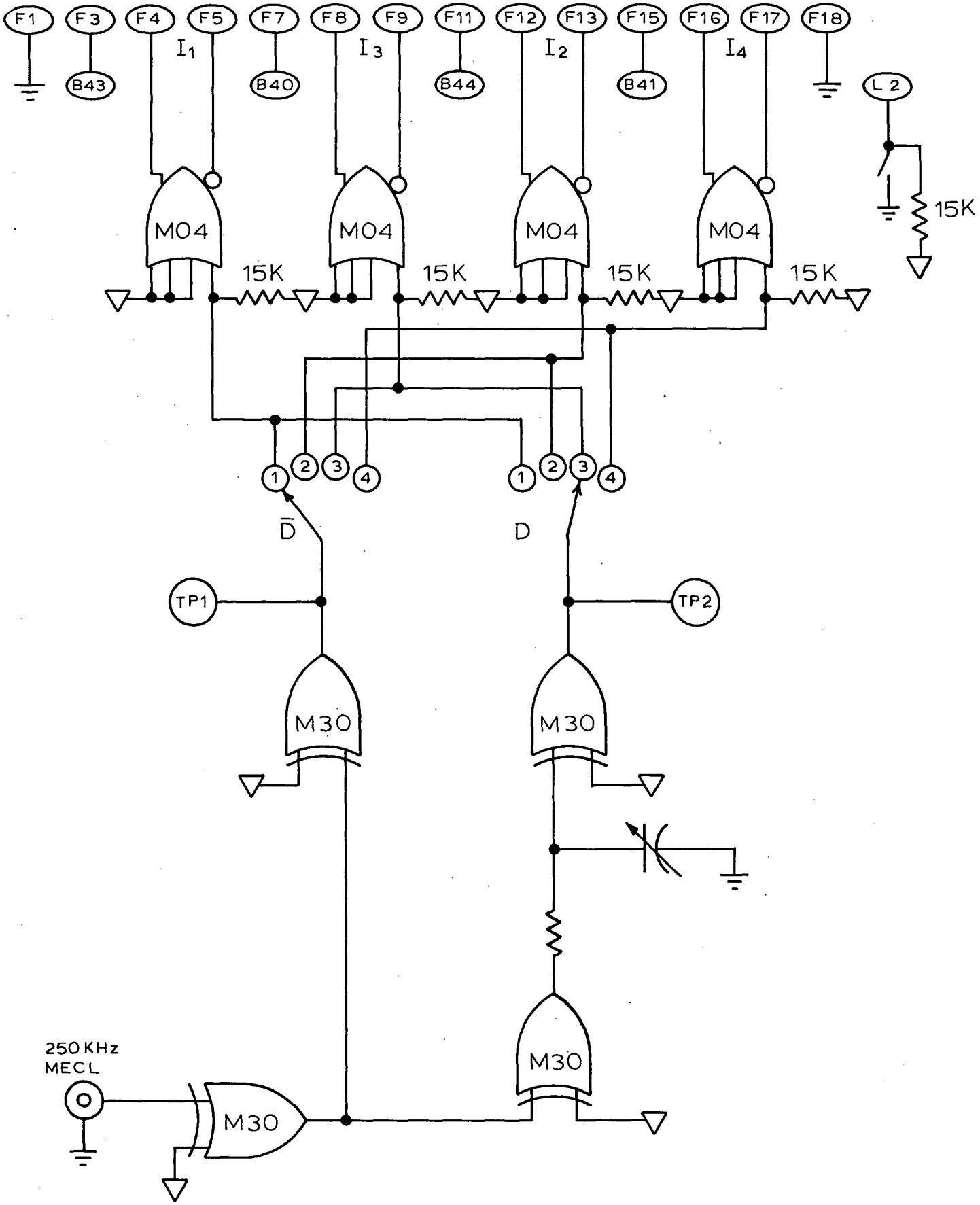
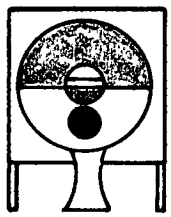

F1
F3
F4
F5
F7
F8
F9
F11
F12
F13
F15
F16
F17
F18
I1
I3
I2
I4
B43
B40
B44
B41
L 2
15K
M04
M04
M04
M04
15K
15K
15K
15K
1
2
3
4
1
2
3
4
D̄
D
TP1
TP2
M30
M30
M30
M30
250 KHz
MECL

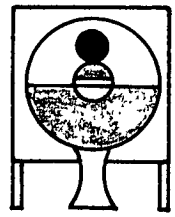
FIG. 1

215.4D8



ID = Maximum

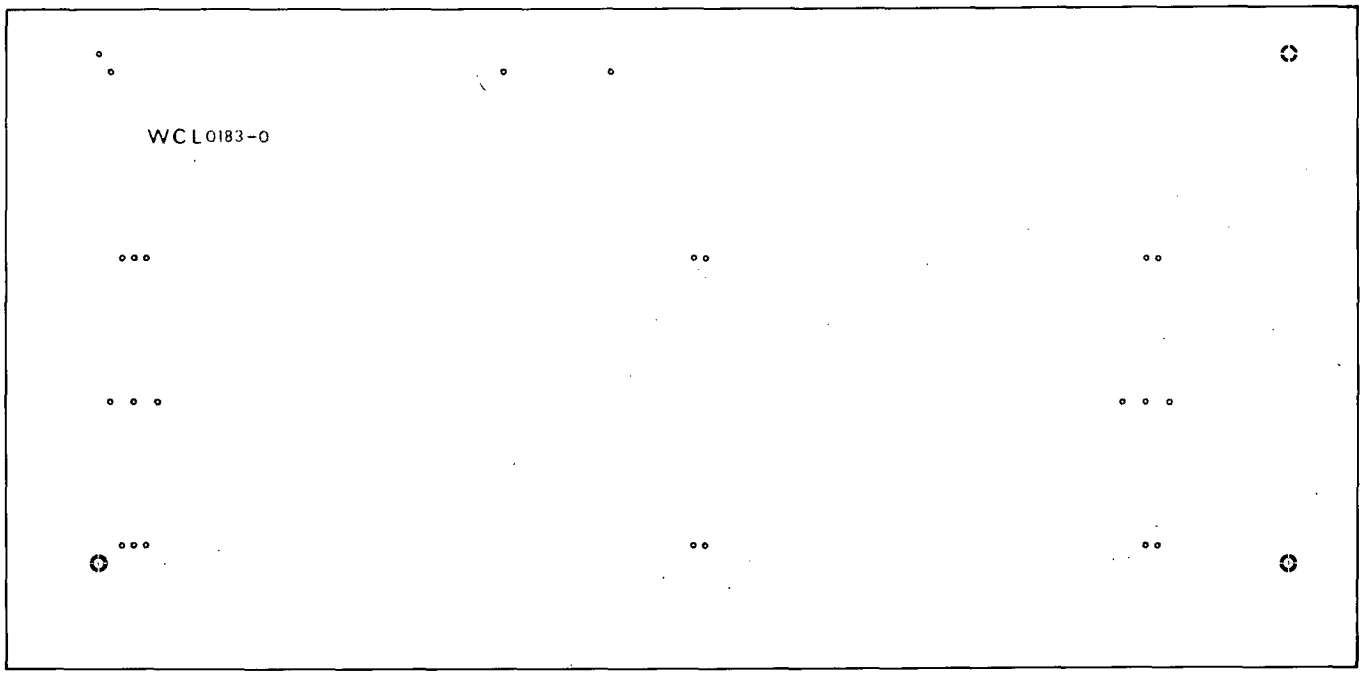
(a)



ID = Minimum

(b)

Fig. 2



NOTES:

1 TOP SIDE SHOWN, BOTTOM SIDE IS ALL COPPER.

2. MALE AMP MODU PINS MUST BE INSTALLED FROM THE BOTTOM SIDE PRECISELY AS SHOWN IN DRAWINGS NO. 200.50D2 AND 200.50D3.

PARTS LIST

MALE AMP MODU CONNECTORS NO. 85931-5	23 REQUIRED
PRINTED CIRCUIT BOARD WCL 0183-0	1 REQUIRED

CHANGE NO.	DATE	DESCRIPTION

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

MACROMODULAR PROJECT

TITLE
COMPONENT IDENTIFICATION
INTERLOCK: TOP MOTHERBOARD
PART NO. 215.5

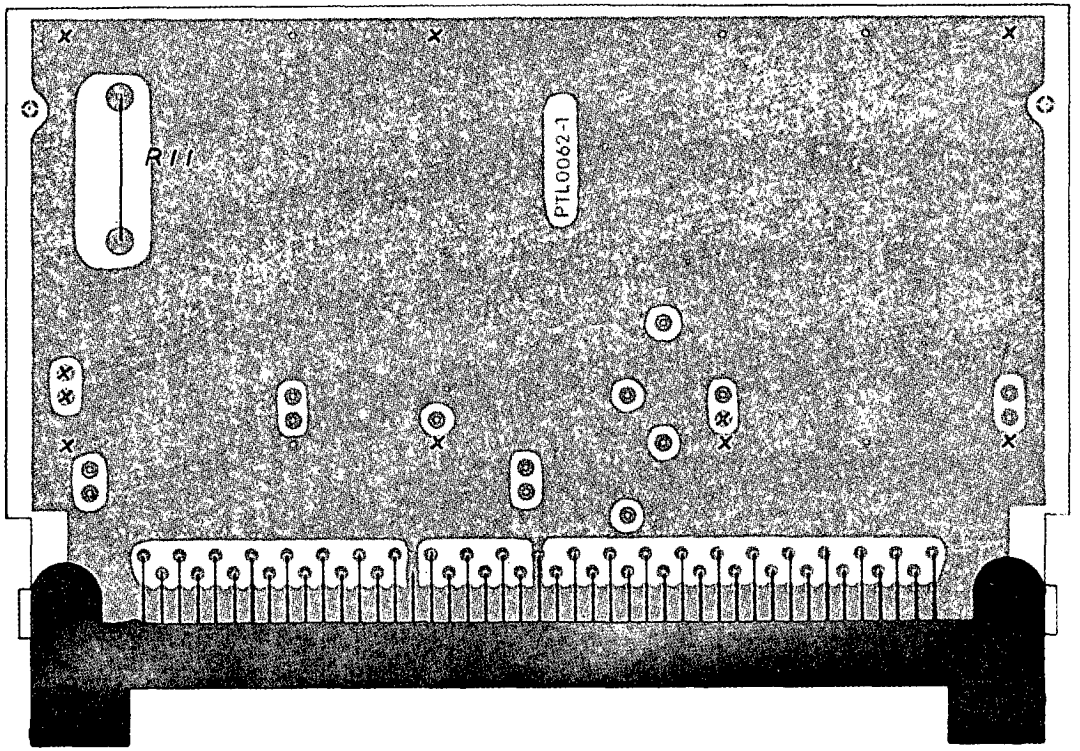
APPROVED BY	FOR	DATE
Cam	PROD	4-23-73

ENG. MLP
DRAWN BY PLL
CHECKED MLP

DRAWING NO. 215.5D1
DATE 3-7-73

NOTE 1: MALE AMP MODU CONNECTORS MUST BE INSTALLED FROM THIS SIDE IN LOCATIONS MARKED "X" PRECISELY AS SHOWN IN DRAWINGS 200.50D2 AND 200.50D3.
(10 PLACES)

NOTE 2: SEE DRAWING NO. 200.50D28 FOR CONNECTOR MOUNTING ORIENTATION.



CHANGE NO.	DATE	DESCRIPTION

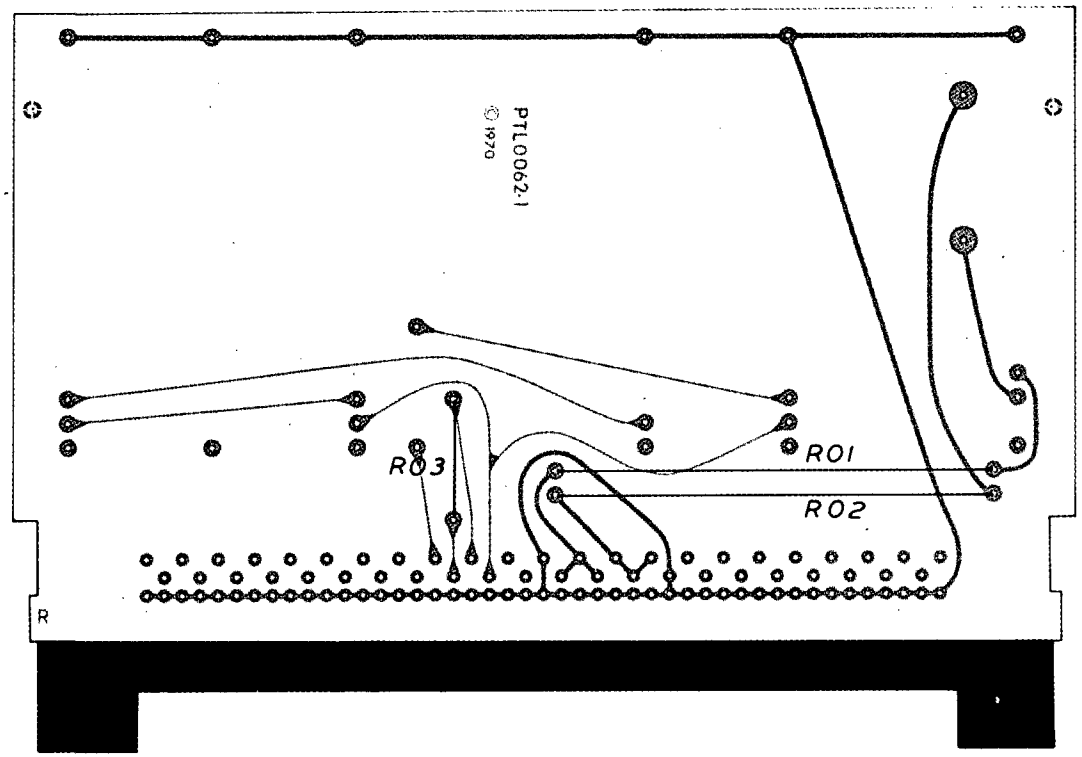
COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

MACROMODULAR PROJECT

TITLE: COMPONENT IDENTIFICATION
INTERLOCK : LATERAL MOTHER BOARD
COMPONENT SIDE PART NO. 215.6

APPROVED BY	FOR	DATE
Tlm	PROD	4-23-73

ENG.	MLP
DRAWN BY	PLL
CHECKED	MLP
DRAWING NO.	215.6D1
DATE	3-7-73



CHANGE NO.	DATE	DESCRIPTION

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

MACROMODULAR PROJECT

TITLE
COMPONENT IDENTIFICATION
INTERLOCK: LATERAL MOTHER BOARD
SIGNAL SIDE PART NO. 215.6

APPROVED BY	FOR	DATE
Clw	PROD	4-23-73

ENG. MLP
DRAWN BY FLL
CHECKED MKP

DRAWING NO. 215.6D2
DATE 3-7-73

RESISTORS

R01 = JUMPER

R02 = JUMPER

R03 = 80.6KΩ ± 1% 1/8W FILM

CONNECTORS

MALE AMP MODU NO. 85931-5

10 REQUIRED

AMP CONNECTOR NO. 583 464-1

1 REQUIRED

FUSE

R11 = BUSSMAN GFA 3/4 AMP

PRINTED CIRCUIT BOARD

PTL 0062-1

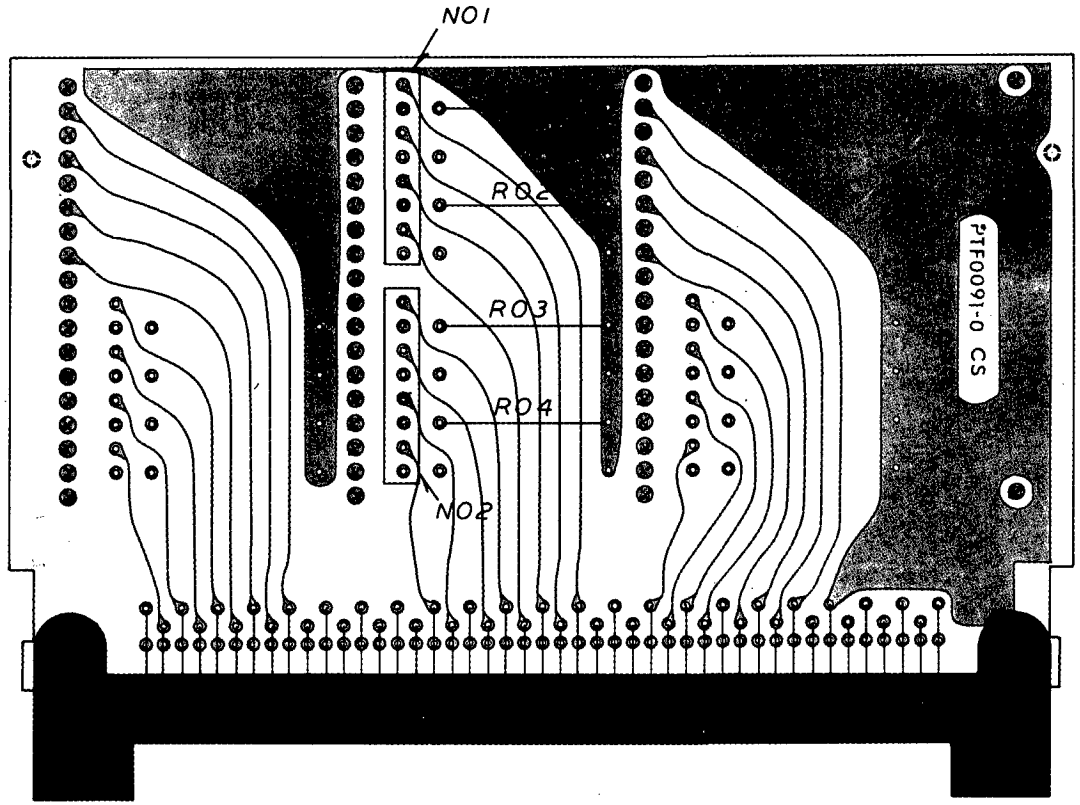
1 REQUIRED

COMPUTER SYSTEMS LABORATORY WASHINGTON UNIVERSITY ST. LOUIS, MISSOURI			MACROMODULAR PROJECT		
			TITLE: PARTS LIST INTERLOCK: LATERAL MOTHER BOARD PART NO. 215.6		
			APPROVED BY: Cerf	APPROVED FOR: PROD	APPROVED DATE: 4-23-73
			ENG: MLP	DRAWN BY: CAH	DRAWING NO.: 215.6D3
			CHECKED: MLP	DATE: 3-7-73	
CHANGE NO.	DATE	DESCRIPTION			

NOTE 1: MALE AMP MODU CONNECTORS MUST BE INSTALLED FROM THIS SIDE IN LOCATIONS MARKED "X" PRECISELY AS SHOWN IN DRAWINGS 200.50D2 AND 200.50D3 (56 PINS)

NOTE 2: SEE DRAWING NUMBER 200.50D29 FOR CONNECTOR MOUNTING ORIENTATION.

NOTE 3: NO1, NO2 CUT PINS 3,4,7, & 8



CHANGE NO.	DATE	DESCRIPTION

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

MACROMODULAR PROJECT

TITLE
COMPONENT IDENTIFICATION
INTERLOCK FACEPLATE MOTHERBOARD
PART NO. 215.7

APPROVED		
BY	FOR	DATE
Cam	PROD	4-23-73

ENG.	MLP
DRAWN BY	PLL
CHECKED	MLP

DRAWING NO.	215.7D1
DATE	3-7-73

RESISTORS

TYPE	REQUIRED	LOCATION
LTN-2	2	NO1
(CUT PINS 3,4,7,&8)		NO2
15,000Ω ± 5% 1/4W CARBON COMP	4	RO1 RO2 RO3 RO4

CONNECTORS

MALE AMP MODU NO. 85931-5 — 56 REQUIRED

AMP NO. 583464-1 — 1 REQUIRED

PRINTED CIRCUIT BOARD

PTF 0091-2 — 1 REQUIRED

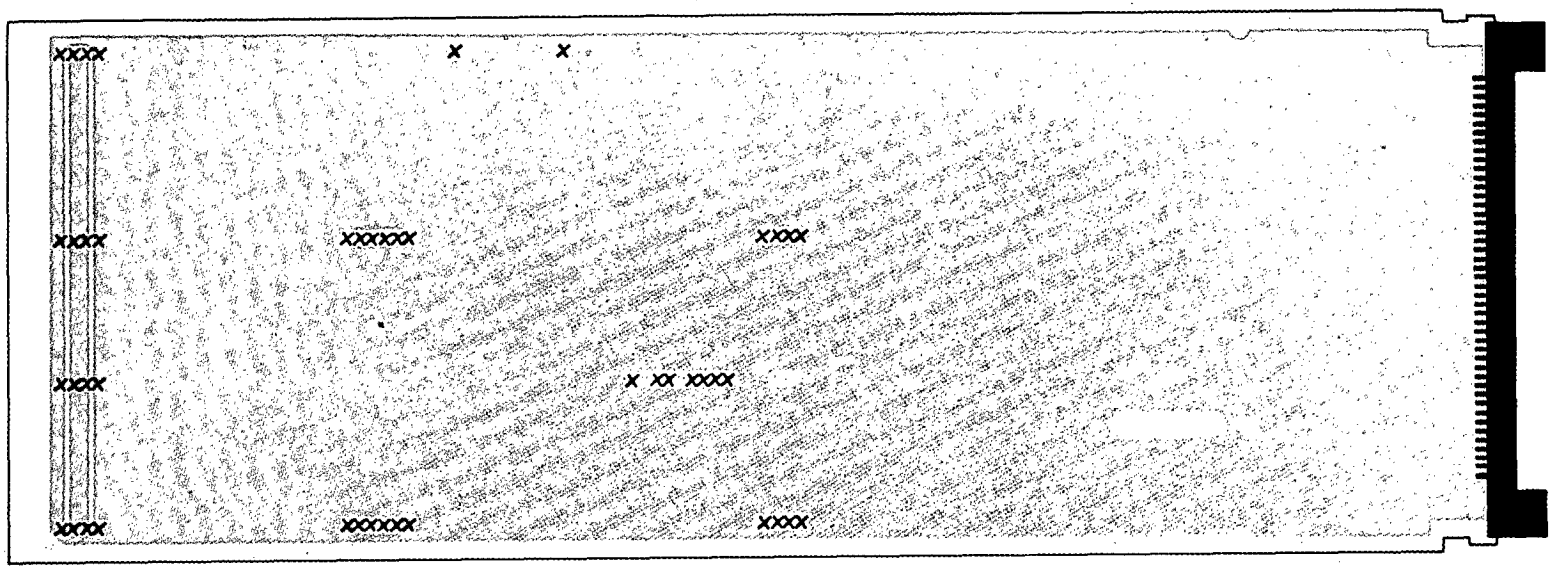
COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

MACROMODULAR PROJECT

TITLE: PARTS LIST
INTERLOCK: FACEPLATE MOTHER BOARD
PART NO. 215.7

APPROVED BY	APPROVED FOR	APPROVED DATE	ENG	DRAWING NO.
			MLP	215.7D2
CA	PROD	4-23-73	DRAWN BY: CAH	
			CHECKED: MLP	DATE: 3-7-73

CHANGE NO.	DATE	DESCRIPTION



NOTE:
AMPMODU PINS MUST BE INSTALLED
FROM THIS SIDE IN LOCATIONS MARKED
X PRECISELY AS SHOWN IN DWGS. 200.50D2
AND 200.50D3

(45 PINS)

NOTE:
SEE DRAWING NUMBER 200.50D27
FOR CONNECTOR ORIENTATION.

CHANGE NO.	DATE	DESCRIPTION

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

MACROMODULAR PROJECT

TITLE
COMPONENT IDENTIFICATION
INTERLOCK BOTTOM MOTHERBOARD
PART NO. 215.8

APPROVED BY	FOR	DATE
Clw	MANUF	4-23-73

ENG. MLP
DRAWN BY PLL
CHECKED MLP

DRAWING NO. 215.8D1
DATE 3-7-73

CONNECTORS

MALE AMP MODU NO. 85931-5

45 REQUIRED

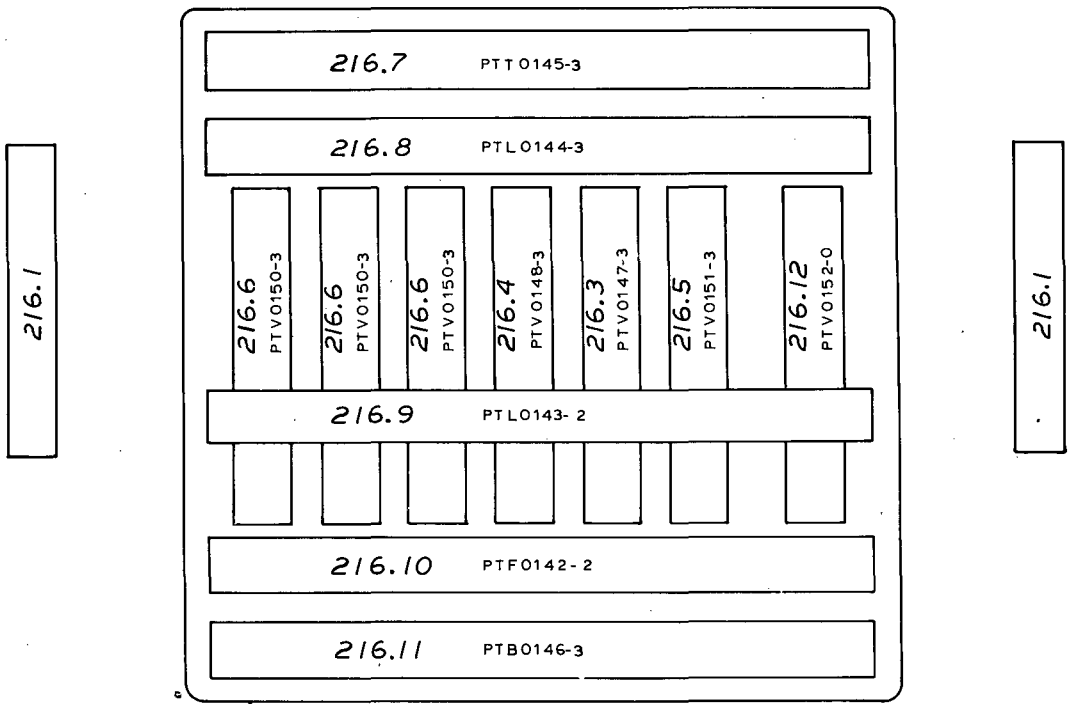
AMP NO. 1-202 845-5

1 REQUIRED

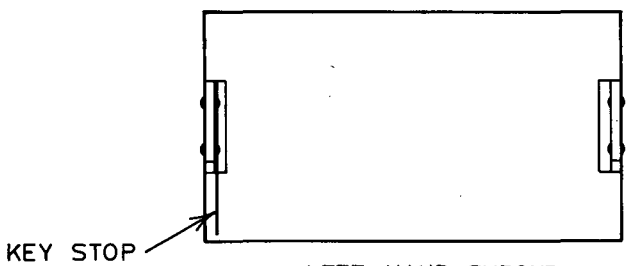
PRINTED CIRCUIT BOARD

PTB 0090-1
1 REQUIRED

COMPUTER SYSTEMS LABORATORY WASHINGTON UNIVERSITY ST. LOUIS, MISSOURI			MACROMODULAR PROJECT		
			TITLE: PARTS LIST INTERLOCK: BOTTOM MOTHER BOARD PART NO. 215.8		
			APPROVED BY:	FOR: PROD	DATE: 4-23-73
			ENG: MLP	DRAWING NO.: 215.8D2	
			DRAWN BY: CAH		
CHANGE NO.	DATE	DESCRIPTION	CHECKED: MLP	DATE: 3-7-73	



200.2
TWO CELL CASE
ASSEMBLY



LEFT HAND SHROUD

CHANGE NO.	DATE	DESCRIPTION

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

MACROMODULAR PROJECT

TITLE ASSEMBLY SCHEMATIC & PARTS LIST
MULTIPLY MODULE
PART NO. 216

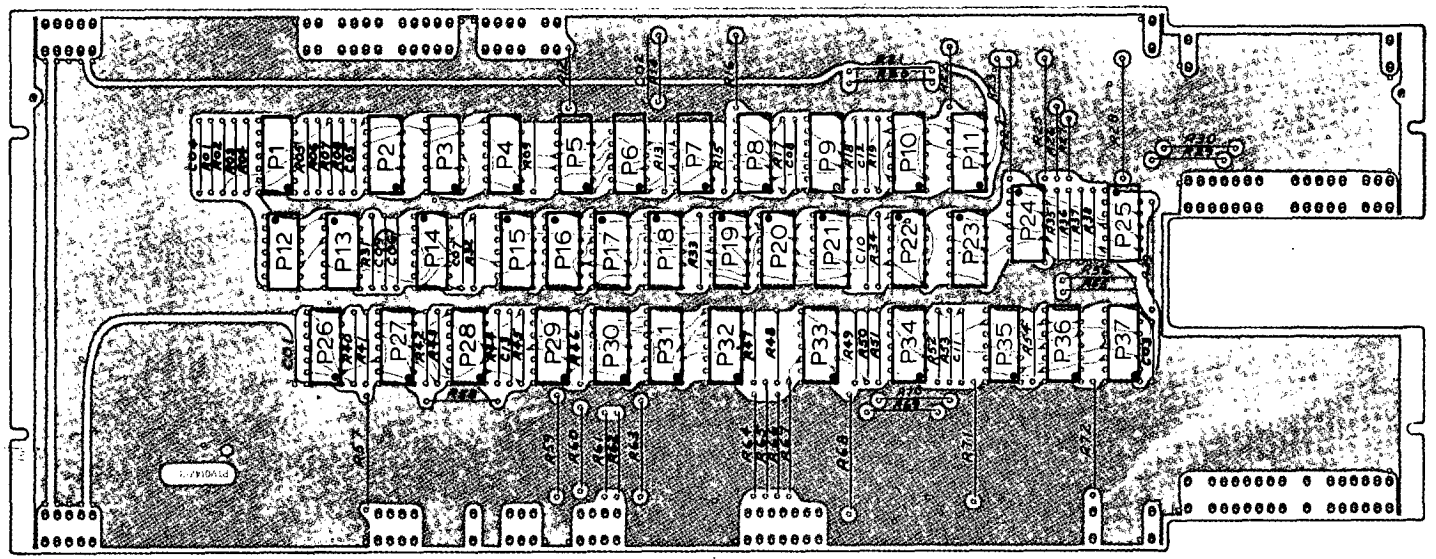
APPROVED			ENG	DRAWING NO.
BY	FOR	DATE	MAW	
	PROD	4-19-73	DRAWN BY PLL	216.0D
			CHECKED dls	DATE 6-21-72

MULTIPLY

METALCRAFT "AUTOGRAPH" OR EQUIVALENT: BLANK SIZE: ¼" X 2" SHEARED WITH SQUARE CORNERS. WHITE LETTERS, VOGUE BOLD 12 POINT BOLD FACE TYPE CENTERED TOP, BOTTOM AND SIDES WITH 6 POINT SPACING ON DARK OLIVE PMS 581 BACKING, MANUFACTURED FROM .016 THICK ALUMINUM WITH SOLVENT ACTIVATED PERMANENT ADHESIVE BACKING.

NOTE: PANTONE MATCHING SYSTEM (PMS)

COMPUTER SYSTEMS LABORATORY WASHINGTON UNIVERSITY ST. LOUIS, MISSOURI			MACROMODULAR PROJECT				
			TITLE: IDENTIFICATION LABEL MULTIPLY MODULE PART NO. 216.1				
			APPROVED			ENG: NTK	DRAWING NO.: 216.1D
			BY: NTK	FOR: PROD	DATE: 8/26	DRAWN BY: MBP	
						CHECKED: EJNO	DATE: 7-25-71
CHANGE NO.	DATE	DESCRIPTION					



NOTE:

INSTALL FEMALE AMP MODU CONNECTORS EXACTLY AS SHOWN IN DRAWING 200.50D2.

CHANGE NO.	DATE	DESCRIPTION

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

MACROMODULAR PROJECT

TITLE: COMPONENT IDENTIFICATION
MULTIPLY MODULE: LOCAL CONTROL BOARD
PART NO. 216.3

APPROVED BY	FOR	DATE
Clem	PROD	4-19-73

ENG. DLS
DRAWN BY PLL
CHECKED dla

DRAWING NO. 216.3D1
DATE 6-26-72

INTEGRATED CIRCUITS

TYPE	REQUIRED	LOCATION
M04	1	P37
M04B	1	P32
M07	1	P21
M08	2	P12
		P35
M10	17	P2
		P3
		P4
		P8
		P11
		P13
		P17
		P18
		P22
		P23
		P24
		P25
		P26
		P27
		P30
		P31
		P36
M11	3	P10
		P29
		P33
M13A	3	P5
		P6
		P7
M16	1	P16
M30	4	P14
		P15
		P19
		P20
M35	4	P1
		P9
		P28
		P34

RESISTORS

TYPE	REQUIRED	LOCATION
R0	15	R01
		R03
		R06
		R08
		R12
		R16
		R24
		R25
		R28
		R60
		R63
		R65
		R67
		R71
		R72
R1	16	R09
		R13
		R15
		R35
		R36
		R37
		R38
		R41
		R42
		R46
		R47
		R48
		R49
		R54
		R55
		R56
R2	17	R02
		R04
		R05
		R07
		R17
		R18
		R19
		R31
		R34
		R40
		R43
		R44
		R45
		R50
		R51
		R52
		R53

RESISTORS (cont.)

TYPE	REQUIRED	LOCATION
R3	22	R14
		R20
		R21
		R22
		R23
		R26
		R27
		R29
		R30
		R32
		R33
		R39
		R57
		R58
		R59
		R61
		R62
		R64
		R66
		R68
		R69
		R70

CAPACITORS

TYPE	REQUIRED	LOCATIONS
C1 10,000pf (Type CK-103 Sprague Ceramic Disc 50WVDC)	3	C01 C02 C03
C2 (omit)	4	C04 C05 C06 C07
C3 10pf (Dipped Silver Mica)	4	C08 C09 C10 C11
C4 15pf (Dipped Silver Mica)	1	C12
C5 27pf (Dipped Silver Mica)	1	C13

CONNECTORS

Amp Modu Female No. 85863-4
81 Required

PRINTED CIRCUIT BOARD

PTV0147-3

NOTES:

R0 = Jumper
R1 = 1,500 Ohms ±1% 1/8W Film Resistor
R2 = 750 Ohms ±1% 1/8W Film Resistor
R3 = 121 Ohms ±1% 1/8W Film Resistor

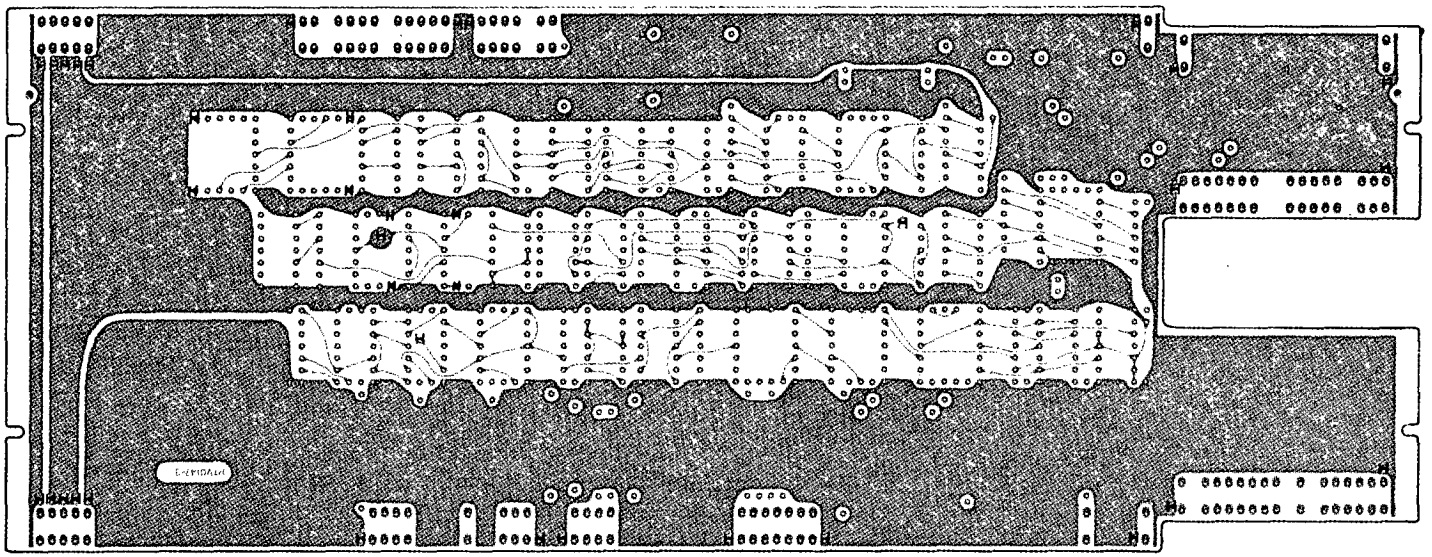
CHANGE NO.	DATE	DESCRIPTION

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

MACROMODULAR PROJECT

TITLE PARTS LIST
MULTIPLY MODULE: LOCAL CONTROL BOARD
PART NO. 216.3

APPROVED BY	FOR	DATE	ENG.	DRAWING NO.
	PROD	4-19-73	DLS	
			DRAWN BY CAH	216.3D2
			CHECKED dlb	DATE 6-26-72



NOTE:

HOLES MARKED WITH AN "H" ARE FEED-THROUGH HOLES WITH NO COMPONENTS INSTALLED. THESE MUST BE KEPT FREE OF SOLDER. (37 PLACES)

CHANGE NO.	DATE	DESCRIPTION

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

MACROMODULAR PROJECT

TITLE: FEED-THROUGH IDENTIFICATION
MULTIPLY MODULE: LOCAL CONTROL BOARD
PART NO. 216.3

APPROVED BY	FOR	DATE
Cem	PROD	4-19-73

ENG. DLS
DRAWN BY CAH
CHECKED dls

DRAWING NO. 216.3D4
DATE 2-5-73

Delay Specifications for the Multiply Macromodule

Introduction

Before the seven vertical boards are assembled into the multiply module, two of these boards must be subjected to a number of tests for the purpose of RC delay verification. The bulk of the testing is performed on a Local Control Board (6 tests), and the remaining test is done on the 3 Data Boards.

If discrepancies are found in the delay wave forms, they can be tuned to meet specifications by increasing the size of the associated capacitor to extend the delay, or conversely, decreasing its value to reduce the delay. Studies have shown that the relationship between time and capacity is approximately 1 nanosecond per pf.

Outlined on the following pages are the delay tests. Immediately following each procedure is a figure depicting the expected waveforms.

The circuit boards should be inspected carefully to insure that the following procedures have not resulted in damage to the Circuit boards, particularly in the areas where fresh soldering has taken place. All flux residues should be thoroughly removed.

CHG.	E.C.O.	DATE	APPR
1	0307	2-25-74	JCK

Test Procedure

Multiply Module Control Board #216.3

I. Preparation for Test 1 & 2:

A. Apply -5.2VDC to T91, T92, T93

B. Apply Ground to T90, T94

C. Connect a source of low to B71

a) low =-1.55VDC

D. Apply a square wave with the following parameters to W13

a) Period : 600 Nsec.

b) Amplitude :-0.75 and -1.55 volts

c) Rise time : 10 Nsec or less

d) Fall time : 10 Nsec or less

E. Connect pulse generator ground to W1B

II. Test Procedure 1:

A. Connect Channel 1 of 454 oscilloscope to W13

B. Connect Channel 2 of scope to W14

C. Synchronize on Channel 1

D. Record the time between the leading edge of the wave form on Channel 1 to the leading edge of the wave form on Channel 2

E. Repeat the measurement of step D using the trailing edges of the wave forms

F. The minimum time of either must be greater than or equal to 16.5 Nsec. If additional time is required, install a small capacitor in the location provided for C207. (less than or equal to 5 pf.)

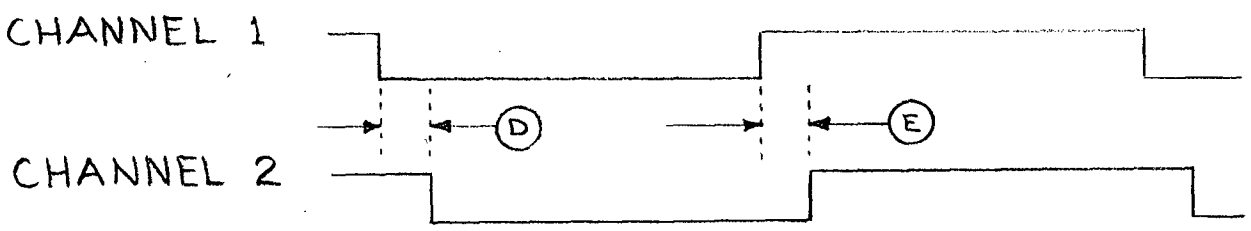


FIG 1

III. Test Procedure 2:

A. Connect Channel 1 input of scope to T63

B. Connect Channel 2 input to T64

C. Synchronize on Channel 1

D. Measure leading edge of Channel 1 to leading edge of Channel 2

E. Measure trailing edge of Channel 1 to trailing edge of Channel 2

F. Each measurement must fall between 32 to 40 nanoseconds, inclusive. If tuning is required, change capacitor C513. (approximately 1 nanosecond per pf.)

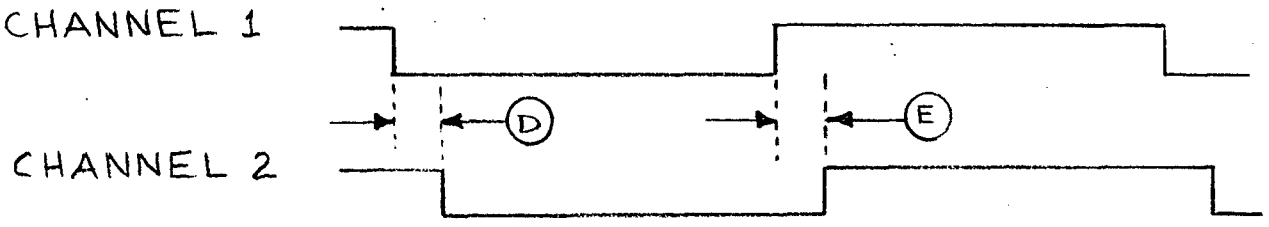


FIG 2

IV. Preparation for Test 3 & 4:

A. Retain power and Ground Connection as in test 1 & 2

B. Apply a source of high to B66

C. Secure an Integrated Circuit Test Clip to Package 12, and short pins 9 and 11

D. Apply the square wave described in ID to W16

E. Connect generator ground to W1B

V. Test Procedure 3:

A. Connect Channel 1 of scope to W16

B. Connect Channel 1 to W15

C. Synchronize on Channel 1

D. Measure the time between the leading edge of Channel 1 versus the leading edge of Channel 2

E. Repeat noting the time between the trailing edges of the wave forms

F. The minimum time of either measurment must be greater than or equal to 18 nanoseconds. Increase delay, if necessary with a small capacitor in location C206

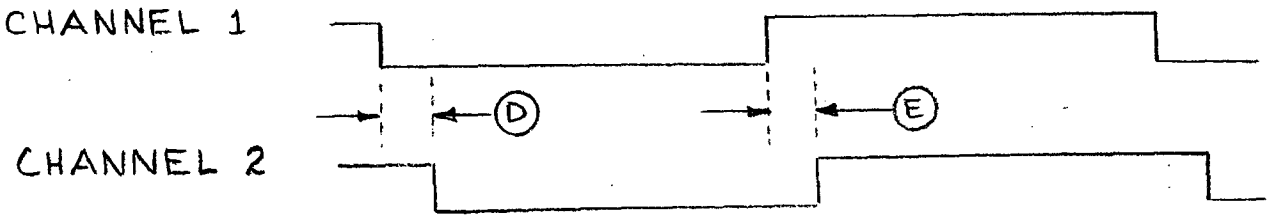


FIG 3

VI. Test Procedure 4:

A. Connect Channel 1 of scope to T65

B. Connect Channel 2 of scope to pin 11 of package 13

C. Synchronize on Channel 1

D. Measure from the leading edge of Channel 1 to the leading edge of Channel 2

E. Measure the time between the trailing edges

F. The minimum time of either measurement must be greater than or equal to 11 nanoseconds. If additional time is required, increase the value of capacitor C309

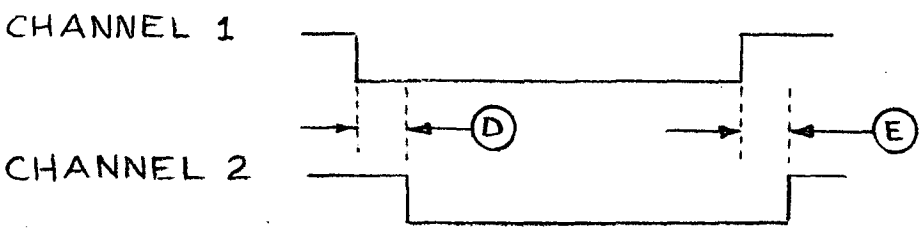


FIG 4

VII. Preparation for Test 5 & 6:

A. Retain power and Ground Connections as in previous tests

B. Apply a source of high to T58 and W10

C. Apply a source of low to B51

D. Connect the square wave described in 1D to T6

E. Connect generator ground to T1

VII. Test Procedure 5:

A. Connect Channel 1 of scope to T6

B. Connect Channel 2 of scope to T47

C. Synchronize on Channel 1

D. Measure the time between the leading edge of Channel 1 to the leading edge of the first pulse on Channel 2

E. Measure the time between the trailing edge of Channel 1 versus the leading edge of the second pulse on Channel 2

F. The minimum measurement must be greater than or equal to 33 nanoseconds. Increase time, if necessary, with capacitor C311

G. Measure the pulse width of two adjacent pulses on Channel 2. The minimum of either must be greater than or equal to 15 nanoseconds. Increase pulse width by changing capacitor C310

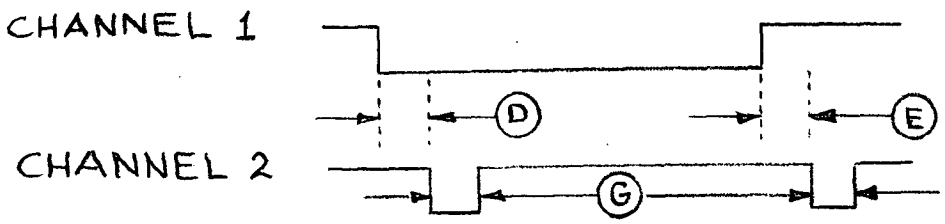


FIG 5

H. Move Channel 2 probe to Y16

a) Measure relationship of the leading edge of Channel 1 versus the leading edge of Channel 2

b) Do the same for the trailing edges

c) If either measurement is less than 17 nanoseconds, replace C311

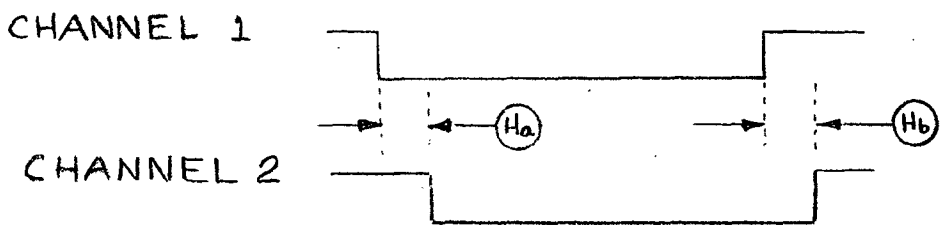


FIG 6

IX. Additional Preparation for Test 6:

A. Move generator input to B67

B. Generator ground to B7Z

C. Apply a source of high to T30

X. Test Procedure 6:

A. Connect Channel 1 of scope to B67

B. Connect Channel 2 of scope to T47

C. Synchronize on Channel 1

D. Check the pulse width of 2 adjacent pulses on Channel 2. The minimum time of either must be greater than or equal to 15 nanoseconds. If additional time is required, increase capacitor C308

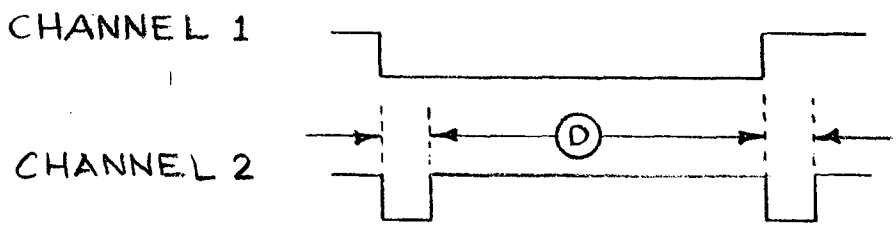


FIG 7

E. Move Channel 1 of scope to T33

F. Move Channel 2 of scope to T32

G. Measure the time between the leading edge of Channel 1 versus the leading edge of Channel 2

H. Repeat using the trailing edges

I. The minimum time of either measurement must be equal to or greater than 27 nanoseconds. If additional time is required, increase the size of C412

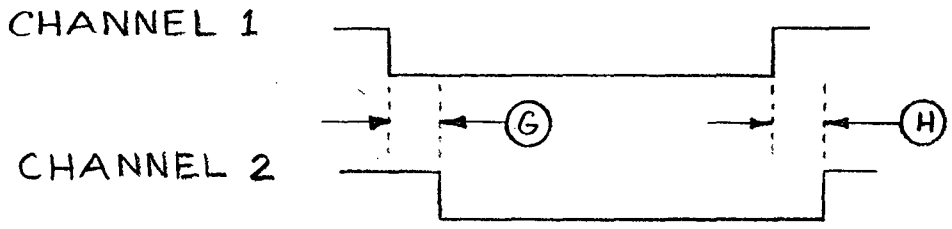
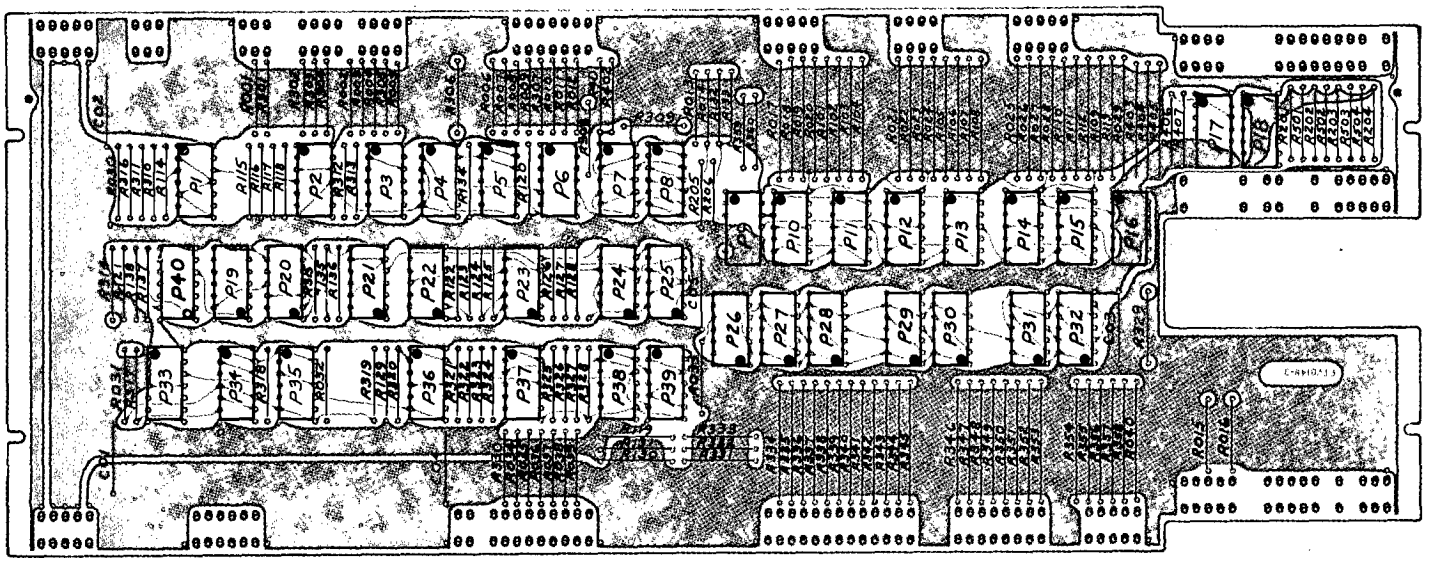


FIG 8



NOTE:
INSTALL FEMALE AMP MODU
CONNECTORS EXACTLY AS SHOWN
IN DRAWING 200.50D2

CHANGE NO.	DATE	DESCRIPTION

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

MACROMODULAR PROJECT

TITLE: COMPONENT IDENTIFICATION
MULTIPLY MODULE: MODE CONTROL BOARD
PART NO 216.4

APPROVED BY	FOR	DATE
Clm	PROD	4-19-73

ENG. DLS
DRAWN BY PLL
CHECKED dls

DRAWING NO. 216.4D1
DATE 6-26-72

INTEGRATED CIRCUITS

TYPE	REQUIRED	LOCATION
M01	1	P23
M01B	3	P9 P22 P26
M04	1	P33
M04B	4	P5 P6 P16 P2
M06	1	P18
M10	14	P1 P3 P20 P21 P27 P28 P29 P30 P31 P32 P34 P37 P38 P39
M11	3	P4 P7 P8
M16	1	P40
M20	1	P17
M21	1	P19
M30	5	P11 P13 P15 P24 P36
M31	4	P10 P12 P14 P25
M47	1	P35

RESISTORS

TYPE	REQUIRED	LOCATION
R0	40	R001 thru R040
R1	38	R101 thru R138
R2	6	R201 thru R206
R3	60	R301 thru R360
R4	7	R401 thru R407
R5	4	R501 thru R504

CAPACITORS

TYPE	REQUIRED	LOCATION
C1 10,000pf (Type CK-103 Sprague Ceramic Disc 50WVDC)	5	C01 C02 C03 C04 C05

CONNECTORS

AMP MODU FEMALE NO. 85863-4
126 Required

PRINTED CIRCUIT BOARD

PTV0148-3
One Required

NOTES:

R0 = Jumper
R1 = 1500 Ohms ±1% 1/8W Film Resistor
R2 = 750 Ohms ±1% 1/8W Film Resistor
R3 = 121 Ohms ±1% 1/8W Film Resistor
R4 = 15000 Ohms ±5% 1/4W Carbon Comp.
R5 = 57.6 Ohms ±1% 1/8W Film Resistor

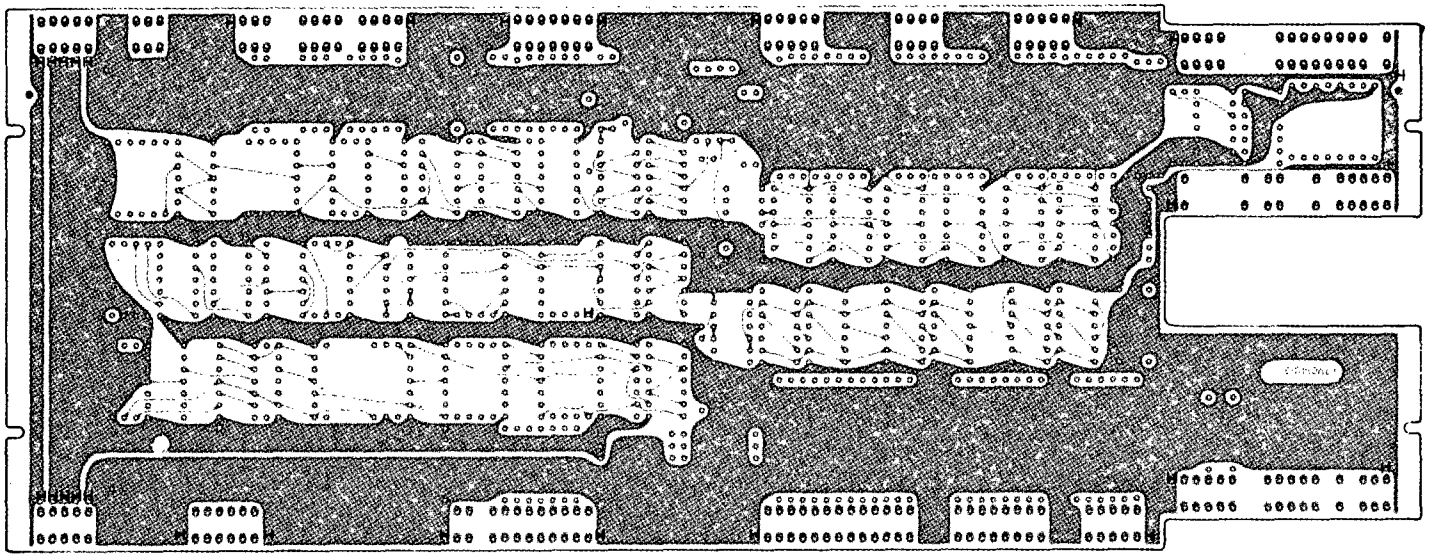
CHANGE NO.	DATE	DESCRIPTION

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

MACROMODULAR PROJECT

TITLE PARTS LIST
MULTIPLY MODULE: MODE CONTROL BOARD
PART NO. 216.4

APPROVED			ENG.	DRAWING NO.
BY	FOR	DATE	DLS	
	PROD	4-19-73	DRAWN BY CAH	216.4D2
			CHECKED dlb	DATE 6-26-72



NOTE:

HOLES MARKED WITH AN "H" ARE FEED-THROUGH HOLES WITH NO COMPONENTS INSTALLED. THESE MUST BE KEPT FREE OF SOLDER. (29 PLACES)

CHANGE NO.	DATE	DESCRIPTION

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

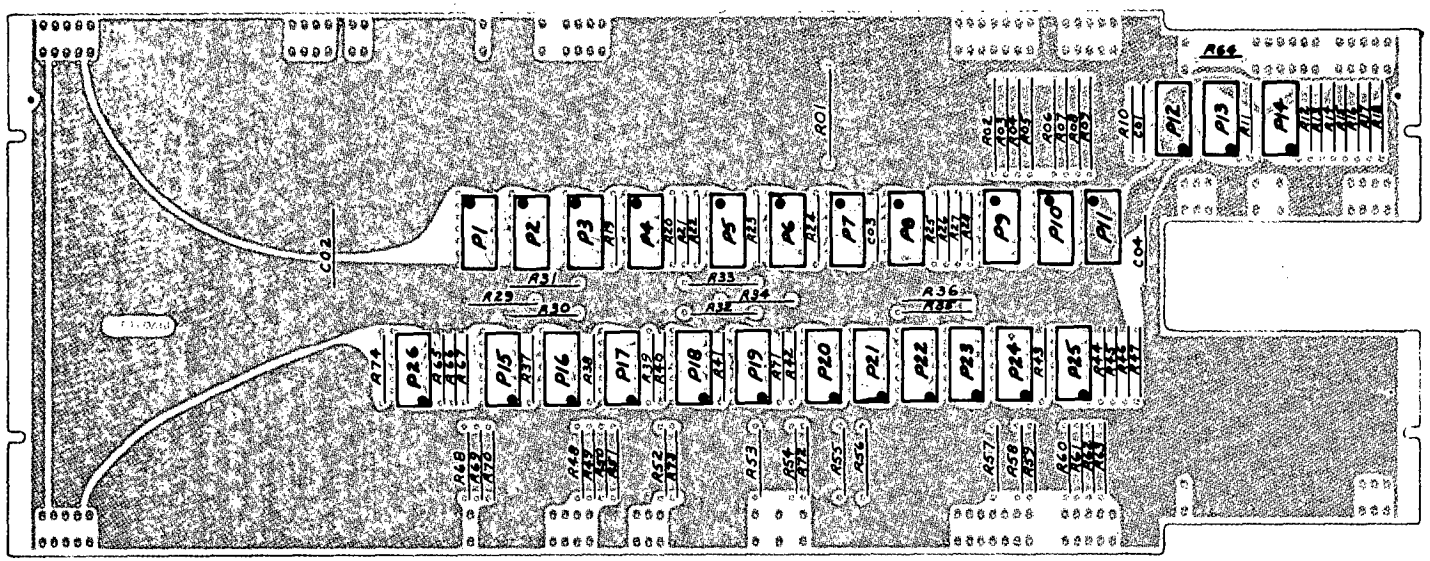
MACROMODULAR PROJECT

TITLE: FEED-THROUGH IDENTIFICATION
MULTIPLY MODULE: MODE CONTROL BOARD
PART NO. 216.4

APPROVED BY	FOR	DATE
Clm	PROD	4-19-73

ENG. DLS
DRAWN BY CAH
CHECKED dlo

DRAWING NO. 216.4D4
DATE 2-5-73



NOTE:

INSTALL FEMALE AMP MODU CONNECTORS EXACTLY
AS SHOWN IN DRAWING 200.50D2.

CHANGE NO.	DATE	DESCRIPTION

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

MACROMODULAR PROJECT

TITLE: COMPONENT IDENTIFICATION
MULTIPLY MODULE: TRANSFER CONTROL BOARDS
216.5

APPROVED BY	FOR	DATE
Cam	PROD	4-19-73

ENG. DLS
DRAWN BY CAH
CHECKED dls

DRAWING NO. 216.5D1
DATE 2-9-73

INTEGRATED CIRCUITS

TYPE	REQUIRED	LOCATION
M04B	4	P10
		P11
		P19
		P20
M07	1	P8
M10	7	P2
		P7
		P9
		P18
		P21
		P23
		P26
M11	4	P3
		P6
		P12
		P15
M16	1	P24
M30	3	P1
		P4
		P16
M31	2	P17
		P22
M35	2	P13
		P14
M47	2	P5
		P25

CONNECTORS

Amp Modu Female 85863-4
80 Required

PRINTED CIRCUIT BOARD

PTV0151-3
One Required

RESISTORS

TYPE	REQUIRED	LOCATION
R0	17	R01
		R03
		R04
		R06
		R07
		R08
		R20
		R34
		R49
		R53
		R55
		R56
		R57
		R58
		R59
		R63
		R73
R1	22	R11
		R14
		R15
		R18
		R21
		R25
		R26
		R29
		R30
		R31
		R36
		R38
		R39
		R40
		R42
		R44
		R45
		R46
		R65
		R66
		R67
		R71
R2	1	R37

RESISTORS (cont.)

TYPE	REQUIRED	LOCATION
R3	26	R02
		R05
		R09
		R10
		R19
		R22
		R24
		R27
		R28
		R32
		R33
		R35
		R47
		R48
		R50
		R51
		R52
		R54
		R60
		R61
		R62
		R68
		R69
		R70
		R72
		R74
R4	4	R23
		R41
		R43
		R64
R5	4	R12
		R13
		R16
		R17

CAPACITORS

TYPE	REQUIRED	LOCATION
C1 10000pfd (Type CK-103 Sprague Ceramic Disc 50WVDC)	3	C02
		C03
		C04
C2 200pf (Dipped Silver Mica)	1	C01

NOTES:

R0 = Jumpers
R1 = 1500 Ohms ±1% 1/8W Film Resistor
R2 = 750 Ohms ±1% 1/8W Film Resistor
R3 = 121 Ohms ±1% 1/8W Film Resistor
R4 = 15000 Ohms ±5% 1/4W Carbon Comp.
R5 = 57.6 Ohms ±1% 1/8W Film Resistor

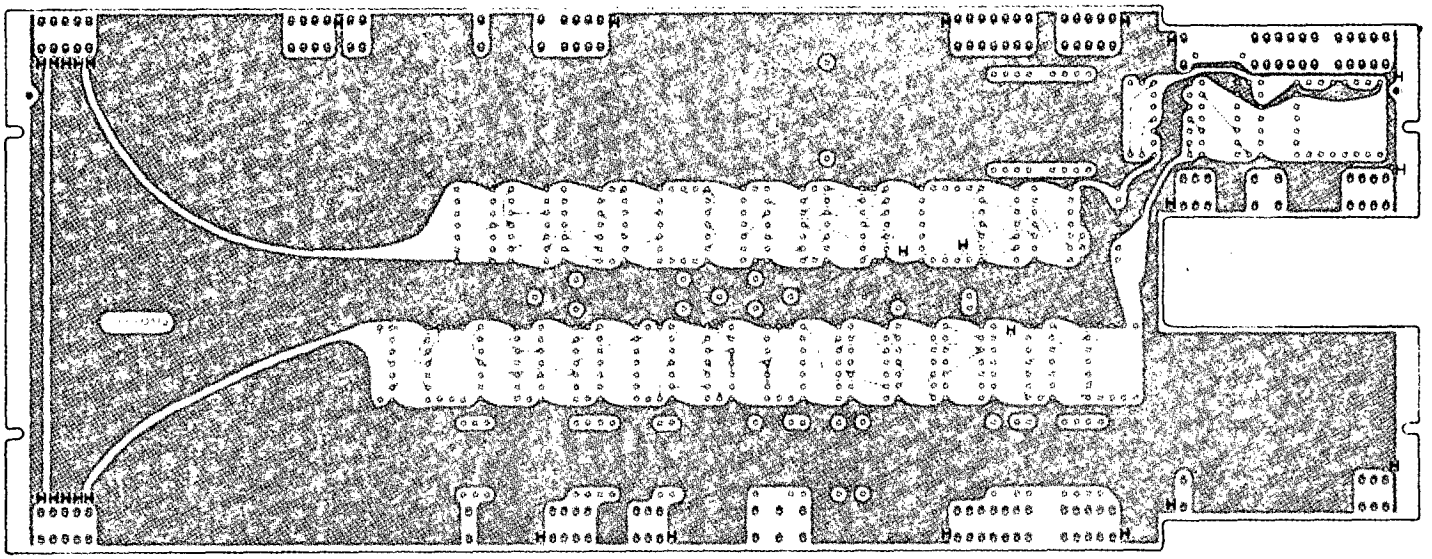
CHANGE NO.	DATE	DESCRIPTION

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

MACROMODULAR PROJECT

TITLE
PARTS LIST
MULTIPLY MODULE: TRANSFER CONTROL BOARD
PART NO 216.5

APPROVED BY	FOR	DATE	ENG.	DRAWING NO.
	PROD	4-19-73	DLS	216.5D2
			DRAWN BY CAH	
			CHECKED dlb	DATE 6-24-72



NOTE: HOLES MARKED WITH AN "H" ARE FEED-THROUGH HOLES WITH NO COMPONENTS INSTALLED. THESE MUST BE KEPT FREE OF SOLDER (27 PLACES).

CHANGE NO.	DATE	DESCRIPTION

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

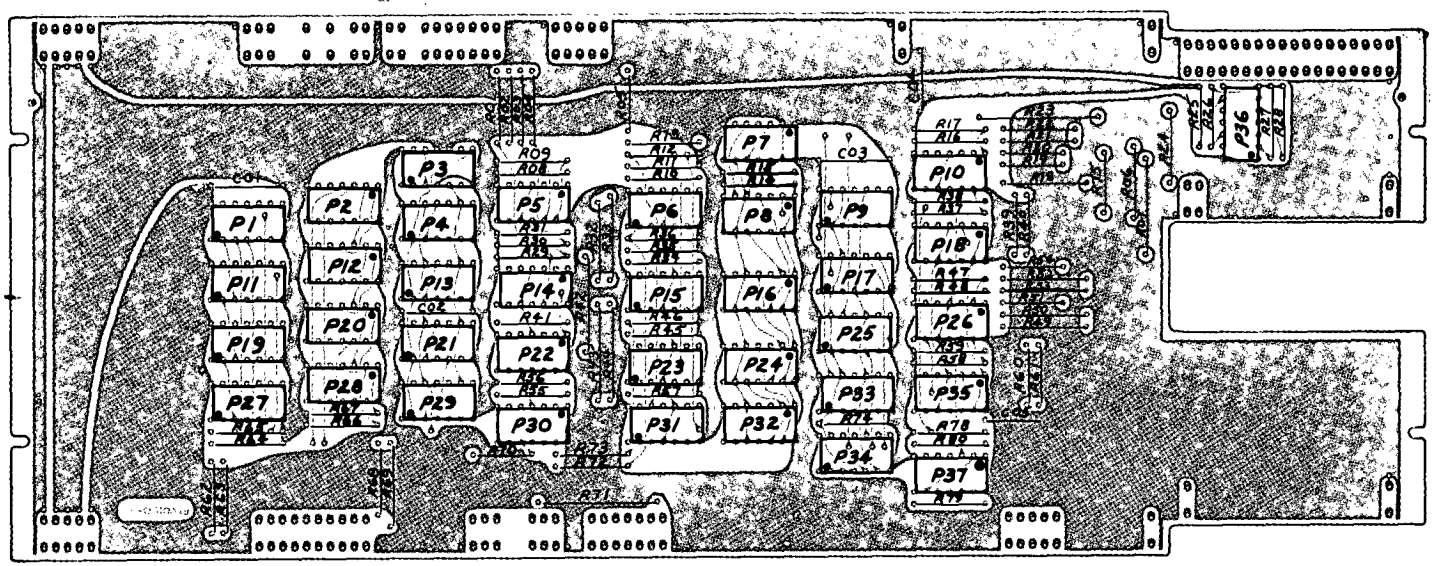
MACROMODULAR PROJECT

TITLE: FEED-THROUGH HOLE IDENTIFICATION
MULTIPLY MODULE: TRANSFER CONTROL BOARD
216.5

APPROVED BY	FOR	DATE
Clem	PROD	4-19-73

ENG. DLS
DRAWN BY CAH
CHECKED dls

DRAWING NO. 216.5D4
DATE 2-9-73



NOTE:

INSTALL FEMALE AMP MODU CONNECTORS EXACTLY
AS SHOWN IN DRAWING 200.50D2.

CHANGE NO.	DATE	DESCRIPTION

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

MACROMODULAR PROJECT

TITLE: COMPONENT IDENTIFICATION
MULTIPLY MODULE: DATA BOARD
PART NO. 216.6

APPROVED BY	FOR	DATE
Cam	PROD	4-19-73

ENG. DLS
DRAWN BY PLL
CHECKED dls

DRAWING NO. 216.6D1
DATE 6-26-72

INTEGRATED CIRCUITS

TYPE	REQUIRED	LOCATION
M04	1	P3
M04B	1	P34
M05	1	P7
M10	11	P8
		P9
		P16
		P17
		P18
		P24
		P25
		P32
		P33
		P35
		P37
M11	4	P4
		P13
		P21
		P29
M16	10	P5
		P6
		P14
		P15
		P22
		P23
		P30
		P31
		P10
		P26
M19	8	P1
		P2
		P11
		P12
		P19
		P20
		P27
		P28
M20	1	P36

RESISTORS

TYPE	REQUIRED	LOCATION
R0	5	R23
		R24
		R51
		R54
		R71
R1	19	R08
		R09
		R11
		R12
		R14
		R29
		R30
		R31
		R35
		R36
		R45
		R46
		R57
		R64
		R65
		R66
		R67
		R74
		R78
R2	13	R15
		R16
		R17
		R37
		R38
		R47
		R48
		R56
		R58
		R59
		R70
		R79
		R80
R3	25	R01
		R02
		R03
		R04
		R05
		R06
		R07
		R13

RESISTORS (cont.)

TYPE	REQUIRED	LOCATION
R3 (cont.)		R20
		R32
		R33
		R39
		R40
		R42
		R43
		R44
		R60
		R61
		R62
		R63
		R68
		R69
		R72
		R73
		R75
R4	4	R25
		R26
		R27
		R28
R5	8	R18
		R19
		R21
		R22
		R49
		R50
		R52
		R53
R9	4	R10
		R34
		R41
		R55

PRINTED CIRCUIT BOARD

PTV0150-3 1 Required

CAPACITORS

TYPE	REQUIRED	LOCATION
C1	4	C01
10,000 pfd		C02
(Type CK-103		C03
Sprague Ceramic		C04
Disk 50WVDC)		
C2	1	C05
(omit)		

CONNECTORS

Amp Modu Female No. 85863-4
85 Required

NOTES:

R0 = Jumper
R1 = 1,500 Ohms ±1% 1/8W Film Resistor
R2 = 750 Ohms ±1% 1/8W Film Resistor
R3 = 121 Ohms ±1% 1/8W Film Resistor
R4 = 15,000 Ohms ±5% 1/4 W Carbon Comp.
R5 = 57.6 Ohms ±1% 1/8W Film Resistor
R9 = 68 Ohms ±1% 1/8W Film Resistor

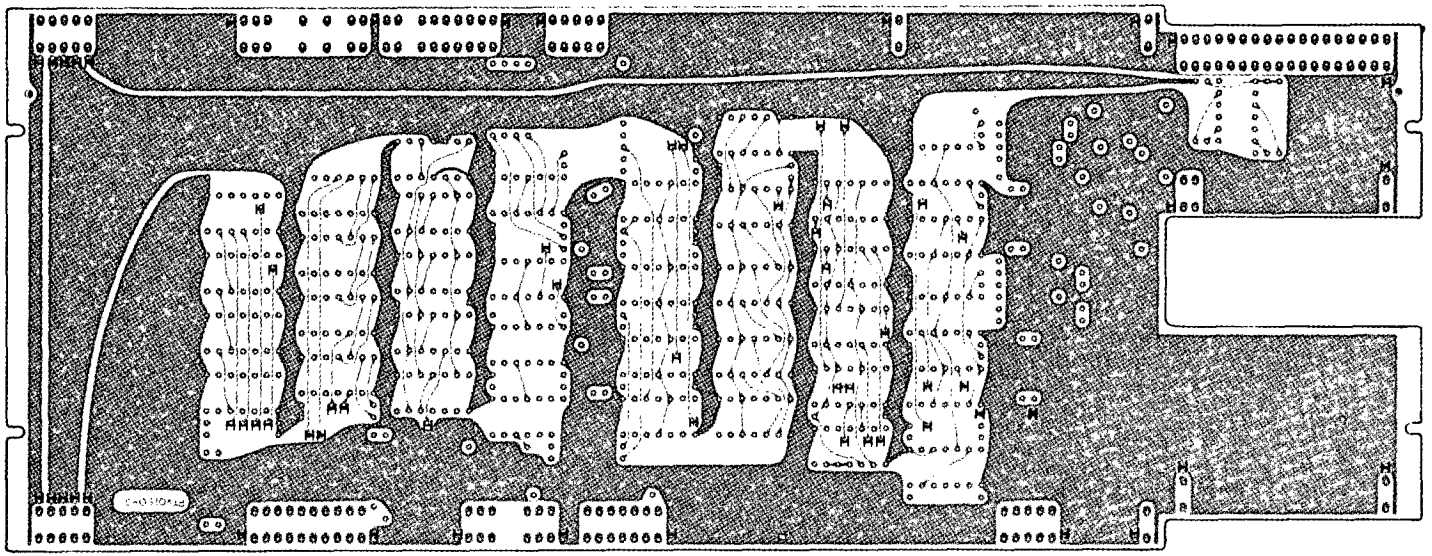
CHANGE NO.	DATE	DESCRIPTION

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

MACROMODULAR PROJECT

TITLE PARTS LIST
MULTIPLY MODULE: DATA BOARD
PART NO. 216.6

APPROVED BY	FOR	DATE	ENG.	DRAWING NO.
			DLS	
[illegible]	PROD	4-19-73	DRAWN BY CAH	216.6D2
			CHECKED dls	DATE 6-22-72



NOTE:

HOLES MARKED WITH AN "H" ARE FEED-THROUGH HOLES WITH NO COMPONENTS INSTALLED. THESE MUST BE KEPT FREE OF SOLDER (65 PLACES)

CHANGE NO.	DATE	DESCRIPTION

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

MACROMODULAR PROJECT

TITLE: FEED-THROUGH HOLE IDENTIFICATION
MULTIPLY MODULE: DATA BOARD
PART NO. 216.6

APPROVED BY	FOR	DATE
Cem	PROD	4-19-73

ENG. DLS
DRAWN BY CAH
CHECKED dls

DRAWING NO. 216.6D4
DATE 2-9-73

Test Procedure

Multiply Module Data Board #216.6

I. Preparation for Test:

A. Apply -5.2 VDC to T91, T92, T93

B. Apply Ground to T90, T94

C. Apply a square wave with the following parameters to T48

a) Period:600 Nsec

b) Ampliture:0.75 and -1.55V

c) Rise time: 10 Nsec or less

d) Fall time: 10 Nsec or less

D. Connect pulse generator ground to T51

II. Test Procedure:

A. Connect Channel 1 of 454 oscilloscope to T48

B. Connect Channel 2 of scope to pin 3 of package 37

C. Synchronize scope on Channel 1

D. Observe pulse wave form on Channel 2. The minimum pulse width must be greater than or equal to 15 nanoseconds. If additional pulse width is required insert a small capacitor in the location provided for C205. ($\leq$ 5pf.)

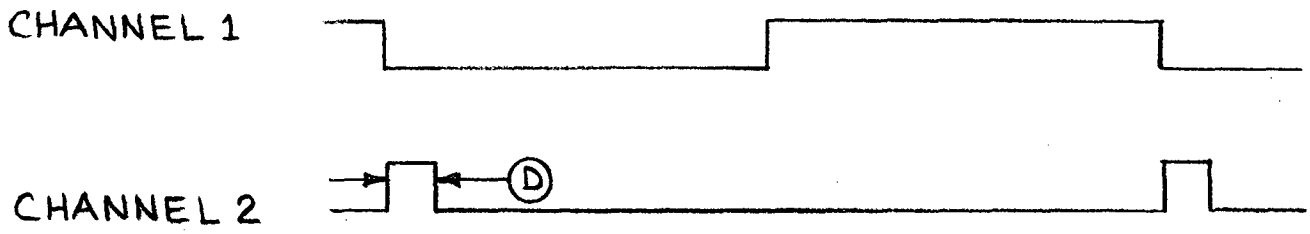
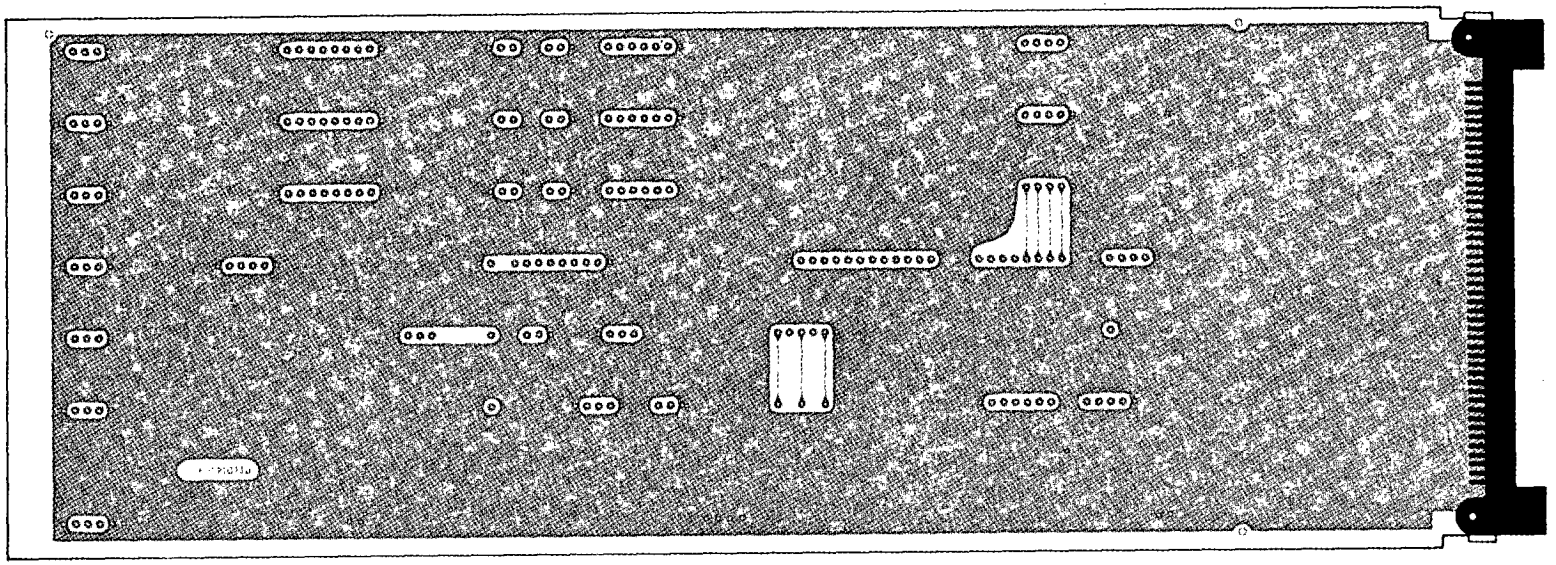


FIG 9

CHG.	E.C.O.	DATE	APPR.
1	0307	2-25-74	HCL



NOTE 1

SEE DRAWING NUMBER 200.50D26 FOR CONNECTOR MOUNTING ORIENTATION

NOTE 2

MALE AMP MODU PINS MUST BE INSTALLED FROM THIS SIDE IN ALL LOCATIONS
PRECISELY AS SHOWN IN DRAWINGS 200.50D2 AND 200.50D3 (218 PINS)

CHANGE NO.	DATE	DESCRIPTION

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

MACROMODULAR PROJECT

TITLE: COMPONENT IDENTIFICATION
MULTIPLY MODULE: TOP MOTHERBOARD
PART NO. 216.7

APPROVED BY	FOR	DATE
Cam	PROD	4-19-73

ENG. DLS
DRAWN BY CAH
CHECKED dls

DRAWING NO. 216.7D1
DATE 2-9-73

CONNECTORS

MALE AMP MODU NO. 85931-5

218 REQUIRED

AMP CONNECTOR NO. 1-202-845-5

1 REQUIRED

PRINTED CIRCUIT BOARD

PTT0145-3

1 REQUIRED

COMPUTER SYSTEMS LABORATORY WASHINGTON UNIVERSITY ST. LOUIS, MISSOURI	**MACROMODULAR PROJECT**	
	TITLE: PARTS LIST MULTIPLY MODULE: TOP MOTHER BOARD PART NO. 216.7	
	APPROVED BY: [signature] FOR: PROD DATE: 4-19-73	ENG: DLS; DRAWN BY: CSP; CHECKED: dls; DRAWING NO.: 216.7D2; DATE: 10-24-72

CHANGE NO.	DATE	DESCRIPTION

NOTE 1

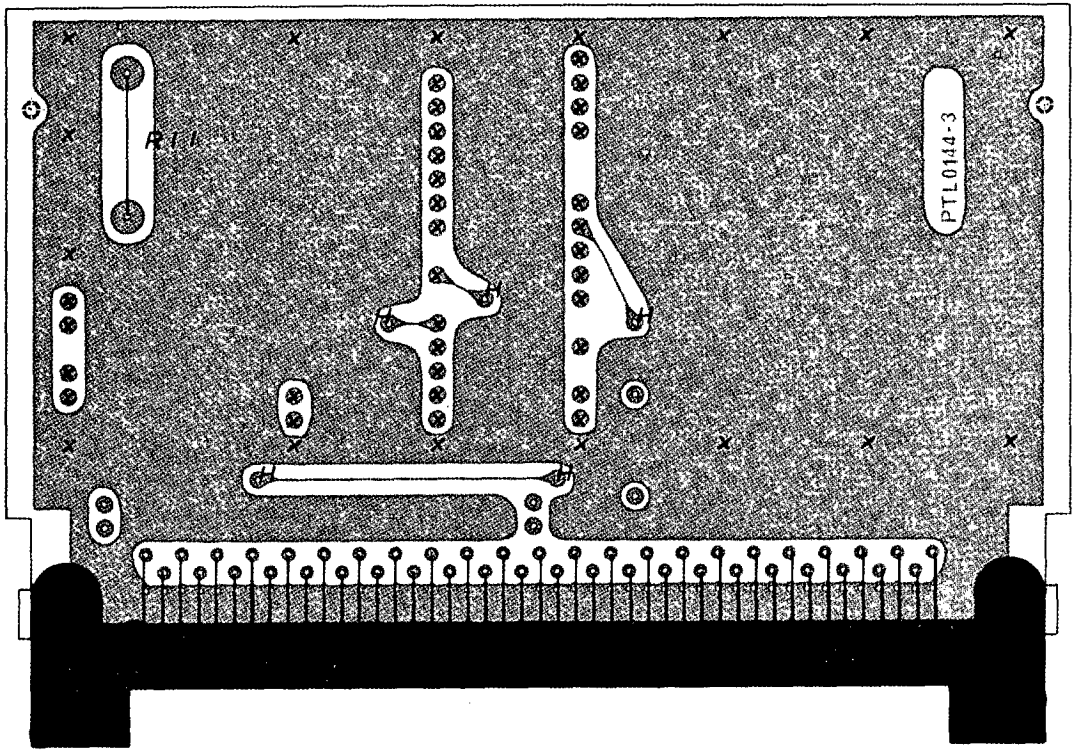
MALE AMP MODU PINS MUST BE INSTALLED FROM THIS SIDE IN LOCATIONS MARKED X PRECISELY AS SHOWN IN DRAWINGS 200.50D2 AND 200.50D3 (47 PINS).

NOTE 2

SEE DRAWING NO. 200.50D28 FOR CONNECTOR MOUNTING ORIENTATION.

NOTE 3

HOLES MARKED WITH A "H" INDICATE FEEDTHROUGH HOLES WITH NO COMPONENTS INSTALLED. THESE MUST BE KEPT FREE OF SOLDER (5 PLACES).



CHANGE NO.	DATE	DESCRIPTION

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

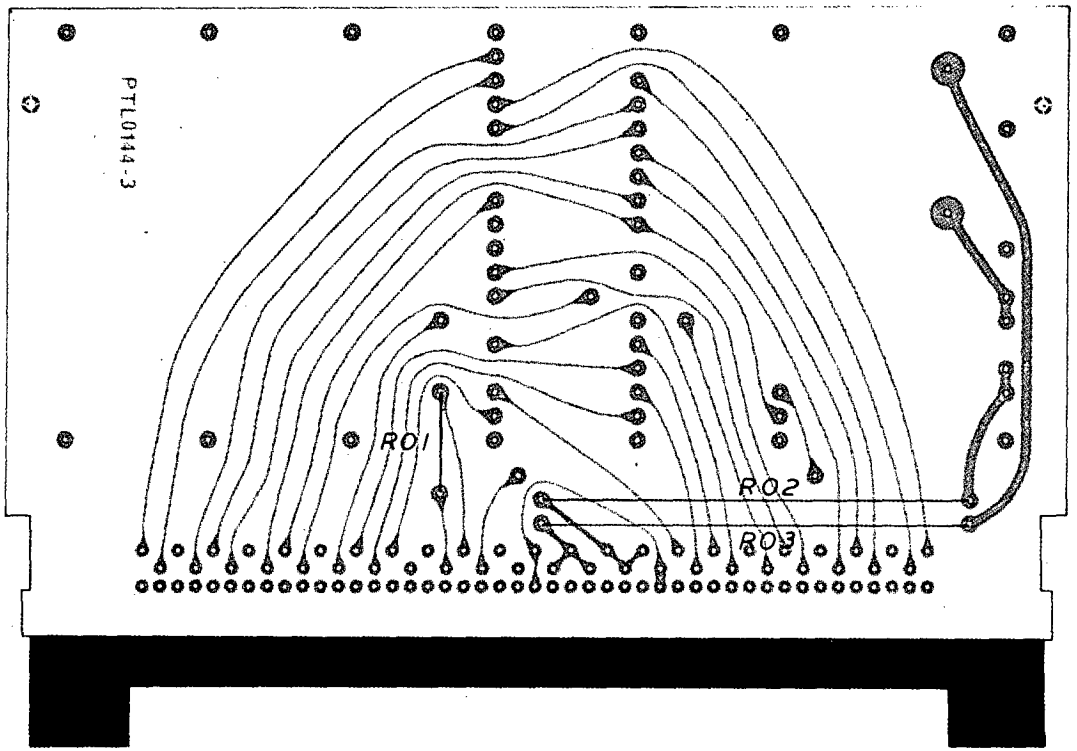
MACROMODULAR PROJECT

TITLE: COMPONENT IDENTIFICATION
MULTIPLY MODULE: UPPER LATERAL MOTHERBOARD
COMPONENT SIDE PART NO. 216.8

APPROVED BY	FOR	DATE
Cem	PROD	4-19-73

ENG. DLS
DRAWN BY CAH
CHECKED dlb

DRAWING NO. 216.8D1
DATE 2-15-73



CHANGE NO.	DATE	DESCRIPTION

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

MACROMODULAR PROJECT

TITLE
COMPONENT IDENTIFICATION
MULTIPLY MODULE: UPPER LATERAL MOTHERBOARD SIGNAL SIDE
PART NO. 216.8

APPROVED BY	FOR	DATE
Cerm	PROD	4-19-73

ENG DLS
DRAWN BY CAH
CHECKED dlb
DRAWING NO. 216.8D2
DATE 2-15-73

RESISTORS

R01=39,000 OHMS 5% 1/4 W CARBON COMP.
R02=ZERO OHMS (JUMPER)
R03=ZERO OHMS (JUMPER)

FUSE

R11 BUSSMAN GFA 2 AMP

CONNECTORS

MALE AMP MODU NO. 85931-5
47 REQUIRED

AMP CONNECTOR NO. 583464-1
1 REQUIRED

PRINTED CIRCUIT BOARD

PTL 0144-3
1 REQUIRED

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

MACROMODULAR PROJECT

TITLE: PARTS LIST
MULTIPLY MODULE: UPPER LATERAL MOTHERBOARD
PART NO. 216.8

CHANGE NO.	DATE	DESCRIPTION

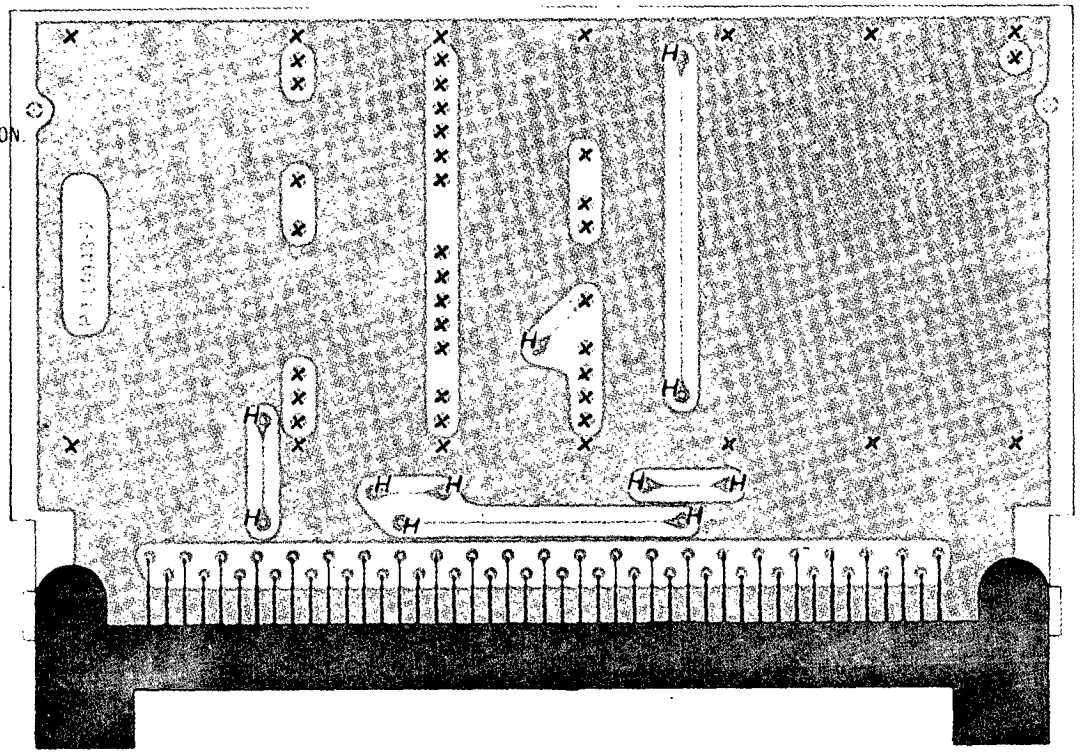
APPROVED BY	FOR	DATE
	PROD	4-19-73

ENG: DLS
DRAWN BY: CSP
CHECKED: dls
DRAWING NO.: 216.8D3
DATE: 10-24-72

NOTE 1: MALE AMP MODU PINS MUST BE INSTALLED FROM THIS SIDE IN LOCATIONS MARKED X PRECISELY AS SHOWN IN DRAWINGS 200.50D2 AND 200.50D3. (43 PINS)

NOTE 2: SEE DRAWING NO. 200.50D28 FOR CONNECTOR MOUNTING ORIENTATION.

NOTE 3: HOLES MARKED WITH A "H" INDICATE FEED-THROUGH HOLES WITH NO COMPONENTS INSTALLED. THESE MUST BE KEPT FREE OF SOLDER. (11 PLACES)



CHANGE NO	DATE	DESCRIPTION

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

MACROMODULAR PROJECT

TITLE: COMPONENT IDENTIFICATION
MULTIPLY MODULE: LOWER LATERAL MOTHER BOARD
PART NO. 216.9

APPROVED BY	FOR	DATE
Chris	PROD	4-19-73

ENG. DLS
DRAWN BY CSP
CHECKED dlo
DRAWING NO. 216.9D1
DATE 10-24-72

CONNECTORS

MALE AMP MODU NO. 85931–5
43 REQUIRED

AMP CONNECTOR NO. 583464–1
1 REQUIRED

PRINTED CIRCUIT BOARD

PTL0143–2
1 REQUIRED

COMPUTER SYSTEMS LABORATORY WASHINGTON UNIVERSITY ST. LOUIS, MISSOURI			MACROMODULAR PROJECT				
			TITLE: PARTS LIST MULTIPLY MODULE: LOWER LATERAL MOTHERBOARD PART NO. 216.9				
			APPROVED			ENG: DLS	DRAWING NO.: 216.9D2
			BY	FOR	DATE		
				PROD	4-19-73	DRAWN BY: CSP	
CHANGE NO.	DATE	DESCRIPTION				CHECKED: dls	DATE: 10–24–72

NOTE 1.

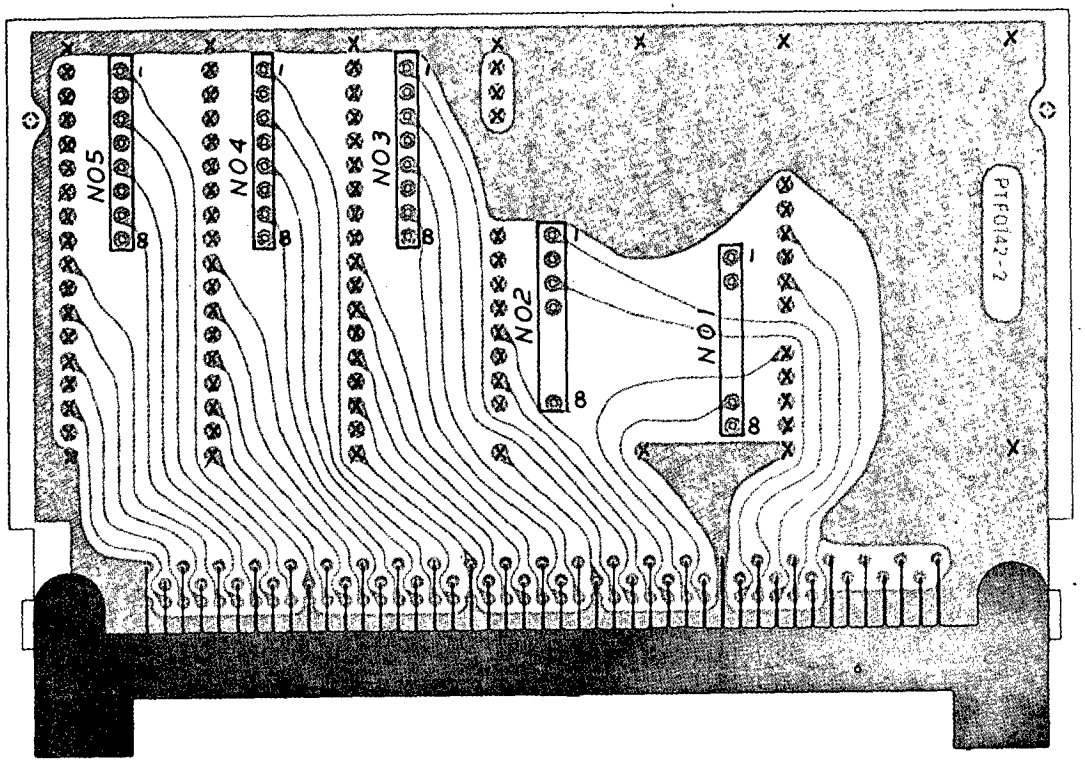
MALE AMP MODU PINS MUST BE INSTALLED FROM THIS SIDE IN LOCATIONS MARKED X PRECISELY AS SHOWN IN DRAWINGS 200.50D2 AND 200.50D3
(83 PINS)

NOTE 2.

SEE DRAWING NO. 200.50D29 FOR CONNECTOR MOUNTING ORIENTATION.

NOTE 3.

NO 1 CUT PINS 3,4,5,6
NO 2 CUT PINS 5,6,7



CHANGE NO.	DATE	DESCRIPTION

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

MACROMODULAR PROJECT

TITLE COMPONENT IDENTIFICATION
MULTIPLY MODULE: FACEPLATE MOTHERBOARD
PART NO. 216.10

APPROVED BY	FOR	DATE
Cerny	PROD	4-19-73

ENG DLS
DRAWN BY PLL
CHECKED dlb
DRAWING NO. 216.10D1
DATE 10-24-72

RESISTORS

TYPE	REQUIRED	LOCATION
LTN-2 NETWORK (SPRAGUE)	5	NO1 NO2 NO3 NO4 NO5

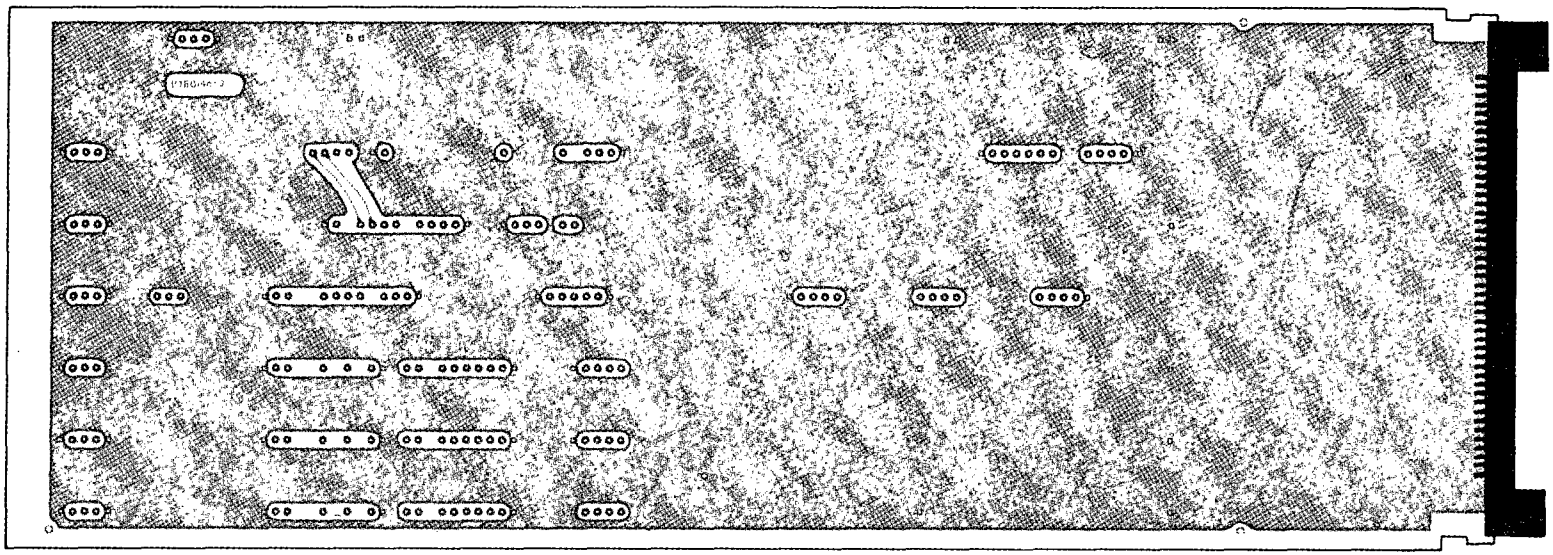
CONNECTORS

TYPE	REQUIRED
MALE AMP MODU NO. 85931-5	83
AMP NO. 583 464-1	1

PRINTED CIRCUIT BOARD

PTF 0142-2 1 REQUIRED

COMPUTER SYSTEMS LABORATORY WASHINGTON UNIVERSITY ST. LOUIS, MISSOURI			MACROMODULAR PROJECT		
			TITLE PARTS LIST MULTIPLY MODULE: FACEPLATE MOTHERBOA PART NO. 218.10		
			APPROVED BY: C.L.A.	FOR: PROD.	DATE: 4-19-73
			ENG: DLS	DRAWN BY: CAH	DRAWING NO.: 216.10D2
			CHECKED: dls	DATE: 10-24-72	
CHANGE NO.	DATE	DESCRIPTION			



NOTE 1

SEE DRAWING NUMBER 200.50D27 FOR CONNECTOR MOUNTING ORIENTATION.

NOTE 2

MALE AMP MODU PINS MUST BE INSTALLED FROM THIS SIDE IN ALL LOCATIONS PRECISELY AS SHOWN IN DRAWINGS 200.50D3 AND 200.50D3 (188 PINS)

CHANGE NO.	DATE	DESCRIPTION

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

MACROMODULAR PROJECT

TITLE: COMPONENT IDENTIFICATION
MULTIPLY MODULE: BOTTOM MOTHERBOARD
PART NO. 216.11

APPROVED BY	FOR	DATE
Clem	PROD	4-19-73

ENG. DLS
DRAWN BY C&H
CHECKED dls

DRAWING NO. 216.11D1
DATE 2-9-73

CONNECTORS

MALE AMP MODU NO. 85931–5

188 REQUIRED

AMP CONNECTOR NO.1–202–845–5

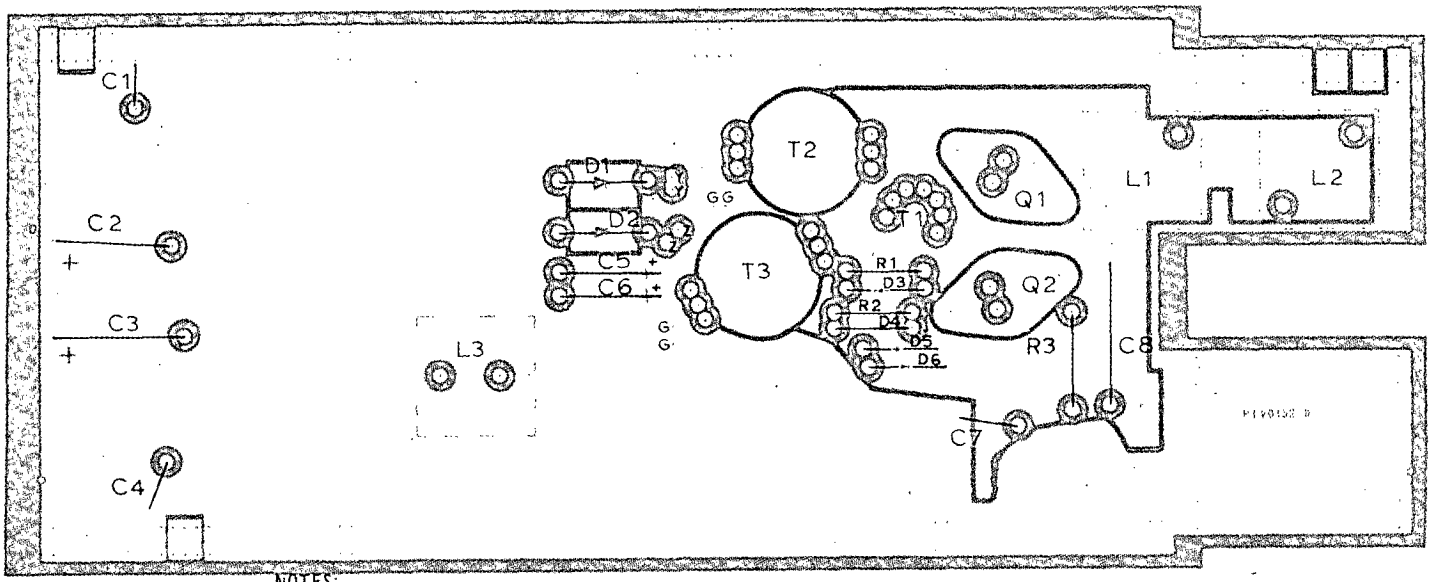
1 REQUIRED

PRINTED CIRCUIT BOARD

PTB0146–3

1 REQUIRED

COMPUTER SYSTEMS LABORATORY WASHINGTON UNIVERSITY ST. LOUIS, MISSOURI		**MACROMODULAR PROJECT**
		TITLE: PARTS LIST MULTIPLY MODULE:BOTTOM MOTHERBOARD PART NO 216.11
		APPROVED BY: [signature] FOR: PROD DATE: 4-19-73
		ENG: DLS DRAWN BY: CSP CHECKED: dlb DATE: 10–24–72
		DRAWING NO.: 216.11D2
CHANGE NO. / DATE / DESCRIPTION		



NOTES;

1) INSTALL FEMALE AMP MODU CONNECTORS AS SHOWN IN DRAWING 200.50D2
2) C5 AND C6 ARE STACKED COMPONENTS. SILICONE RUBBER, G.E. RTV-102 OR EQUIV., MUST BE USED BETWEEN AND UNDER THE CAPACITORS.
3) SILICONE RUBBER ALSO USED TO MOUNT L1, L2, L3, T2 AND T3. SEE CSL 010, PAGES 36 AND 37.
4) Q1 AND Q2 ARE MOUNTED USING A SILICONE HEAT SHRINKING COMPOUND (NO INSULATING WASHERS ARE REQUIRED) AND THE HARDWARE. THE SCREW HEADS ARE ON THE SIGNAL SIDE OF THE BOARD WITH A LOCK WASHER UNDER THE SCREW HEAD AND A LOCK WASHER UNDER THE NUT.
5) HOLES MARKED WITH A "G" (4 PLACES) RECEIVE THE TWISTED PAIR WIRES FROM T2 AND T3. THE HOLES MARKED WITH A "Y" (2PLACES) RECEIVE THE 2 WIRES, ONE EACH FROM T2 AND T3, MARKED WITH A "7". THE HOLES MARKED WITH A "Z" (2 PLACES) RECEIVE THE 2 WIRES, ONE EACH FROM T2 AND T3 MARKED WITH A "9".

CHANGE NO.	DATE	DESCRIPTION

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

MACROMODULAR PROJECT

TITLE COMPONENT IDENTIFICATION
MULTIPLY MODULE: POWER SUPPLY BOARD
PART NO. 216.12

APPROVED BY	FOR	DATE
TJC	PROD	Feb 5 73

ENG. TJC
DRAWN BY PLL
CHECKED TJC
DRAWING NO. 216.12D1
DATE 7-6-72

MAGNETIC COMPONENTS

(SEE PSS SERIES DOCUMENTS FOR MANUFACTURING INFORMATION)

TYPE	REQUIRED	LOCATION
MPS–L1	2	L1 L2
MPS–L4	1	L3
MMS–T1	1	T1
MPS–T2-47	2	T2 T3

SEMICONDUCTORS

TYPE	REQUIRED	LOCATION
1714–1402 (WESTINGHOUSE)	2	Q1 Q2
MBD5300 or 1N5823 (MOTOROLA)	2	D1 D2
MR810 (MOTOROLA)	4	D3 D4 D5 D6

FIXED RESISTORS

ALLEN BRADLEY TYPE EB OR EQUIV.
½W ±5% HOT MOLDED COMPOSITION

RESISTANCE (OHMS)	REQUIRED	LOCATION
16	2	R1 R2

FIXED RESISTORS (cont)

ALLEN BRADLEY TYPE EB OR EQUIV.
1 WATT ±5% HOT MOLDED COMPOSITION

RESISTANCE (OHMS)	REQUIRED	LOCATION
6800	1	R3

POLARIZED CAPACITORS

TYPE	REQUIRED	LOCATION
25ufd 60V (SPRAGUE TYPE 600D256G060DD4)	1	C8
180ufd (SPRAGUE TYPE 150D187X0006R2 OR MALLORY TAS187K006P1F)	2	C2 C3

CERAMIC CAPACITORS

TYPE	REQUIRED	LOCATION
0.01 ufd 100V (SPRAGUE TYPE C023B101F103M OR CENTRALAB DDM–103)	1	C7
0.47 ufd (SPRAGUE TYPE C05CA120P474Y OR CENTRALAB UK10–474)	4	C1 C4 C5 C6

CONNECTORS

AMP MODU FEMALE NO. 85863–4
38 REQUIRED

PRINTED CIRCUIT BOARD

PTV0152–0 ONE REQUIRED

HARDWARE

TYPE	REQUIRED
6–32 x 1/2" BINDING HEAD SCREW	4
INTERNAL STAR LOCK WASHERS FOR 6–32 SCREW	8
6–32 NUTS	4

CHANGE NO.	DATE	DESCRIPTION
1	2–16–73	E.C.O. 0285

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

MACROMODULAR PROJECT

TITLE: PARTS LIST
MULTIPLY MODULE: POWER SUPPLY BOARD
PART NO. 216.12

APPROVED BY	APPROVED FOR	APPROVED DATE	ENG.	DRAWING NO.
T.J.C.	PROD	12/5/73	TJC	216.12D2
			DRAWN BY CAH	
			CHECKED T.J.C.	DATE 7-6-72

See section 200.5 in Volume II for the description of MPS-L1.

See section 211.2 of this Volume for the description of MMS-T1.

PSS - 7

COMPUTER SYSTEMS LABORATORY

WASHINGTON UNIVERSITY

INDUCTOR DESCRIPTION AND SPECIFICATION

Part Number MPS-L4

216.12D2B

Inductor Description:

The inductor is a single layer coil of 18 ±1 turns of number 18 magnet wire wound on a *Magnetics Incorporated permalloy power toroidal core number 55120-A2. The magnet wire is insulated with polyurethane (sodereze or equal) for 90°C operation.

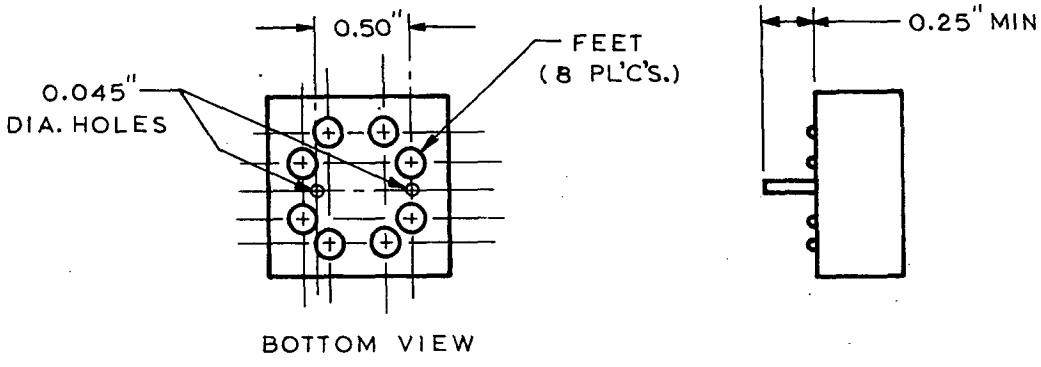
The wound inductor is potted in a **Milton Ross shell 50071 and header 60200 with Scotcheast number 222 polyurethane resin. The two leads of the wound inductor extend through the header as shown in the figure. The leads extend through the header a minimum of 0.25 inches and, beginning at a distance of 0.05 inch from the package , are tinned.

The characters "MPS-L4" in white, at least 0.1 inch high, appear on the top of the package.

Finished Inductor Specifications:

I. Identification: The characters "MPS-L4" in white at least 0.1 inch high will appear on the top of the inductor package and shall remain readable after hard rubbing with thumb.

II. Inductance: The inductance of the inductor shall be Lp>15μhy and Q>8 when measured on a General Radio type 1650-A impedance bridge. The bridge controls are set to: OSC LEVEL control adjusted for maximum output; the function switch to INT 1 KC; the CRL SELECTOR to Lp; and the CRL MULTIPLIER to 100μH.



*Magnetics Incorporated
Butler, Pa. 16001

**Milton Ross Company
511 South Street Pike Box 158
Southampton,Pa. 18966

PSS - 13

COMPUTER SYSTEMS LABORATORY

WASHINGTON UNIVERSITY

POWER TRANSFORMER DESCRIPTION AND SPECIFICATION

Part Number MPS-T2-47

216.12D2D

Trnasformer Description:

The coil form is a *Ferroxcube type number 2616PCB1 printed circuit bobbin. Windings T1 and T2 are first wound on the bobbin as a 47 turn bifilar winding of number 28 copper wire uniformly covering the length of the bobbin. Next, windings T3 and T4 are wound on the bobbin as a 3 turn bifilar winding of number 28 copper wire. A single layer of mylar tape 0.003 to 0.007 inch thick is then placed over the windings. Windings T5 and T6 are then wound on the bobbin as a 5 turn bifilar winding of number 18 copper wire. The wire insulation shall be polyurethane nylon overcoat (Nyleze) for 120°C operation.

Windings T1, T2, T3, and T4 are connected to the bobbins' pins as shown in Figures 1 and 2. The ends of windings T5 and T6 extend out the side shown in Figure 2 and are 1.5 to 1.75 inch long. Wires 8A and 8B must be identified together. WIRES 7 AND 9 MUST BE INDIVIDUALLY IDENTIFIED.

The wound bobbin is then placed inside two *Ferroxcube number 2616-L00-3B7 flat ground half-pot cores. The cores are then cemented together, with the center posts of the cores aligned, using Biggs R312 epoxy cement. The two slits in the side of the transformer are both completely filled with a rigid epoxy such as **Mista Pox 103. The completed transformer is then sprayed with a light coat of clear varnish.

Finished Transformer Specifications:

I. Identification: The characters "MPS-T2-47 at least 0.1 inches high will appear on the transformer and shall remain readable after hard rubbing with the thumb.

*Ferroxcube Corporation
Saugerties, New York

**M and R Plastics & Coatings, Inc.
11460 Dorsett Road
Maryland Heights, Mo. 63042

II. Turns: The number of turns on each winding must be exact:

a. T1 = 47 turns

b. T2 = 47 turns

c. T3 = 3 turns

d. T4 = 3 turns

e. T5 = 5 turns

f. T6 = 5 turns

III. Inductance: The inductance between pins 1 and 2 shall be L_p>10mhy and Q>15 with all other windings open circuited when measured on a General Radio type 1650-A impedance bridge. The bridge controls are set to: OSC LEVEL control adjusted for maximum output; the function switch to INT 1 KC; the CRL SELECTOR to L_p; and CRL MULTIPLIER to 10 mH.

IV. High Voltage Breakdown: Less than 0.1 milliampere shall flow when 200 V_{RMS} AC is applied for one minute across: pins 1, 2, and 3 shorted together and pins 4, 5, and 6 shorted together.

Less than 0.1 milliampere shall flow when 500 V_{RMS} Ac is applied for one minute across:

a. pins 1, 2, 3, 4, 5, and 6 shorted together and wires 7, 8A, 8B, and 9 shorted together.

b. pins 1, 2, 3, 4, 5, and 6 with wires 7, 8A, 8B, and 9 all shorted together and the core.

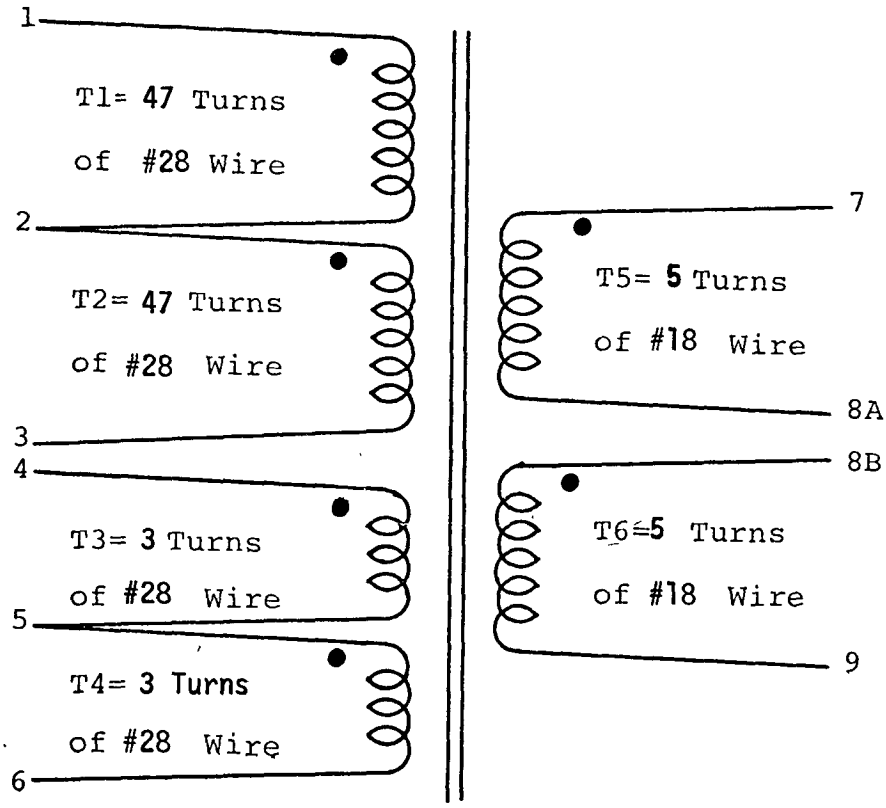
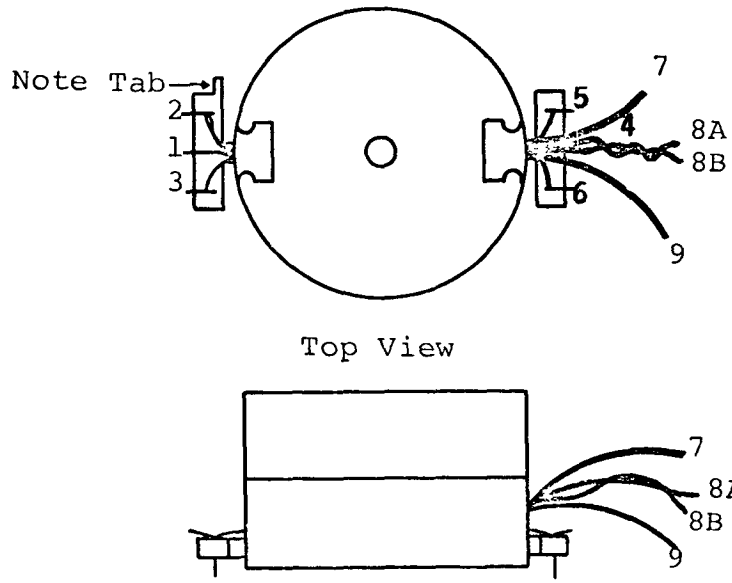


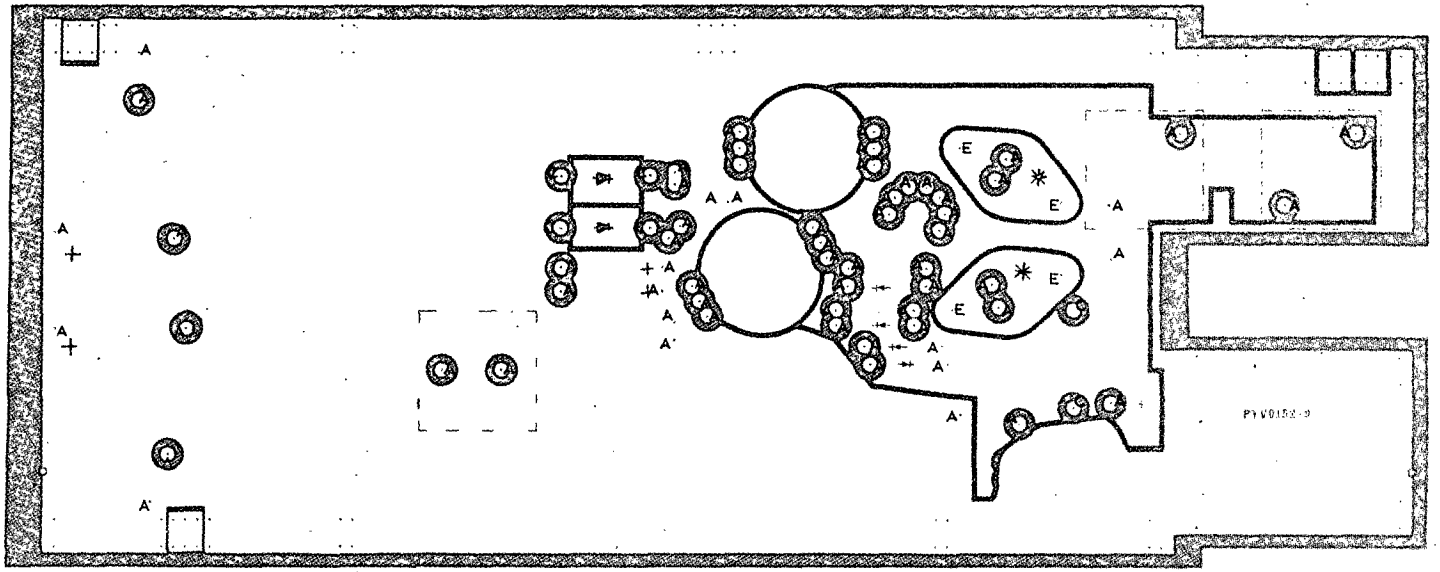
Figure 1



Top View

Figure 2

216.12D2G



TYPE A 65 PLACES
TYPE C 6 PLACES
TYPE E 4 PLACES
TYPE B ALL OTHERS (76 PLACES)

NOTE:

SEE CSL DOCUMENT 010 (GENERAL STANDARDS) PAGES 13 AND 14 FOR HOLE SIZES.

*THE FOUR HOLES IN EACH OF THE TWO DIAMONDS MUST NOT BE PLATED THROUGH.

CHANGE NO.	DATE	DESCRIPTION

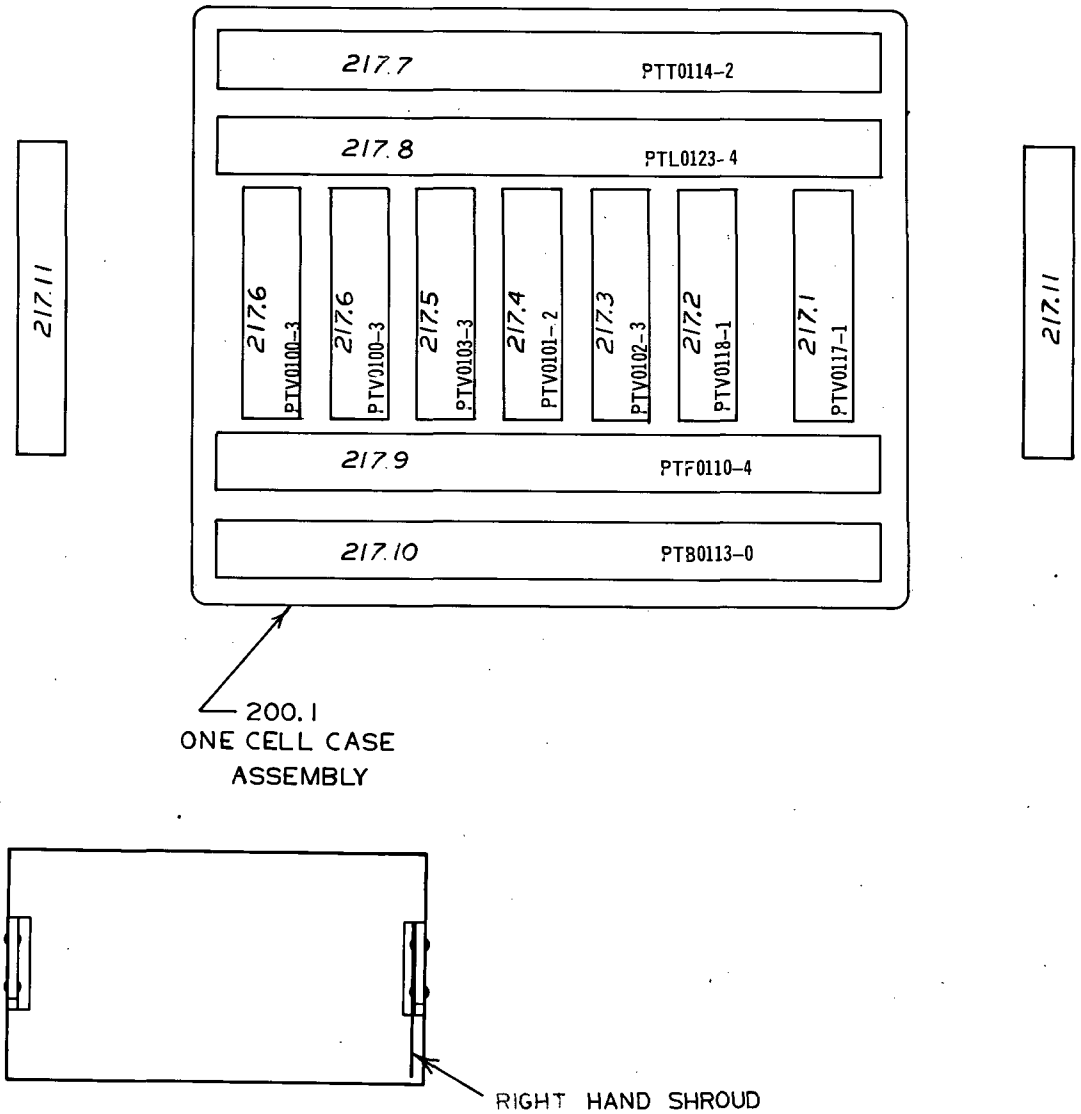
COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

MACROMODULAR PROJECT

TITLE: HOLE SIZES
MULTIPLY MODULE: POWER SUPPLY BOARD
PART NO. 216.12

APPROVED BY	FOR	DATE
T.J.C.	PROD	Feb. 5,73

ENG TJC
DRAWN BY PLL
CHECKED T.J.C.
DRAWING NO. 216.12D4
DATE 7-6-72



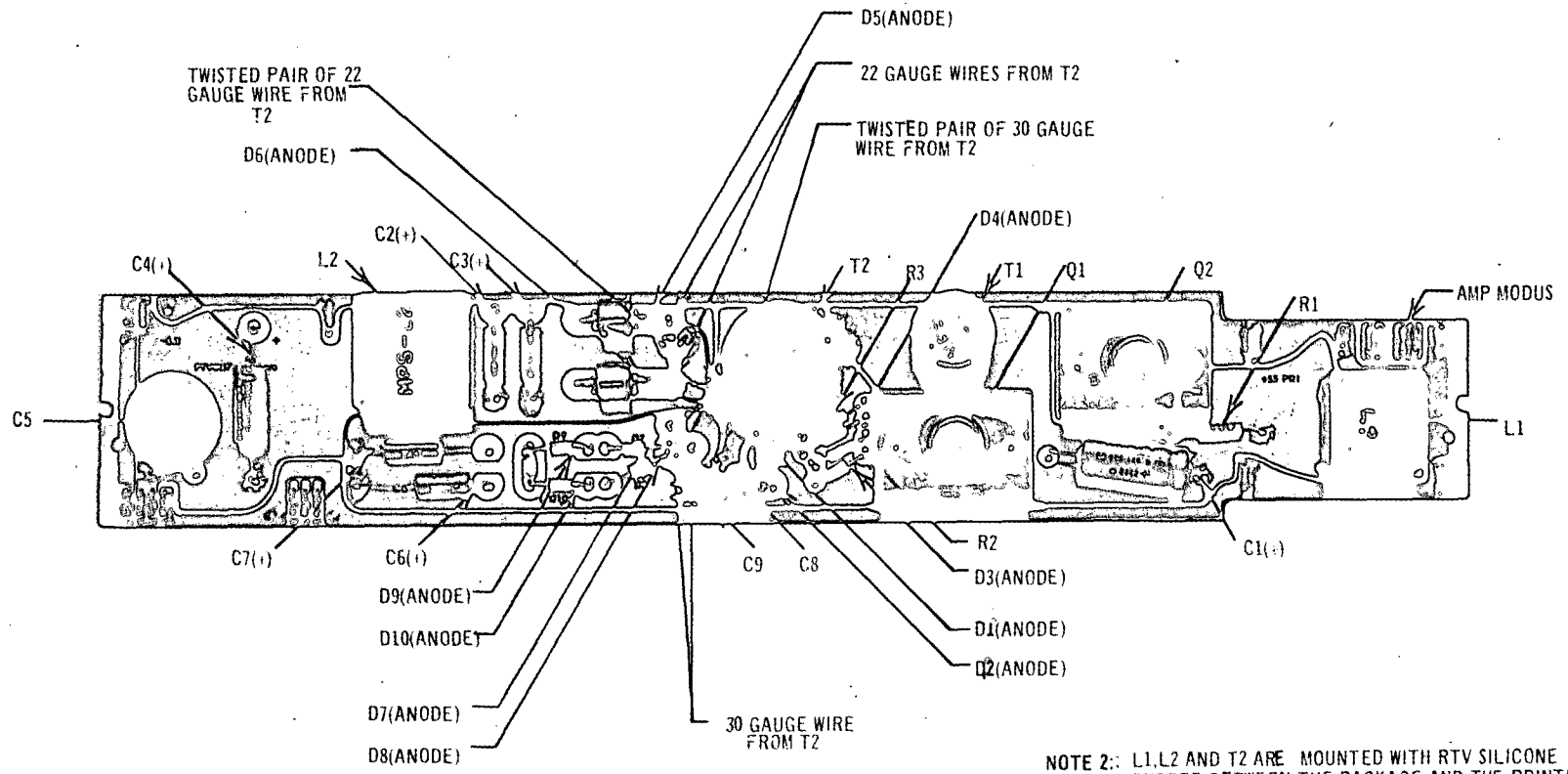
CHANGE NO.	DATE	DESCRIPTION

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

MACROMODULAR PROJECT

TITLE ASSEMBLY SCHEMATIC & PARTS LIST
D/A MODULE
PART NO. 217

APPROVED BY	FOR	DATE	ENG	DRAWING NO.
cem	Manuf	11-23-71	FUR	217.0D
			DRAWN BY PLL	
			CHECKED FJK	DATE 1-13-71



NOTE 1: INSTALL FEMALE AMP MODU CONNECTORS EXACTLY AS SHOWN ON DRAWING 200.50D2

NOTE 2:: L1,L2 AND T2 ARE MOUNTED WITH RTV SILICONE RUBBER BETWEEN THE PACKAGE AND THE PRINTED CIRCUIT BOARD

CHANGE NO.	DATE	DESCRIPTION

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

MACROMODULAR PROJECT

TITLE
COMPONENT IDENTIFICATION D/A MODULE POWER SUPPLY BOARD
PART NO. 217.1

APPROVED BY	FOR	DATE
Cem	PROD.	11-23-71

ENG. FUR
DRAWN BY MAK DHO
CHECKED [illegible]
DRAWING NO. 217.1D1
DATE 8-19-71

TRANSFORMERS

TWO REQUIRED

TYPE	LOCATION
MPS-T1	T1
MPS-T2-78-6-9-31	T2

INDUCTORS

TWO REQUIRED

TYPE	LOCATION
MPS-L3	L1
MPS-L2	L2

TRANSISTORS

TWO REQUIRED

TYPE	LOCATION
RCA 40374	Q1 Q2

DIODES

TEN REQUIRED

TYPE	LOCATION
MOTOROLA MR810	D1 D2 D3 D4 D7 D8 D9 D10
MOTOROLA SR1922A	D5 D6

CAPACITORS

NINE REQUIRED

TYPE	LOCATION
SPRAGUE ALUMINUM 600D 256 G060 DD4	C1
SPRAGUE TANTALUM 150D 475X 0050 B2	C2 C3 C6 C7
SPRAGUE TANTALUM 150D 187X 0006 R2	C4
SPRAGUE DISC CERAMIC C080A 120 P474 V	C5 C8 C9

RESISTORS

5% CARBON COMP.

THREE REQUIRED

TYPE	LOCATION
13 K OHM ½W	R1
75 OHM ¼ W	R2 R3

CONNECTORS

19 REQUIRED

AMPMODU 85863-4

PRINTED CIRCUIT BOARD

PTV0117-1

ONE REQUIRED

CHANGE NO.	DATE	DESCRIPTION

COMPUTER SYSTEMS LABORATORY

WASHINGTON UNIVERSITY

ST. LOUIS, MISSOURI

MACROMODULAR PROJECT

TITLE PARTS LIST
D/A MODULE POWER SUPPLY BOARD
PART NO. 217.1

APPROVED BY	APPROVED FOR	APPROVED DATE	ENG. FUR	DRAWING NO. 217.1D2
Cerm	Manuf.	11-23-71	DRAWN BY MBP	
			CHECKED FUR	DATE 3-18-71

See section 200.5 in Volume II for the description of MPS-T1 and MPS-L2.

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COMPUTER SYSTEMS LABORATORY

WASHINGTON UNIVERSITY

POWER TRANSFORMER DESCRIPTION AND SPECIFICATION

Part Number MPS-T2-78-6-9-31

217.1D2B

Transformer Description:

The coil form is a *Ferroxcube type number 2616PCB1 printed circuit bobbin.

Windings T1 and T2 are first wound on the bobbin as a 78 turn bifilar winding of number 30 copper wire uniformly covering the length of the bobbin. Next, windings T3 and T4 are wound on the bobbin as a 6 turn bifilar winding of number 30 copper wire. A single layer of tape (Mylar or equivalent) less than 0.007 inch thick is then placed over the windings. Windings T5 and T6 are then wound on the bobbin as a 9 turn bifilar winding of number 22 copper wire. Windings T7 and T8 are then wound on the bobbin as a 31 turn bifilar winding of number 30 copper wire. The wire insulation shall be polyurethane nylon overcoat (Nyleze) or better for 120°C operation.

Windings T1, T2, T3, and T4 are connected to the bobbins' pins as shown in Figures 1 and 2. The ends of windings T5, T6, T7, and T8 extend out the side shown in Figure 2 and are 0.7 to 1.0 inch long. Wire pairs 8A, 8B, and 11A, and 11B must each be identified together. Wires 7, 9, 10, and 12 need not be individually identified.

The wound bobbin is then placed inside two *Ferroxcube number 2616P-L00-3B7 flat ground half-pot cores. The cores are then cemented together, with the center posts of the cores aligned, using Biggs R312 epoxy cement. The two slits in the side of the transformer are both completely filled with a rigid epoxy such as **Mista Pox 103. The completed transformer is then sprayed with a light coat of clear varnish.

Finished Transformer Specifications:

I. Identification: The characters "MPS-T2-78-6-9-31" at least 0.1 inches high will appear on the transformer and shall remain readable after hard rubbing with the thumb.

*Ferroxcube Corporation
Saugerties, New York

**M and R Plastics & Coatings, Inc.
11460 Dorsett Road
Maryland Heights, Mo. 63042

II. Turns: the number of turns on each winding must be exact:

a. T1 = 78 turns

b. T2 = 78 turns

c. T3 = 6 turns

d. T4 = 6 turns

e. T5 = 9 turns

f. T6 = 9 turns

g. T7 = 31 turns

h. T8 = 31 turns

III. Inductance: The inductance between pins 1 and 2 shall be Lp>16mhy and Q>15 with all other windings open circuited when measured on a General Radio type 1650-A impedance bridge. The bridge controls are set to: OSC LEVEL control adjusted for maximum output; the function switch to INT 1 KC; the CRL SELECTOR to Lp; and the CRL MULTIPLIER to 10 mH.

IV. High Voltage Breakdown: Less than 0.1 milliampere shall flow when 200 V_{RMS} Ac is applied for one minute across:

a. pins 1,2, and 3 shorted together and pins 4,5, and 6 shorted together.

b. wires 7, 8A, 8B, and 9 shorted together and wires 10, 11A, 11B, and 12 shorted together.

Less than 0.1 milliampere shall flow when 500 V_{RMS} AC is applied for one minute across:

a. pins 1, 2, 3, 4, 5, and 6 shorted together and wires 7, 8A, 8B 9, 10, 11A, 11B, and 12 shorted together.

b. pins 1, 2, 3, 4, 5, and 6 with wires 7, 8A, 8B, 9, 10, 11A, 11B, and 12 all shorted together and the core.

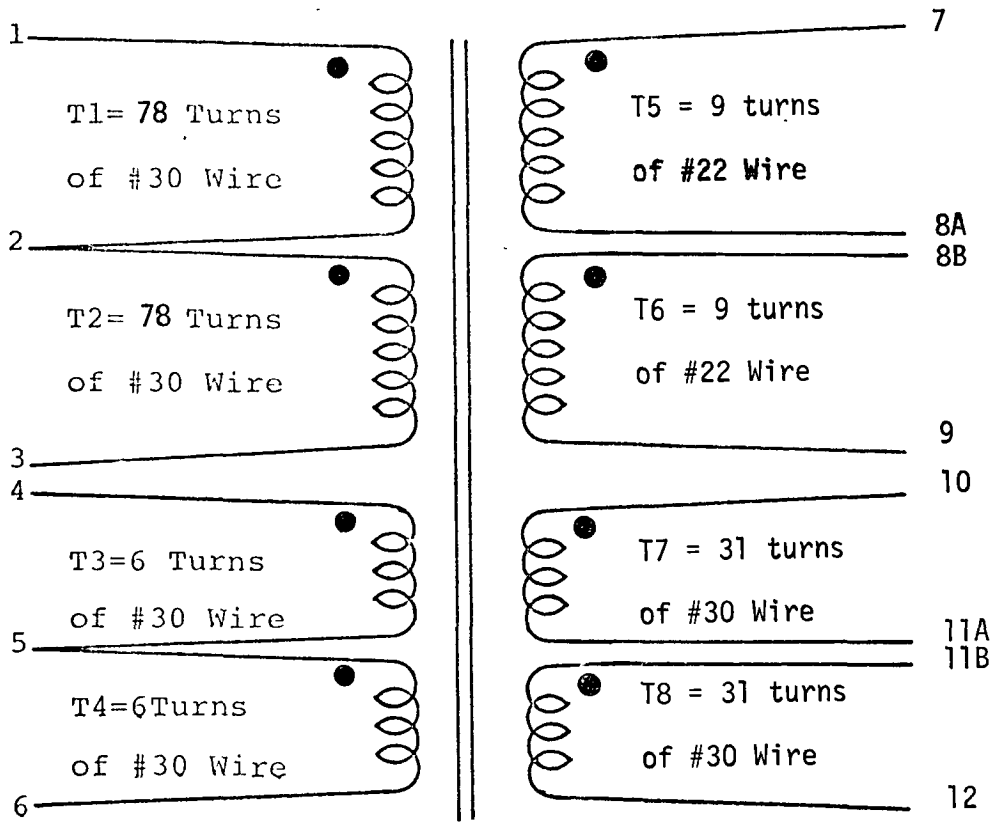
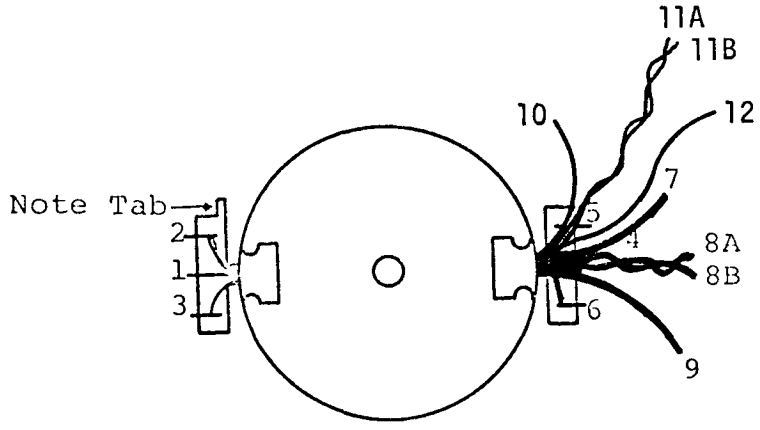


Figure 1



Top View

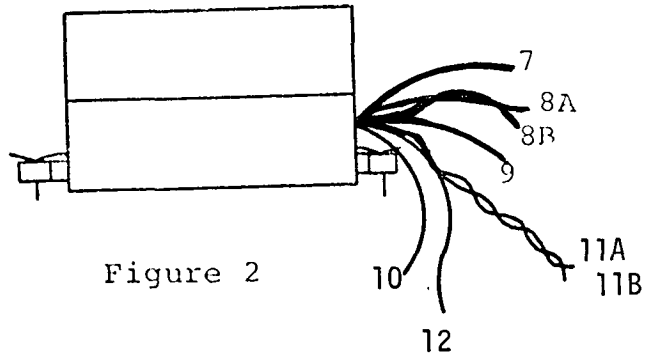


Figure 2

PSS - 6

COMPUTER SYSTEMS LABORATORY

WASHINGTON UNIVERSITY

INDUCTOR DESCRIPTION AND SPECIFICATION

Part Number MPS-L3

217.1D2F

Inductor Description:

The package contains 2 inductors. Each is a single layer coil of 35 $\pm$1 turns of number 24 magnet wire wound on a *Magnetics Incorporated permalloy power toroidal core number 5118-A2. The magnet wire is insulated with polyurethane (sodereze or equal) for 90°C operation.

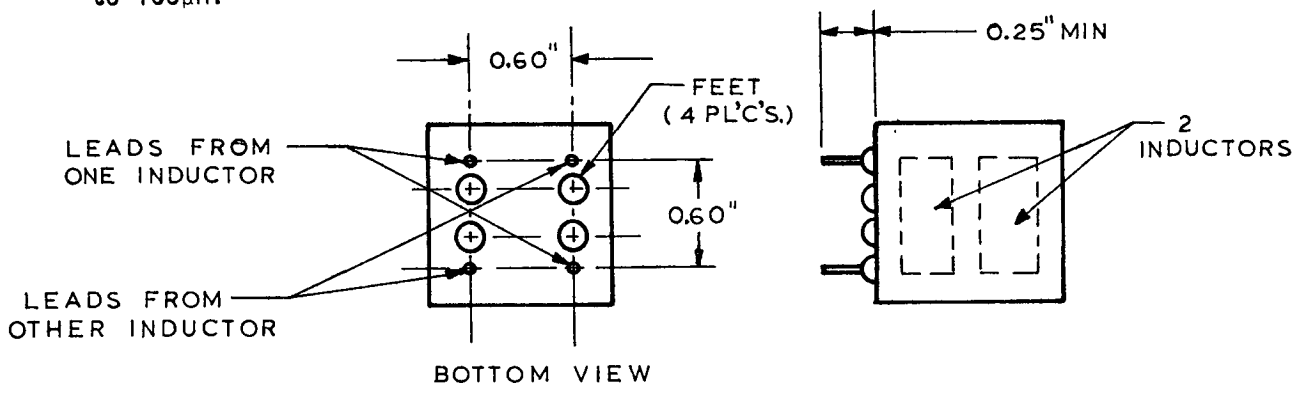
The wound inductors are potted in a **Grayhill Moldtronics shell 3B2143-2 and header 3B2040-2 with Scotcheast number 222 polyurethane resin. The two leads of each of the wound inductor extend through the header as shown in the figure. The leads extend through the header a minimum of 0.25 inches and, beginning at a distance of 0.05 inch from the package, are tinned.

The characters "MPS-L3" in white at least 0.1 inch high appear on the top of the package.

Finished Inductor Specifications:

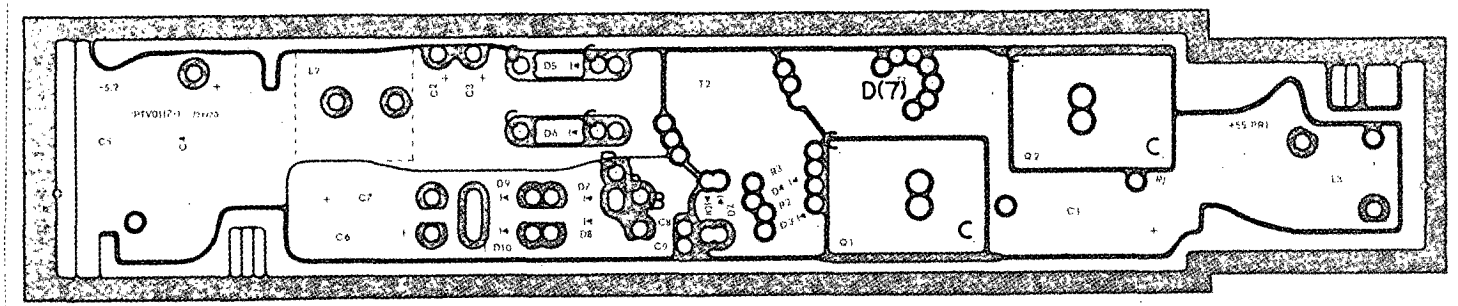
I. Identification: The characters "MPS-L3" in white at least 0.1 inch high will appear on the top of the inductor package and shall remain readable after hard rubbing with thumb.

II. Inductance: The inductance of each inductor shall be Lp>100μhy and Q>8 when measured on a General Radio type 1650-A impedance bridge. The bridge controls are set to: OSC LEVEL control adjusted for maximum output; the function switch to INT 1 KC; the CRL SELECTOR to Lp; and the CRL MULTIPLIER to 100μH.



*Magnetics Incorporated
•Butler, Pa. 16001

**Grayhill Moldtronics, Inc.
703 Rogers St.
Downers Grove, Ill,60515



TYPE B 3 PLACES

TYPE C 8 PLACES

TYPE D 7 PLACES

TYPE A ALL OTHERS (101 PLACES)

SEE: CSL DOCUMENT GENERAL STANDARDS 010 (PAGES 13 & 14)
FOR HOLE SIZES.

CHANGE NO.	DATE	DESCRIPTION

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

MACROMODULAR PROJECT

TITLE: D/A MODULE POWER SUPPLY BOARD
HOLE SIZES

APPROVED BY	FOR	DATE
Cerw	Manuf.	11-23-71

ENG. FUR
DRAWN BY
CHECKED FUR

DRAWING NO. 217.1D4
DATE 9-22-71

This does not apply to any other converter boards. The assembly specifications are the same as specified in CSL Document "General Standards 010" (pages 35-37) with the following exceptions:

3. (a) First sentence should read:

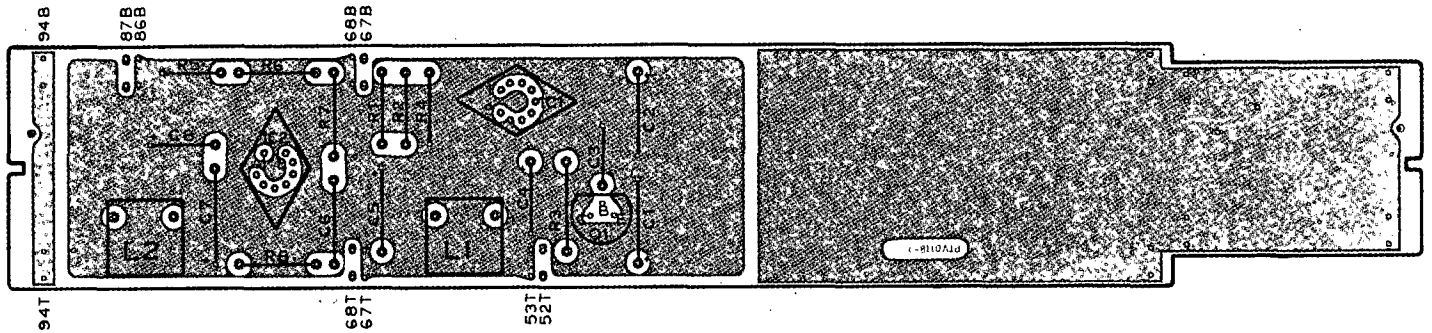
L1 may be mounted in four orientations, any of these is acceptable.

4. (b) The last sentence in the paragraph should read:

The wire leads extending from T2 shall be inserted in the P. C. board holes as shown on parts placement document.

CHG.	E.C.O.	DATE	APPR.
X	X	11-23-71	cem

NOTE: INSTALL FEMALE AMP MODU CONNECTORS EXACTLY AS SHOWN IN DRAWING 200.50D2.



CHANGE NO	DATE	DESCRIPTION

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

MACROMODULAR PROJECT

TITLE: COMPONENT IDENTIFICATION
D/A MODULE SERIES REGULATOR
PART NO. 217.2

APPROVED BY	FOR	DATE
Cerr	Manuf	11-23-71

ENG. FUR
DRAWN BY PLL
CHECKED FUR

DRAWING NO. 217.2D1
DATE 7-29-71

RESISTORS
EIGHT REQUIRED

TYPE	LOCATION
510 OHMS 1/4 WATT 5% CARBON COMP.	R1
1300 OHMS 1/4 WATT 5% CARBON COMP.	R6
22.1K OHMS 1/8 WATT 1% METAL FILM	R2
	R7
3.0 OHMS ¼WATT, 5% CARBON COMP	R3
6.8K OHMS 1/8 WATT, 1% METAL FILM	R4
	R5
8.2 OHMS ¼WATT, 5% CARBON COMP	R8

CAPACITORS
EIGHT REQUIRED

TYPE	LOCATION
SPRAGUE TANTALUM	C1
150D 106X 0020B2 10μf 20V	C5
SPRAGUE TANTALUM	C2
150D 105X 0035A2 1μf 35V	C8
SPRAGUE DISC CERAMIC	C3
C016B 102 G102M .001μf	C6
SPRAGUE TANTALUM	C4
150D 475X 0050B2 4.7μf 50V	C7

INDUCTORS
TWO REQUIRED

TYPE	LOCATION
MPS-L2	L1
	L2

TRANSISTORS
ONE REQUIRED

TYPE	LOCATION
2N4400	Q1

SERIES REGULATORS (MOTOROLA)

TYPE	LOCATION
MC1469R	IC1
MC1463R	IC2

PRINTED CIRCUIT BOARD

ONE REQUIRED
PTV0118-1

CONNECTORS

SIXTEEN REQUIRED
AMPMODU NO. 85863-4

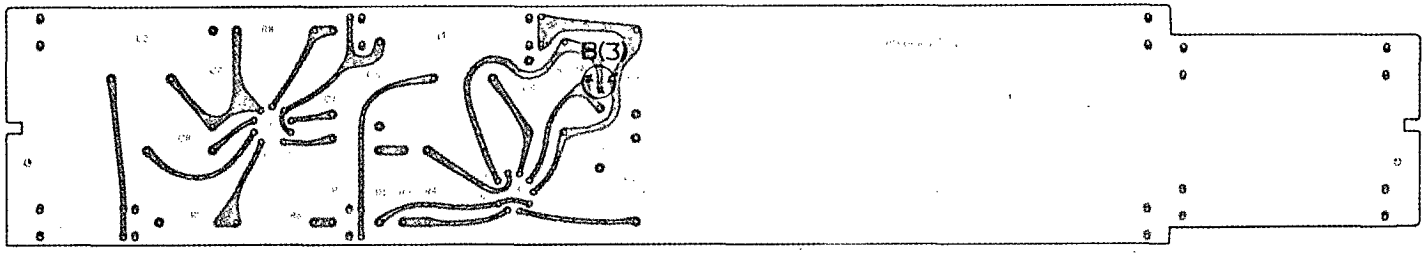
CHANGE NO.	DATE	DESCRIPTION

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

MACROMODULAR PROJECT

TITLE
PARTS LIST
D/A MODULE SERIES REGULATOR BOARD
PART NO. 217.2

APPROVED BY	APPROVED FOR	APPROVED DATE	ENG.	DRAWING NO.
Cerr	Manuf.	11-23-71	FUR	217.2D2
			DRAWN BY MBP	
			CHECKED FUR	DATE 1-29-71



TYPE B MARKED X 3 PLACES

TYPE A ALL OTHERS 86 PLACES

SEE CSL DOCUMENT GENERAL STANDARDS 010 (PAGES 13 & 14)
FOR HOLE SIZES

CHANGE NO.	DATE	DESCRIPTION

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

MACROMODULAR PROJECT

TITLE: D/A MODULE SERIES REGULATOR BOARD
HOLE SIZES

APPROVED BY	FOR	DATE
cem	Manuf.	11-23-71

ENG. FUR
DRAWN BY
CHECKED FUR
DRAWING NO. 217.2D4
DATE 9-22-71

Assembly Specification for Series Regulator Board 217.2

General:

Unless specifically modified herein, general assembly specification 010-24 thru 010-34 applies.

Assembly:

1. Axial-lead Components:

   (a) Orientation

   Those components requiring orientation (electrolytic capacitors and diodes) have orientation specified on the assembly document. Diode polarity is given by a white band, which designates the cathode end; or a diode symbol on the case of the diode. Capacitor polarity is printed as (+) or (-) on the capacitor body.

   (b) Insertion

   There is no standard distance between mounting holes. Components are formed to fit. Leads may be bent if required for secure mounting during handling and soldering. Bent leads must be trimmed so that they do not extend beyond the edge of the conductor to which they are soldered.

2. IC1 and IC2

   (a) Orientation

   IC1 and IC2 will fit the mounting holes in only one orientation. In no instance is the orientation to be based upon the identification number or the date code orientation.

CHG.	E.C.O.	DATE	APPR.
X	X	11-23-71	Com

(b) Insertion

IC1 and IC2 are to be inserted fully, so that their cases are in contact with the surface of the printed circuit board. The leads may be bent if required for secure mounting during handling and soldering. Bent leads must be trimmed so that they do not extend beyond the edge of the conductor to which they are soldered. The cases must be hand soldered to the ground plane on the board.

Inductors:

(a) Orientation

L1 must be mounted to provide maximum spacing between L1 and C4. L2 must be mounted to provide maximum spacing between L2 and C7. In no instance is the orientation of either inductor to be based on the identification number orientation.

(b) Insertion

The inductors are mounted with RTV silicone rubber between the inductor and the printed circuit board. The inductor feet shall be within 0.020 inches of the printed circuit board and the RTV shall fill at least 3/4 of the area under the inductor. No RTV shall extend more than 0.050 inches beyond the edge of the inductor. The leads may be bent if required for secure mounting during handling and soldering. Bent leads must be trimmed so that they do not extend beyond the edge of the conductor to which they are soldered.

CHG.	E.C.O.	DATE	APPR.
X	X	11-23-71	CWM

Test Procedure

D/A Module Series Regulator Board #217.2

This board contains four resistors whose value must be selected to provide the desired output voltages of plus and minus 15 volts.

Procedure

Test 1:

Connect Pins 68B and 86B to ground. Connect a decade resistor box with an accuracy of .1% or less and set to 22K ohms between pins 8 and 9 of IC1. Place a 1K resistor from pin 52T to ground and apply +20 volts to pin 67B. Adjust the decade box resistance until the voltage measured at pin 52T is between +14.975 volts and 15.025 volts. Select the value of R2 from the following table and select R1 so that the sum of R1 and R2 equals the decade box setting.

Decade Box Setting	R2
less than 22K	20K
22.2K to 23.8K	22.1K
greater than 23.8K	22.7K

Remove the decade box, install R1 and R2, and measure the output voltage at pin 52T. If the voltage is within the range +14.850 to +15.150 volts proceed to test 2. If the voltage is outside the range +14.850 to +15.150 the value of R1 must be increased or decreased to bring the voltage within range.

Test 2:

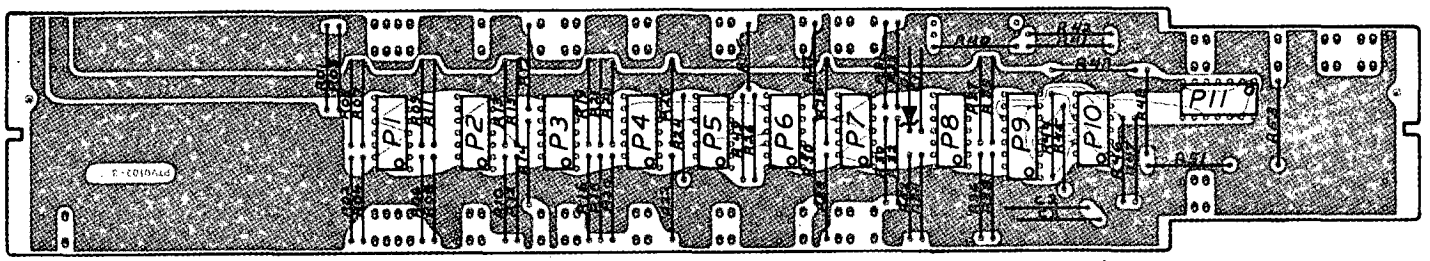
Connect Pins 68B and 86B to ground. Connect a decade resistor box with an accuracy of .1% or less and set to 22K ohms between pins 8 and 9 of IC2. Place a 1K resistor from pin 68T to ground and apply -20 volts to pin 87B. Adjust the decade box resistance until the voltage measured at pin 68T is between -14.975 volts and -15.025 volts. Select the value of R7 from the following table and select R6 so that the sum of R6 and R7 equals the decade box setting.

Decade Box Setting	R7
less than 22K	20K
22.2K to 23.8K	22.1K
greater than 23.8K	22.7K

CHG.	E.C.O.	DATE	APPR
1	0307	2/4/74	TVR

Remove the decade box, install R6 and R7 and measure the output voltage at pin 68T. If the voltage is outside the range +14.850 to +15.150 the value of R6 must be increased or decreased to bring the voltage within range.

INSTALL FEMALE AMPMODU CONNECTORS
EXACTLY AS SHOWN ON DWG. 200.50D2.



CHANGE NO	DATE	DESCRIPTION

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

MACROMODULAR PROJECT

TITLE: COMPONENT IDENTIFICATION
D/A MODULE CONTROL BUS BOARD
PART NO. 217.3

APPROVED BY	FOR	DATE
Cem	Manuf.	11-23-71

ENG: FUR
DRAWN BY: DHO
CHECKED: FUR

DRAWING NO: 217.3D1
DATE: 11-17-71

INTEGRATED CIRCUITS

TYPE	REQUIRED	LOCATION
M04	1	P8
M04B	2	P2 P4
M10	2	P5 P6
M20	1	P11
M30	3	P1 P3 P7
M35	1	P10
M39	1	P9

CAPACITORS*

TYPE	REQUIRED	LOCATION
1200 pf	2	C02 C03

DIODES**

TYPE	REQUIRED	LOCATION
1N5231B	1	D01

*DIPPED SILVER MICA 5% 50 WVDC
**5.2 VOLT 400 MILLI WATT ZENER

RESISTORS

TYPE	REQUIRED	LOCATION
R0	2	R51 R53
R1	19	R05 R07 R09 R11 R13 R14 R15 R19 R21 R23 R25 R29 R30 R32 R37 R39 R43 R48 R49
R2	4	R44 R45 R46 R47
R3	18	R02 R04 R06 R08 R10 R12 R16 R17 R18 R20 R22 R24 R27 R28 R31 R33 R35 R41

RESISTORS (cont)

TYPE	REQUIRED	LOCATION
R4	5	R01 R03 R26 R42 R50
R5	2	R36 R38
R9	2	R34 R52

CONNECTORS
AMPMODU NO. 85863-4
58 REQUIRED

CIRCUIT BOARD
PTV0102-3
ONE REQUIRED

NOTE:

R1 = 1.5K OHM 1% FILM RESISTOR
R2 = 750 OHM 1% FILM RESISTOR
R3 = 121 OHM 1% FILM RESISTOR
R4 = 15K OHM 5% ¼WATT CARBON COMP.
R5 = 57.6 OHM 1% FILM RESISTOR
R9 = 910 OHM 5% ¼WATT CARBON COMP.

CHANGE NO.	DATE	DESCRIPTION

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

MACROMODULAR PROJECT

TITLE
PARTS LIST
D/A MODULE CONTROL BUS BOARD
PART NO. 217.3

APPROVED BY	APPROVED FOR	APPROVED DATE	ENG. FUR	DRAWING NO. 217.3D2
Cerr	Manuf.	11-23-71	DRAWN BY MBP	
			CHECKED FUR	DATE 1-22-71

Test Procedure

D/A Module Control Bus Board #217.3

This board contains two critical delays whose proper value must be checked on each board prior to assembly into a D/A Module.

Both delay values must be between a specified minimum and maximum value.

Procedure

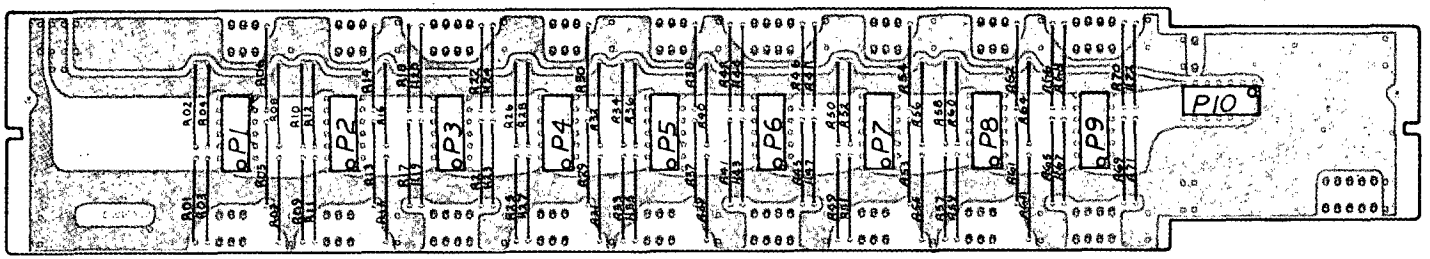
Test 1: Tie pin 16L low. Apply a differential square wave signal with a period of 2.5μs to pins 17F and 16F. The signal should have a rise and fall time not greater than 10 nanoseconds. Observe the waveform at pin 17F with channel one of a 454 oscilloscope. Observe the waveform at pin 10F with the second channel.

The delay from the midpoint of the input signal transition at pin 17F to the midpoint of the positive-going output transition at pin 10F must be within the range from 1.0 to 1.2 μs for both polarities of input transition. If the value of the delay is outside the range allowed then the value of C03 should be increased to increase the delay or decreased to decrease the delay. If it is impossible to select a value for C03 such that the delay is within the specified limits for both polarities of input signal package P10 must be replaced.

Test 2: With the same setup as test 1 the delay from the positive going transition at pin 10F to the negative going transition at pin 10F must be between 1.0 μs and 1.2 μs. If the value of the delay is outside the range allowed then the value of C02 should be increased to increase the delay or decreased to decrease the delay. If it is impossible to select a value for C02 such that the delay is within the specified limits for both polarities of input signal package P10 must be replaced and tests 1 and 2 repeated.

CHG.	E.C.N.	DATE	APPR.
1	0307	2/4/74	TWR

INSTALL FEMALE AMPMODU
CONNECTORS EXACTLY AS
SHOWN ON DWG. 200.50D2



CHANGE NO	DATE	DESCRIPTION

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

MACROMODULAR PROJECT

TITLE: COMPONENT IDENTIFICATION
D/A MODULE BUS BOARD ASSEMBLY
217.4

APPROVED BY	FOR	DATE
cem	Manuf.	11-23-71

ENG: FUR
DRAWN BY: SMS
CHECKED: FUR
DRAWING NO: 217.4D1
DATE: 9-9-71

INTEGRATED CIRCUITS

TYPE	REQUIRED	LOCATION
M04 B	6	P1
		P2
		P4
		P5
		P7
		P8
M30	4	P3
		P6
		P9
		P10

RESISTORS

TYPE	REQUIRED	LOCATION
R1	36	R02
		R04
		R05
		R08
		R10
		R12
		R13
		R16
		R17
		R19
		R21
		R23
		R26
		R28
		R29
		R32
		R34
		R36
		R37
		R40
		R41
		R43
		R45
		R47
		R50
		R52
		R53
		R56
		R58
		R60
		R61
		R64
		R65
		R67
		R69
		R71

RESISTORS

TYPE	REQUIRED	LOCATION
R3	36	R01
		R03
		R06
		R07
		R09
		R11
		R14
		R15
		R18
		R20
		R22
		R24
		R25
		R27
		R30
		R31
		R33
		R35
		R38
		R39
		R42
		R44
		R46
		R48
		R49
		R51
		R54
		R55
		R57
		R59
		R62
		R63
		R66
		R68
		R70
		R72

CONNECTORS
AMPMODU NO. 85863-4
94 REQUIRED

CIRCUIT BOARD
PTV0101-2
ONE REQUIRED

NOTE:

R1 = 1.5K OHM 1% FILM RESISTOR
R3 = 121 OHM 1% FILM RESISTOR

CHANGE NO.	DATE	DESCRIPTION
2	9-9-71	INT. CRK. TYPE CHG.
1	8-2-71	PTV Crk Bd. Level No.

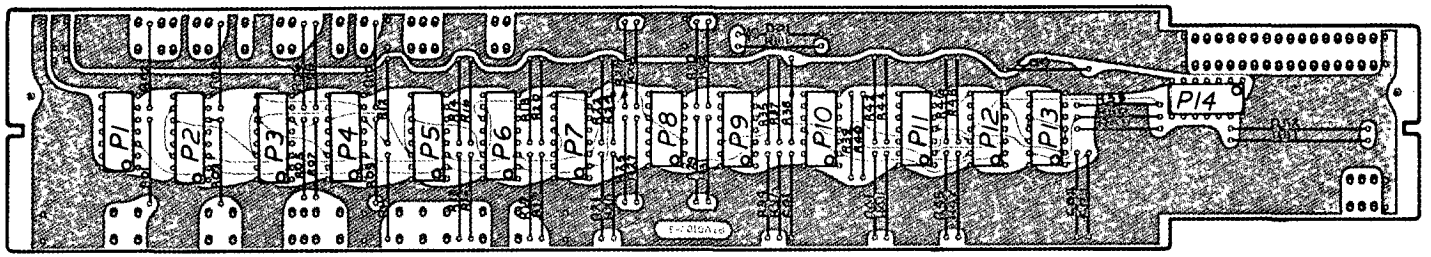
COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

MACROMODULAR PROJECT

TITLE
PARTS LIST
D/A MODULE BUS BOARD ASSEMBLY
PART NO. 217.4

APPROVED BY	FOR	DATE	ENG. FUR	DRAWING NO. 217.4D2
Cam	Manuf.	11-23-71	DRAWN BY MBP	
			CHECKED MTK	DATE 1-14-71

NOTE:
INSTALL FEMALE AMPMODU CONNECTORS
EXACTLY AS SHOWN ON DRAWING 200.50D2.



CHANGE NO	DATE	DESCRIPTION

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST LOUIS, MISSOURI

MACROMODULAR PROJECT

TITLE: COMPONENT IDENTIFICATION
D/A MODULE: SHIFT BOARD
PART NO. 217.5

APPROVED BY	FOR	DATE
clm	MANUF.	11-23-71

ENG. FUR
DRAWN BY SMS
CHECKED FUR

DRAWING NO 217.5D1
DATE 9-14-71

INTEGRATED CIRCUITS

TYPE	REQUIRED	LOCATION
M04	1	P11
M20	1	P14
M28	6	P2
		P3
		P4
		P5
		P6
		P7
M30	1	P13
M31	2	P1
		P12
M35	1	P10
M47	1	P9
M48	1	P8

CAPACITORS *

TYPE	REQUIRED	LOCATION
1200 pf	1	C01
51 pf	3	C02
		C03
		C04

DIODES

TYPE	REQUIRED	LOCATION
1N3604	1	D01

*DIPPED SILVER MICA 5% 50 WVDC

RESISTORS

TYPE	REQUIRED	LOCATION
R0	2	R51
		R52
R1	23	R01
		R03
		R05
		R07
		R09
		R12
		R14
		R16
		R18
		R20
		R22
		R24
		R25
		R27
		R29
		R31
		R35
		R37
		R40
		R42
		R44
		R46
		R48
R2	5	R38
		R39
		R49
		R50
		R53

RESISTORS (Cont)

TYPE	REQUIRED	LOCATION
R3	16	R02
		R04
		R06
		R08
		R10
		R11
		R13
		R15
		R17
		R19
		R21
		R23
		R26
		R28
		R30
		R32
R4	1	R33
R5	6	R34
		R36
		R41
		R43
		R45
		R47

CONNECTORS
AMPMODU NO. 85864-4
59 REQUIRED

CIRCUIT BOARD
PTV0103-3
ONE REQUIRED

NOTE:

R0 = JUMPERS
R1 = 1.5K OHMS 1% FILM RESISTOR
R2 = 750 OHMS 1% FILM RESISTOR
R3 = 121 OHMS 1% FILM RESISTOR
R4 = 15K OHMS 5% ¼WATT CARBON COMP.
R5 = 57.6 OHMS 1% FILM RESISTOR

CHANGE NO.	DATE	DESCRIPTION
1	2-8-72	E.C.O.0253 S.N.O.

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

MACROMODULAR PROJECT

TITLE
PARTS LIST
D/A MODULE: SHIFT BOARD
PART NO. 217.5

APPROVED BY	APPROVED FOR	APPROVED DATE	ENG. FUR	DRAWING NO. 217.5D2
cew	Manuf.	11-23-71	DRAWN BY MBP	
			CHECKED FUR	DATE 2-10-71

Test Procedure

D/A Module Shift Board #217.5

This board contains four critical delays whose proper value must be checked on each board prior to assembly into a D/A Module.

Procedure

Test 1: Tie pins 3L and 4L low. Apply a differential square wave signal with a period of 1.5 μs or greater to pin 16F and 17F. The signal should have a rise and fall time not greater than 10 nanoseconds. Observe the waveform at pin 17F with channel one of a 454 oscilloscope. Observe the waveform at pin 61B with the second channel. The width, from midpoint of rising edge to midpoint of falling edge, of the output pulse at pin 61B must be at least 20 ns. If the width of the output pulse is less than 20 ns for either direction of input transition, the value of C04 should be increased.

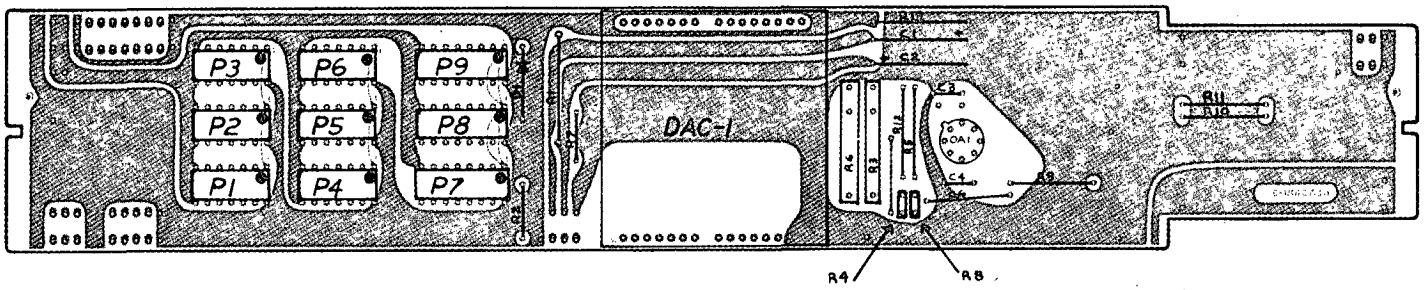
Test 2: Tie pins 3L and 4L low. Apply a differential square wave signal with a period of 1.5 μs or greater to pins 16F and 17F. The signal should have a rise and fall time not greater than 10 nanoseconds. Observe the waveform at pin 17F with channel one of a 454 oscilloscope. Observe the waveform at pin 6F with the second channel. The delay between waveforms measured from mid-point of each transition, should be between 1.0 and 1.2 μs for both polarities of transition. If the value of the delay is outside the allowed range then the value of C01 should be increased to increase the delay or decreased to decrease the delay. If it is impossible to select a value for C01 such that the delay is within the specified limits for both polarities of input signal package P10 must be replaced and tests 1 and 2 repeated.

Test 3: Tie pins 3L and 4L low and tie pin 2L high. Apply a differential square wave signal with a period of 500 nanoseconds or greater to pins 13F and 12F. The signal should have a rise and fall time not greater than 10 nanoseconds. Observe the waveform at pin 13F with channel one of a 454 oscilloscope. Observe the waveform at pin 62B with the second channel. The width, from midpoint of rising edge to midpoint of falling edge, of the output pulse at pin 62B must be at least 20 ns. If the width of the output pulse is less than 20 ns for either direction of input transition the value of C03 must be increased.

CHG.	E.C.O.	DATE	APPR.
1	0307	2/4/74	TMR

Test 4: Tie pins 3L and 4L low and tie pin 2L high. Apply a differential square wave signal with a period of 500 nanoseconds or greater to pins 15F and 14F. The signal should have a rise and fall time not greater than 10 nanoseconds. Observe the waveform at pin 15F with channel one of a 454 oscilloscope. Observe the waveform at pin 56B with the second channel. The width, from midpoint of rising edge to midpoint of falling edge, of the output pulse at pin 56B must be at least 20 ns. If the width of the output pulse is less than 20 ns for either direction of input transition the value of C02 must be increased.

INSTALL FEMALE AMPMODU
CONNECTORS EXACTLY AS
SHOWN ON DWG. 200.50D2



CHANGE NO	DATE	DESCRIPTION
1	12-5-72	E.C.O. 0276 cem

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS MISSOURI

MACROMODULAR PROJECT

TITLE: COMPONENT IDENTIFICATION
D/A MODULE CONVERTER BOARD
PART NO. 2176

APPROVED BY	FOR	DATE
cem	PROD	11-23-71

ENG: FUR
DRAWN BY: SMS
CHECKED: [illegible] UR

DRAWING NO: 2176D1
DATE: 9-9-71

INTEGRATED CIRCUITS

TYPE	REQUIRED	LOCATION
M39	3	P7 P8 P9
M40	6	P1 P2 P3 P4 P5 P6

OPERATIONAL AMPLIFIERS

TYPE	REQUIRED	LOCATION
HARRIS RA2525	1	OA1

DIGITAL/ANALOG CONVERTERS

TYPE	REQUIRED	LOCATION
ANALOG DEVICES MINIDAC 12L	1	DAC1

CAPACITORS

TYPE	REQUIRED	LOCATION
15D106X0020B2 10 uf 20v	2	C1 C2
C069B250F103Z .01 uf	2	C3 C4
24 pf SDM (typ)	1	C6

RESISTORS

TYPE	REQUIRED	LOCATION
JUMPERS	2	R7 R13
51 OHMS ¼ W. 5% CARBON COMP.	1	R9
110 OHMS ¼ W. 5% CARBON COMP.	1	R10
200 OHMS 1/8 W. 1% ANGSTROM C60-9	1	R12
200 OHMS ½ W. 5% CARBON COMP.	1	R1
250 OHMS 5% VISHAY 1202P	2	R3 R6
240 OHMS ¼ W 5% CARBON COMP.	1	R2
330 OHMS ¼ W. 5% CARBON COMP.	1	R11
402 OHMS 1/8 W. 1% ANGSTROM C60-9	1	R5
5K OHMS.1% VISHAY S102	1	R8
6K OHMS.1% VISHAY S102	1	R4

DIODES

TYPE	REQUIRED	LOCATION
1N5231B	1	D1

CONNECTORS

AMPMODU NO. 85863-4
THIRTY ONE REQUIRED

CIRCUIT BOARD
PTV0100-3
ONE REQUIRED

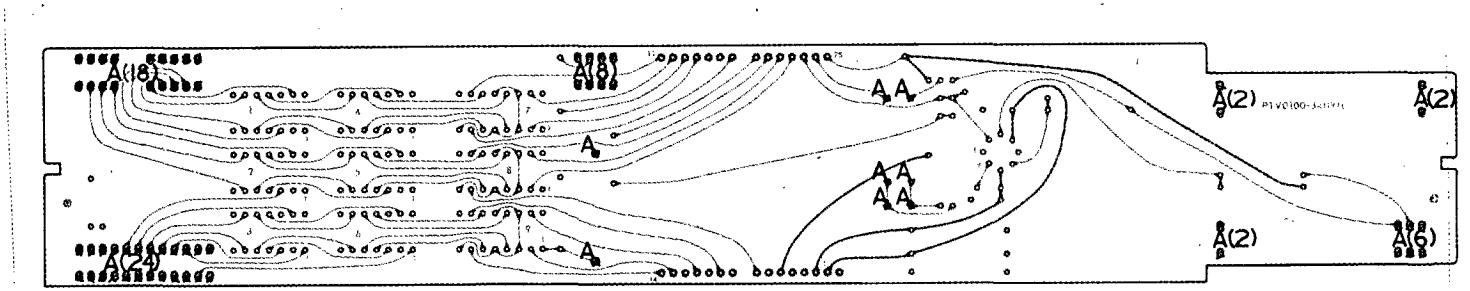
CHANGE NO.	DATE	DESCRIPTION
1	1-8-73	ECO 0278 FUR

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

MACROMODULAR PROJECT

TITLE
PARTS LIST
D/A MODULE CONVERTER BOARD
PART NO. 217.6

APPROVED BY	FOR	DATE	ENG FUR	DRAWING NO. 217.6D2
Cena	PROD	11-23-71	DRAWN BY MBP	
			CHECKED FUR	DATE 9-9-71



TYPE A MARKED X 70 PLACES

TYPE B ALL OTHERS (209 PLACES)

SEE CSL DOCUMENT GENERAL STANDARDS 010 (PAGES 13 & 14)
FOR HOLE SIZES

CHANGE NO.	DATE	DESCRIPTION

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

MACROMODULAR PROJECT

TITLE: D/A MODULE CONVERTER BOARD
HOLE SIZES

APPROVED BY	FOR	DATE
cerm	Manuf.	11-23-71

ENG. FUR
DRAWN BY
CHECKED FUR

DRAWING NO. 217.6D4

DATE 9-22-71

Test Procedure

D/A Module Converter Board #217.6

This board contains two potentiometers used to set gain and zero of the analog output.

Test 1:

Connect -5.2 volts, ground. and ±15 volt power supplies to the card. The 15 volt supplies must be within 150 mV of 15 volts. Tie pins 84B and 85B high and tie pins 86B, 87B, 88B, 89B, 90B, 85T, 86T, 87T, 88T, 91T, 92T, and 93T low. Measure the output voltage from pin 3F to pin 2F with a FLUKE 883B DIFFERENTIAL VOLTMETER or equivalent. Isolate the meter lead connected to pin 3F by a 1K series resistor. Adjust R03 until the output voltage is between 4.9965 and 4.9985 volts. If the voltage cannot be adjusted low enough replace R12 with a 402 ohm 1% resistor and repeat the adjustment. If the voltage cannot be adjusted high enough replace R12 with a 0 ohm jumper and repeat the adjustment.

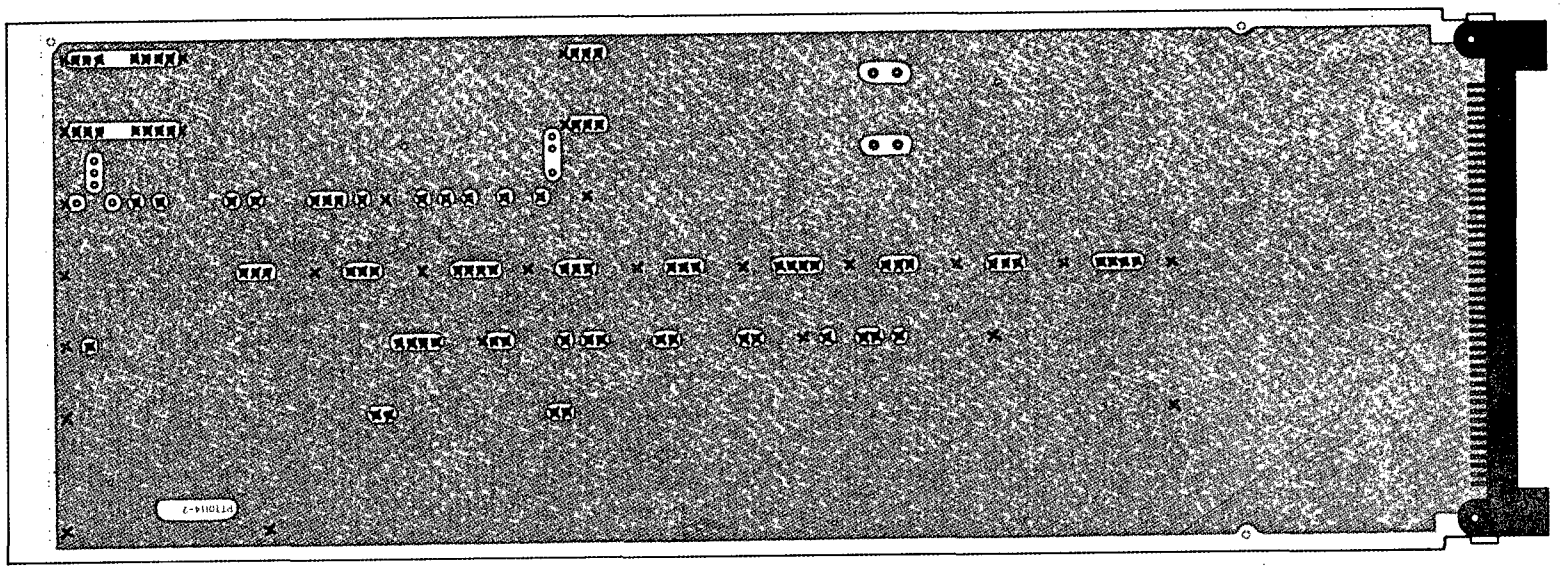
Test 2:

Tie pins 84B, 85B, 86B 87B, 88B, 89B, 85T, 86T, 87T, 88T, 91T, 92T, and 93T high and pin 90B low. With the meter connected as before adjust R06 until the output voltage is between -0.001 and +0.001 volts. If the voltage is more positive than 0.001 volts for every setting of R03 then replace R45 with a 590 ohm 1% resistor and repeat the adjustment. If the voltage is more negative than -0.001 volts for every setting of R03 then replace R05 with a 200 ohm 1% resistor and repeat the adjustment.

Test 3:

Tie pins 84B, 85B, 86B, 87B, 88B, 89B, 90B, 85T, 86T, 87T, 88T, 91T, and 93T high. Tie pin 90B low. With the meter connected as before the output voltage should be between -5.0035 and -4.9965 volts. If the voltage is not between these limits repeat tests 1 and 2.

CHG.	E.C.O.	DATE	APPR.
1	0307	2/4/74	IAR



NOTE:
MALE AMPMODU PINS MUST BE INSTALLED FROM THIS SIDE IN LOCATIONS MARKED X PRECISELY AS SHOWN IN DRAWINGS 200.50D1 AND 200.50D2.
(112 PINS)

NOTE:
SEE DRAWING NUMBER 200.50D26 FOR CONNECTOR MOUNTING ORIENTATION.

CHANGE NO.	DATE	DESCRIPTION

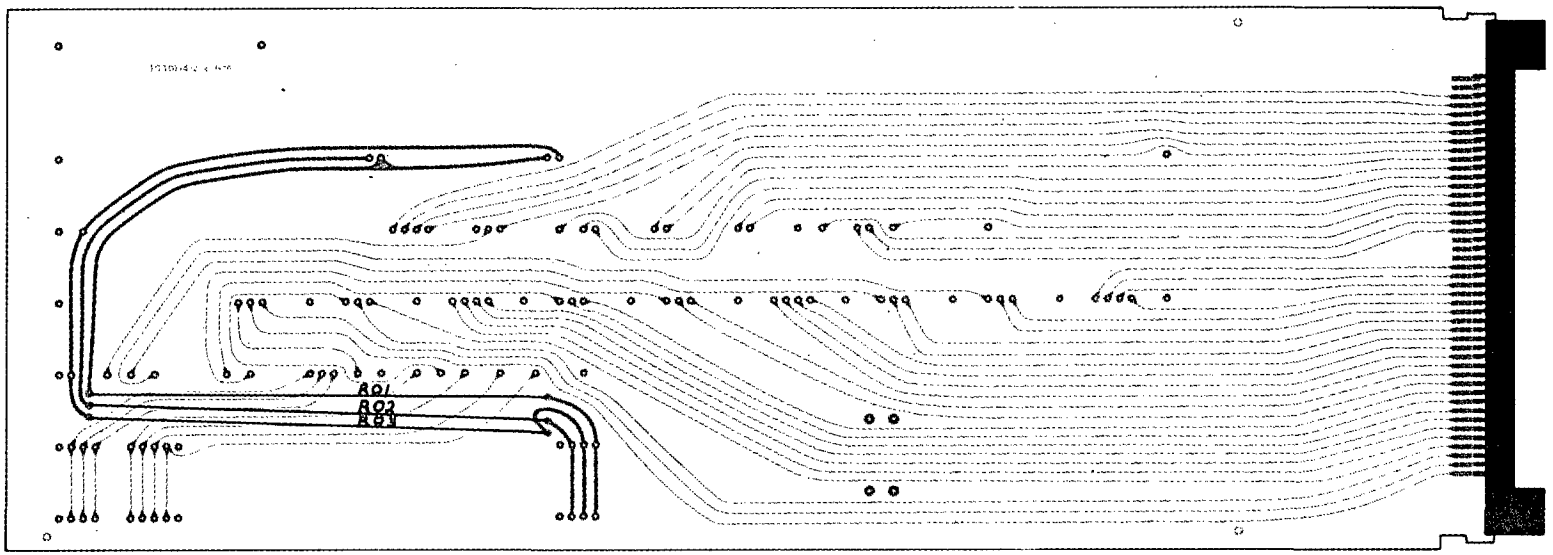
COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

MACROMODULAR PROJECT

TITLE: COMPONENT IDENTIFICATION
D/A MODULE TOP MOTHERBOARD COMPONENT SIDE
PART NO. 217.7

APPROVED BY	FOR	DATE
Cerm	Manuf.	11-23-71

ENG. FUR
DRAWN BY MBP
CHECKED FUR
DRAWING NO. 217.7D1
DATE 9-10-71



CHANGE NO.	DATE	DESCRIPTION

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

MACROMODULAR PROJECT

TITLE: COMPONENT IDENTIFICATION
D/A MODULE TOP MOTHERBOARD SIGNAL SIDE
PART NO. 217.7

APPROVED BY	FOR	DATE
Cerm	Manuf.	11-23-71

ENG. FUR
DRAWN BY MBP
CHECKED FJR

DRAWING NO. 217.7D2
DATE 9-10-71

AMP CONNECTOR
1-202845-5
ONE REQUIRED

CONNECTOR
AMPMODU NO. 85931-5
ONE HUNDRED TWELVE REQUIRED

CIRCUIT BOARD
PTT0114- 2
ONE REQUIRED

JUMPERS
THREE REQUIRED
R01
R02
R03

CHANGE NO.	DATE	DESCRIPTION

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

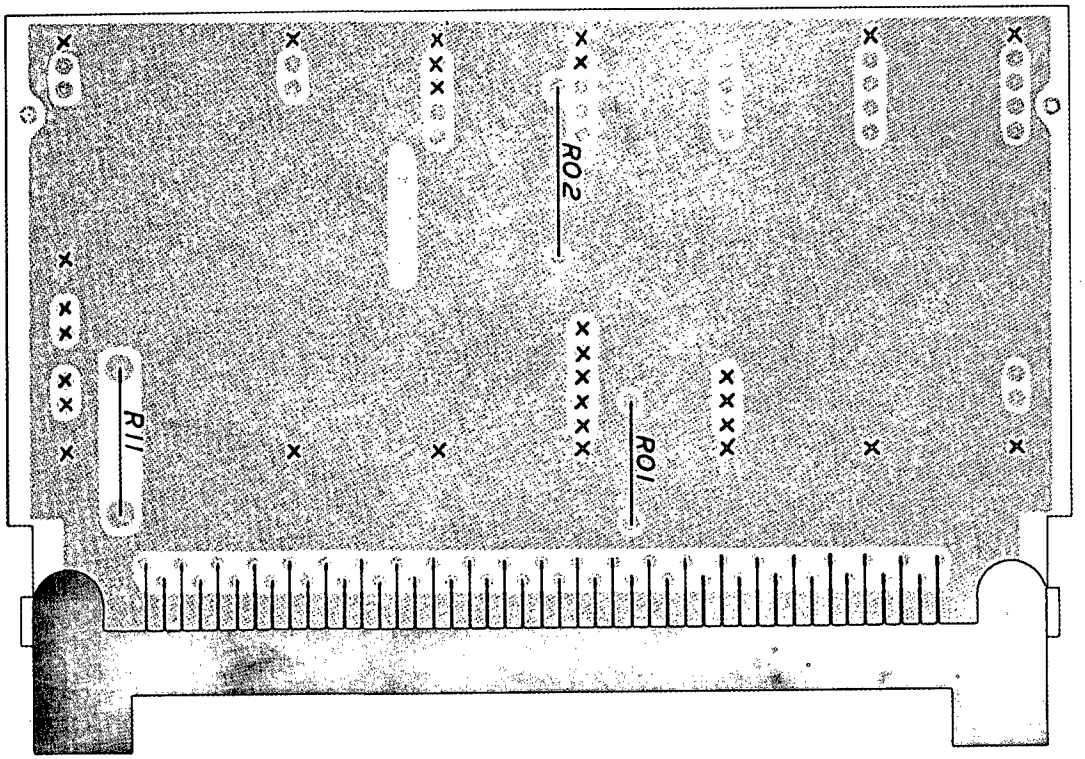
MACROMODULAR PROJECT

TITLE
PARTS LIST
D/A MODULE TOP MOTHERBOARD
PART NO. 217.7

APPROVED BY	APPROVED FOR	APPROVED DATE	ENG.	DRAWING NO.
Cem	Manuf.	11-23-71	FUR	217.7D3
			DRAWN BY MBP	
			CHECKED FUR	DATE 3-18-71

NOTE:
AMPMODU PINS MUST BE INSTALLED FROM THIS SIDE IN LOCATIONS MARKED X PRECISELY AS SHOWN IN DWG. 200.50D1 AND 200.50D2.
(29 PINS)

NOTE:
SEE DRAWING NUMBER 200.50D28 FOR CONNECTOR MOUNTING ORIENTATION.



CHANGE NO.	DATE	DESCRIPTION

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

MACROMODULAR PROJECT

TITLE: COMPONENT IDENTIFICATION
D/A MODULE LATERAL MOTHERBOARD
PART NO. 217.8

APPROVED BY	FOR	DATE
Sew	Manuf	11-23-71

ENG. FUR
DRAWN BY DHO
CHECKED FVR

DRAWING NO. 217.8D1
DATE 11-16-71

JUMPERS
ONE REQUIRED
R02

RESISTOR 35.7K OHM 1% FILM
ONE REQUIRED
R01

FUSE BUSSMAN GFA ¾ AMP
ONE REQUIRED
R11

AMP CONNECTOR
583 464-1
ONE REQUIRED

CONNECTORS
AMPMODU NO 85931-5
TWENTY NINE REQUIRED

CIRCUIT BOARD
PTL0123-4
ONE REQUIRED

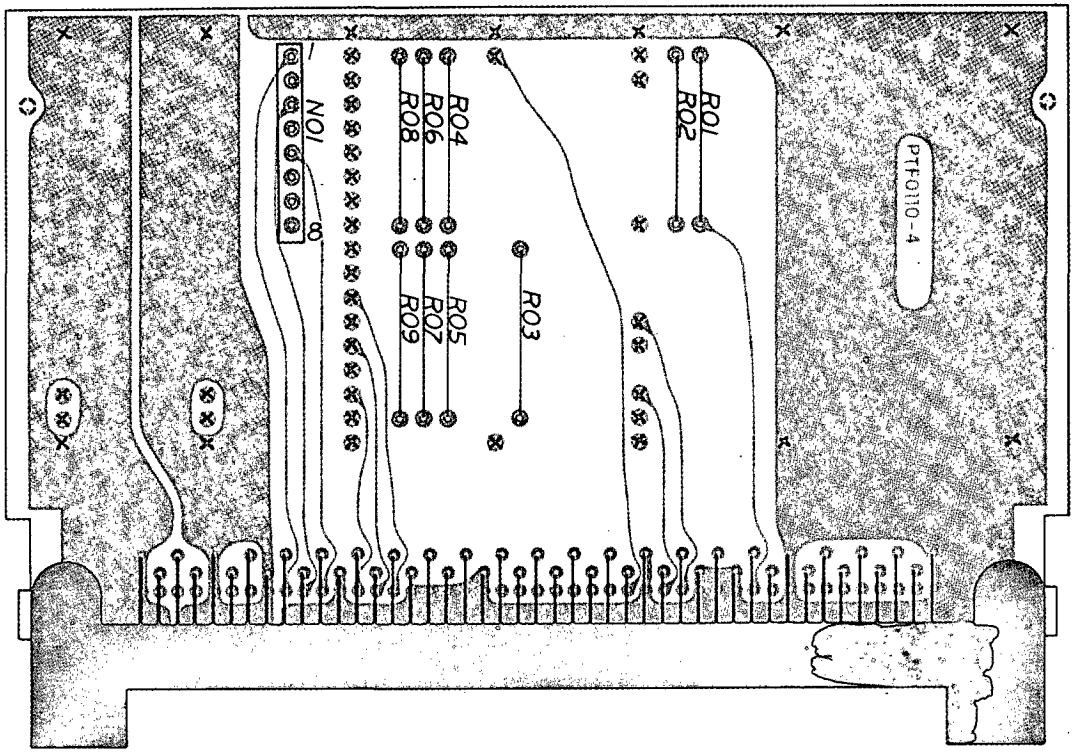
CHANGE NO	DATE	DESCRIPTION

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST LOUIS, MISSOURI

MACROMODULAR PROJECT

TITLE
PARTS LIST
D/A MODULE LATERAL MOTHERBOARD
PART NO. 217.8

APPROVED BY	APPROVED FOR	APPROVED DATE	ENG FUR	DRAWING NO 217.8D2
Clem	Manuf.	11-23-71	DRAWN BY MBP	
			CHECKED [illegible]	DATE 2-18-71



NOTE: 1
SEE DRAWING NUMBER 200.50D29
FOR CONNECTOR ORIENTATION.

NOTE: 2
AMPMODU PINS MUST BE INSTALLED
FROM THIS SIDE IN LOCATIONS
MARKED "X" PRECISELY AS
SHOWN IN DRAWINGS 200.50D1
AND 200.50D2.
(42 PINS)

CHANGE NO.	DATE	DESCRIPTION

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

MACROMODULAR PROJECT

TITLE
COMPONENT IDENTIFICATION
D/A MODULE FACEPLATE MOTHERBOARD ASSEMBLY
PART NO. 217.9

APPROVED		
BY	FOR	DATE
Cem	Manuf.	11-23-71

ENG.	FJR
DRAWN BY	MBP
CHECKED	FJR
DATE	9-10-71
DRAWING NO.	217.9D1

RESISTORS 15K OHM
¼ WATT 5% CARBON COMP.
EIGHT REQUIRED
R02
R03
R04
R05
R06
R07
R08
R09

RESISTOR 130 OHM
¼ WATT 1% FILM
ONE REQUIRED
R01

SPRAGUE NETWORK LTN-2
ONE REQUIRED
N01

AMP CONNECTOR
583464-1
ONE REQUIRED

CONNECTORS
AMPMODU NO 85931-5
42 REQUIRED

CIRCUIT BOARD
PTF0110-4
ONE REQUIRED

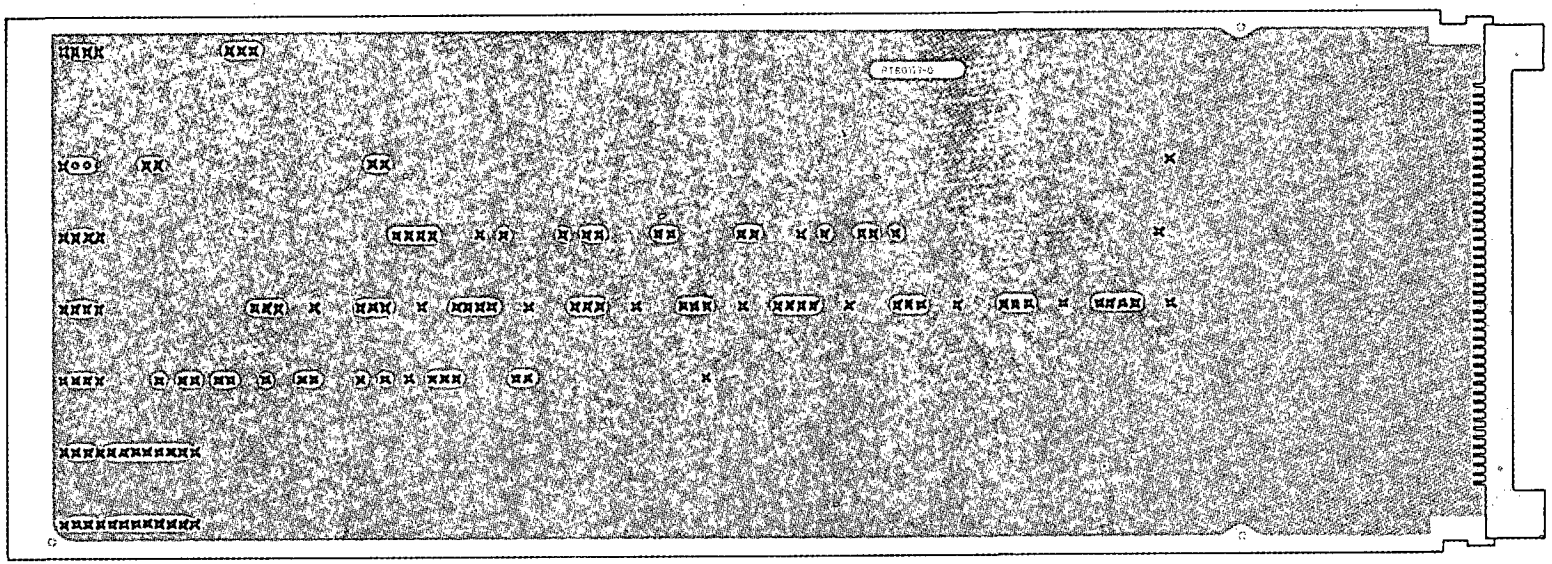
CHANGE NO	DATE	DESCRIPTION

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST LOUIS, MISSOURI

MACROMODULAR PROJECT

TITLE
PARTS LIST
D/A MODULE FACEPLATE MOTHERBOARD ASSEMBLY
PART NO. 217 9

APPROVED BY	FOR	DATE	ENG	DRAWING NO
cem	Manuf.	11-23-71	FUR	217.9D2
			DRAWN BY MBP	
			CHECKED FUR	DATE 1-21-71



NOTE:
MALE AMPMODU PINS MUST BE INSTALLED FROM THIS SIDE IN LOCATIONS MARKED X PRECISELY AS SHOWN IN DRAWINGS 200.50D1 AND 200.50D2.
(124 PINS)

NOTE:
SEE DRAWING NUMBER 200.50D27 FOR CONNECTOR MOUNTING ORIENTATION.

CHANGE NO.	DATE	DESCRIPTION

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

MACROMODULAR PROJECT

TITLE: COMPONENT IDENTIFICATION
D/A MODULE BOTTOM MOTHERBOARD
PART NO. 217.10

APPROVED BY	FOR	DATE
[illegible]	Manuf.	11-23-71

ENG. FUR
DRAWN BY DHO
CHECKED [illegible]

DRAWING NO. 217.10D1
DATE 3-11-71

AMP CONNECTOR
1-202845-5
ONE REQUIRED

CONNECTOR
AMPMODU NO. 85931-5
ONE HUNDRED TWENTY FOUR REQUIRED

CIRCUIT BOARD
PTB0113-0
ONE REQUIRED

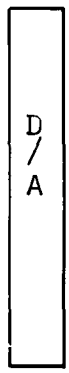
CHANGE NO	DATE	DESCRIPTION

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST LOUIS, MISSOURI

MACROMODULAR PROJECT

TITLE PARTS LIST
D/A MODULE BOTTOM MOTHERBOARD
PART NO. 217 10

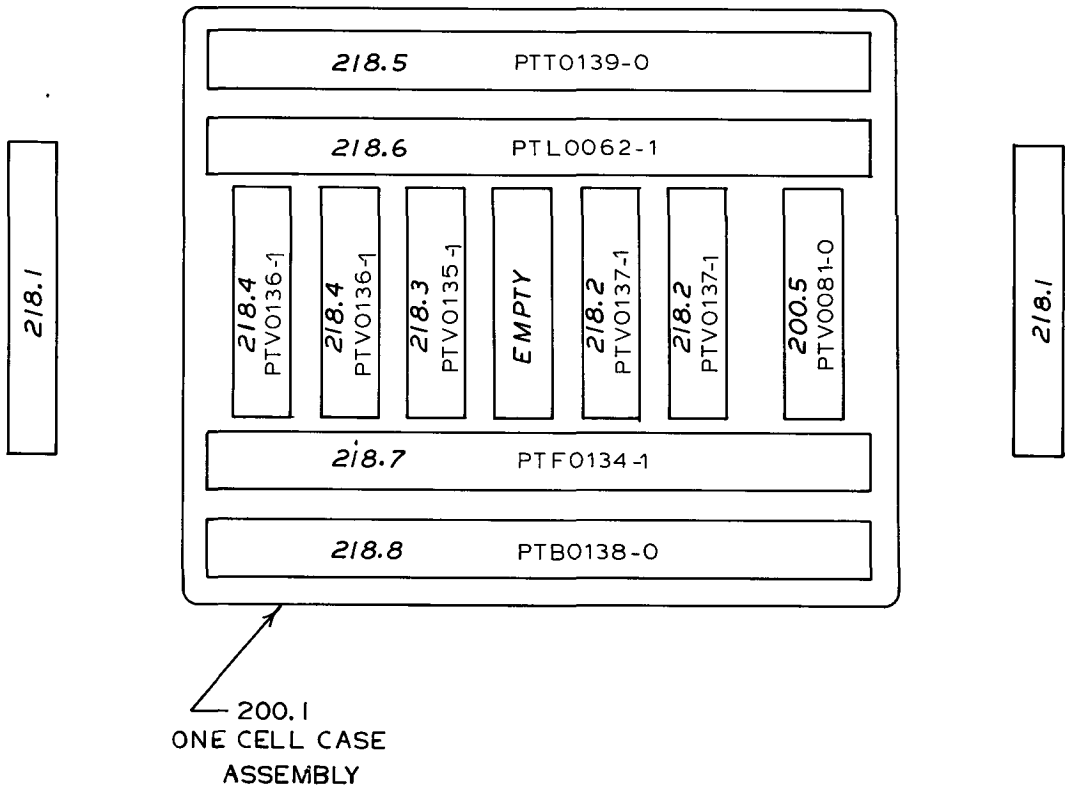
APPROVED BY	FOR	DATE	ENG	DRAWING NO
Cerr	Manuf.	11-23-71	FUR	217.10D2
			DRAWN BY MBP	
			CHECKED FJR	DATE 3-18-71



METALCRAFT "AUTOGRAPH" OR EQUIVALENT: BLANK SIZE: ¼" X 2" SHEARED WITH SQUARE CORNERS. BLACK LETTERS, VOGUE BOLD 12 POINT BOLD FACE TYPE CENTERED TOP, BOTTOM AND SIDES WITH 6 POINT SPACING ON LIGHT LIME PMS 346 BACKING, MANUFACTURED FROM .016 THICK ALUMINUM WITH SOLVENT ACTIVATED PERMANENT ADHESIVE BACKING.

NOTE: PANTONE MATCHING SYSTEM (PMS)

COMPUTER SYSTEMS LABORATORY WASHINGTON UNIVERSITY ST. LOUIS, MISSOURI			MACROMODULAR PROJECT				
			TITLE: IDENTIFICATION LABEL D/A MODULE PART NO. 217.11				
			APPROVED			ENG: NTK	DRAWING NO.: 217.11D
			BY: MTR	FOR: PROD.	DATE: 8/26	DRAWN BY: MBP	
CHANGE NO.	DATE	DESCRIPTION				CHECKED: SJHO	DATE: 1-21-71



CHANGE NO	DATE	DESCRIPTION

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

MACROMODULAR PROJECT

TITLE ASSEMBLY SCHEMATIC & PARTS LIST
FUNCTION CALLER
PART NO. 218

APPROVED BY	FOR	DATE	ENG	DRAWING NO
CJ M	PROD	11/13/72	MLP	218.0D
			DRAWN BY PLL	
			CHECKED dls	DATE 10-18-72

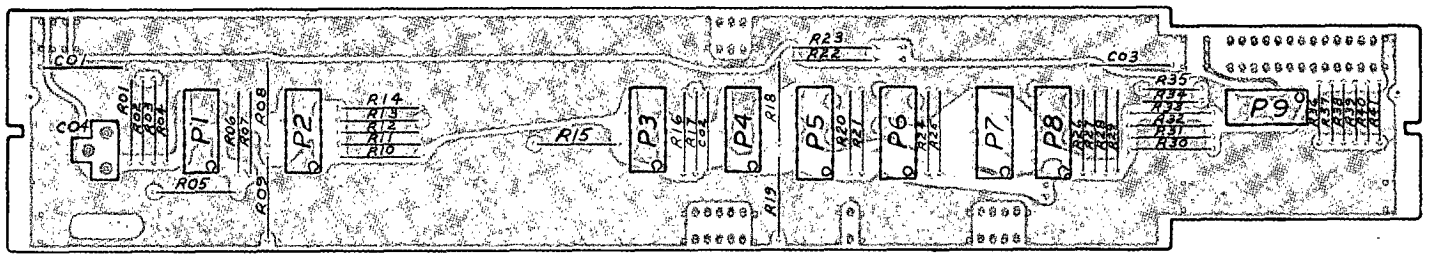
NOTE: NOT TO SCALE

METALCRAFT "AUTOGRAPH" OR EQUIVALENT:
BLANK SIZE: ¼" X 2" SHEARED WITH
SQUARE CORNERS. BLACK LETTERS,
VOGUE BOLD 12 POINT BOLD FACE TYPE
CENTERED TOP, BOTTOM AND SIDES WITH
6 POINT SPACING ON PINK PMS 183 BACKING.
MANUFACTURED FROM .016 THICK ALUMINUM
WITH SOLVENT ACTIVATED PERMANENT
ADHESIVE BACKING.

NOTE: PANTONE MATCHING SYSTEM (PMS)

COMPUTER SYSTEMS LABORATORY WASHINGTON UNIVERSITY ST. LOUIS, MISSOURI	**MACROMODULAR PROJECT**	
	TITLE: IDENTIFICATION LABEL FUNCTION CALLER MODULE PART #218.1	
	APPROVED: BY MATK / FOR PROD / DATE 1-4-72	ENG MLP; DRAWN BY MBP; CHECKED D.K.O.
		DRAWING NO. 218.1D
		DATE 1-4-72

CHANGE NO.	DATE	DESCRIPTION



NOTE: FEMALE AMP MODU CONNECTORS MUST BE INSTALLED PRECISELY AS SHOWN IN DRAWING NUMBER 200.50D2

CHANGE NO	DATE	DESCRIPTION

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST LOUIS MISSOURI

MACROMODULAR PROJECT

TITLE: COMPONENT IDENTIFICATION
FUNCTION CALLER: COMPLETION BOARD
PART NO. 218.2

APPROVED BY	FOR	DATE
Cem	PROD	11/18/72

ENG: MLP
DRAWN BY: PLL
CHECKED: dls
DRAWING NO: 218.2D1
DATE: 10-25-72

INTEGRATED CIRCUITS

TYPE	REQUIRED	LOCATION
M10	2	P4 P7
M20	1	P9
M30	2	P2 P3
M32B	3	P5 P6 P8
M35	1	P1

RESISTORS

TYPE	REQUIRED	LOCATION
R1	20	R01 R04 R06 R07 R08 R11 R12 R16 R18 R20 R21 R22 R23 R24 R25 R26 R27 R28 R29 R34
R2	1	R05
R3	7	R09 R10 R13 R15 R17 R19 R35
R4	1	R14
R5	10	R30 R31 R32 R33 R36 R37

RESISTORS (cont.)

TYPE	REQUIRED	LOCATION
R5 (cont.)		R38 R39 R40 R41
R802	1	R02
R803	1	R03

CAPACITORS

TYPE	REQUIRED	LOCATION
.01 uf CERAMIC DISC	3	C01 C02 C03
VARIABLE (JOHANSON 9334)	1	C04

CONNECTORS

AMP MODU FEMALE NO 85863-4
45 REQUIRED

PRINTED CIRCUIT BOARD

PTV0137-1
1 REQUIRED

NOTE:

R1 = 1500 OHMS 1/8 W ± 1% FILM RESISTOR
R2 = 750 OHMS 1/8 W ± 1% FILM RESISTOR
R3 = 121 OHMS 1/8 W ± 1% FILM RESISTOR
R4 = 15,000 OHMS ± 5% 1/4 W CARBON COMP.
R5 = 57.6 OHMS ± 1/8 W FILM RESISTOR
R802 = 3,000 OHMS ± 1% 1/8 W FILM RESISTOR
R803 = 1,000 OHMS ± 1% 1/8 W FILM RESISTOR

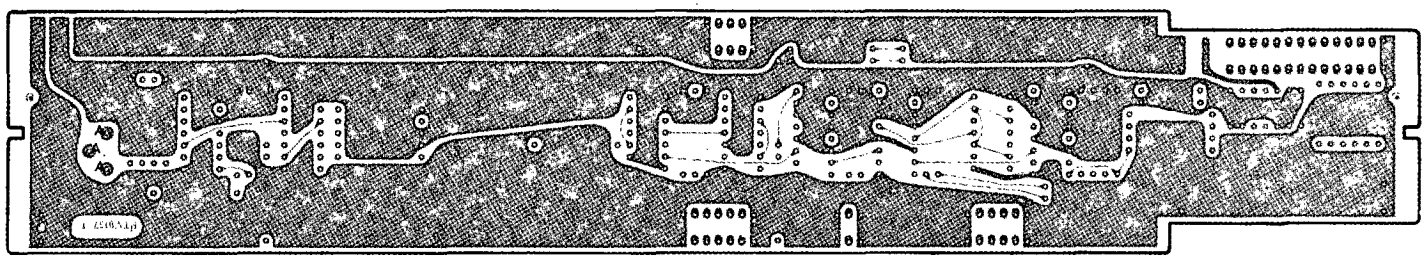
COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

MACROMODULAR PROJECT

TITLE
PARTS LIST
FUNCTION CALLER: COMPLETION BOARD
PART NO. 218.2

APPROVED BY	APPROVED FOR	APPROVED DATE	ENG	DRAWING NO
Cerm	PROJ	11/18/72	MLP	218.2D2
			DRAWN BY CAH	
			CHECKED dlle	DATE 8/4/72

CHANGE NO	DATE	DESCRIPTION



TYPE "A" HOLES
3 PLACES (OTHER THAN FEMALE AMP MODU CONNECTORS)

SEE CSL DOCUMENT 010 (GENERAL STANDARDS)
PAGES 13 AND 14 FOR HOLE SIZES.

CHANGE NO	DATE	DESCRIPTION

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST LOUIS MISSOURI

MACROMODULAR PROJECT

TITLE
HOLE SIZES
FUNCTION CALLER: COMPLETION BOARD
PART NO. 218.2

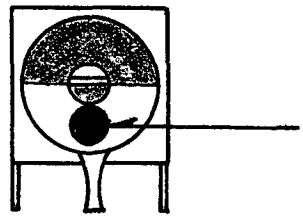
APPROVED BY	FOR	DATE
cem	PROD	11/18/72

ENG: MLP
DRAWN BY: CSP
CHECKED: dls
DRAWING NO: 218.2D4
DATE: 10-25-72

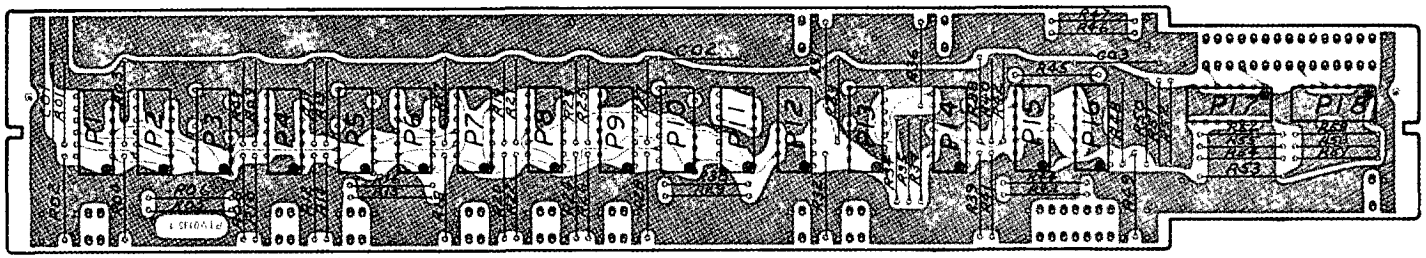
Assembly Note

Function Caller Completion Board #218.2

Before assembly, the variable capacitor on each Completion Board should be set to its maximum value. This is done by rotating the adjustment so that the solder blob is near the board as shown below.



CHG.	E.C.O.	DATE	APPR
1	0306	2-18-74	MZP



NOTE: FEMALE AMP MODU CONNECTORS MUST BE INSTALLED PRECISELY AS SHOWN IN DRAWING 200.50D2

CHANGE NO	DATE	DESCRIPTION

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST LOUIS MISSOURI

MACROMODULAR PROJECT

TITLE: COMPONENT IDENTIFICATION
FUNCTION CALLER: INITIATE BOARD
PART NO. 218.3

APPROVED BY	FOR	DATE
Cam	PROD	11/18/72

ENG: MLP
DRAWN BY: CSP
CHECKED: dls

DRAWING NO: 218.3D1
DATE: 10-25-72

INTEGRATED CIRCUITS

TYPE	REQUIRED	LOCATION
M01B	1	P12
M04	4	P2 P6 P11 P15
M10	3	P4 P9 P14
M20	2	P17 P18
M30	4	P1 P7 P8 P16
M32B	4	P3 P5 P10 P13

CAPACITORS

TYPE	REQUIRED	LOCATION
.01 uf CERAMIC DISC	3	C01 C02 C03

CONNECTORS

AMP MODU FEMALE NO. 85863-4
73 REQUIRED

PRINTED CIRCUIT BOARD

PTV0135-1
1 REQUIRED

RESISTORS

TYPE	REQUIRED	LOCATION
R0	1	R36
R1	24	R01 R03 R07 R09 R11
R1 (cont.)		R13 R17 R19 R21 R23 R25 R27 R33 thru R35 R40 R42 R48 R50 thru R52 R57 thru R59
R2	6	R05 R06 R15 R16 R29 R30
R3	24	R02 R04 R08 R10 R12 R14 R18 R20 R22 R24 R26 R28 R31 R32 R38 R39 R41 R45 thru R47 R49 R54 thru R56
R4	2	R37 R53
R5	2	R43 R44

NOTE:

R0 = ZERO OHMS (JUMPER)
R1 = 1,500 OHMS ± 1% 1/8 W FILM RESISTOR
R2 = 750 OHMS ± 1% 1/8 W FILM RESISTOR
R3 = 121 OHMS ± 1% 1/8 W FILM RESISTOR
R4 = 15,000 OHMS ± 5% 1/4 W CARBON COMP.
R5 = 57.6 OHMS ± 1% 1/8 W FILM RESISTOR

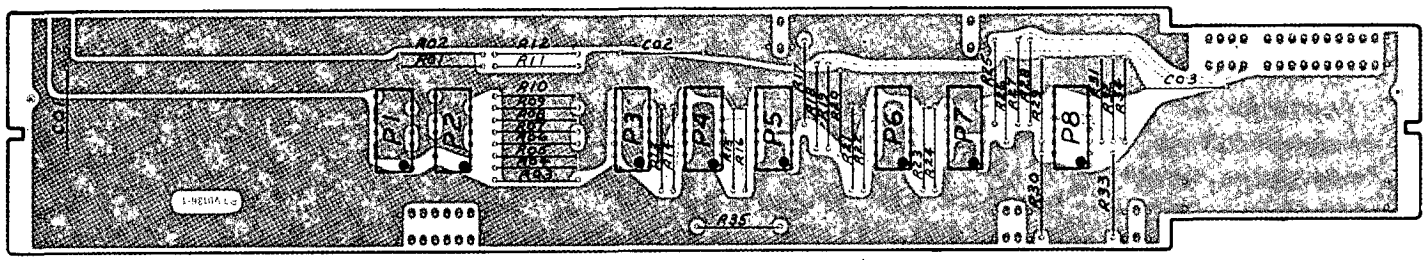
COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

MACROMODULAR PROJECT

TITLE: PARTS LIST
FUNCTION CALLER: INITIATE BOARD
PART NO. 218.3

CHANGE NO.	DATE	DESCRIPTION

APPROVED BY	FOR	DATE	ENG	DRAWING NO.
Cesa	PROD	11/13/72	MLP	218.3D2
			DRAWN BY CAH	
			CHECKED dls	DATE 8/4/72



NOTE: FEMALE AMP MODU CONNECTORS MUST BE INSTALLED PRECISELY AS SHOWN IN DRAWING 200.50D2

CHANGE NO	DATE	DESCRIPTION

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
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MACROMODULAR PROJECT

TITLE: COMPONENT IDENTIFICATION
FUNCTION CALLER: MULTIPLEXER BOARD
PART NO. 218.4

APPROVED BY	FOR	DATE
Cem	PROD	11/18/72

ENG: MLP
DRAWN BY: PLL
CHECKED: dls
DRAWING NO: 218.4D1
DATE: 10-25-72

INTEGRATED CIRCUITS

TYPE	REQUIRED	LOCATION
M01	3	P3
		P5
		P7
M10	2	P1
		P2
M47	3	P4
		P6
		P8

RESISTORS

TYPE	REQUIRED	LOCATION
R0	2	R30
		R33
R1	8	R01
		R02
		R04
		R05
		R08
		R10
		R20
		R26
R3	9	R03
		R06
		R07
		R09
		R11
		R12
		R17
		R25
		R35
R4	12	R13
		R14
		R15
		R16
		R21
		R22
		R23
		R24
		R29
		R31

RESISTORS (cont)

TYPE	REQUIRED	LOCATION
R4(cont.)		R32
		R34
R5	4	R18
		R19
		R27
		R28

CAPACITORS

TYPE	REQUIRED	LOCATION
.01 uf CERAMIC DISC	3	C01
		C02
		C03

CONNECTORS

AMP MODU FEMALE
NO. 85863-4
44 REQUIRED

PRINTED CIRCUIT BOARD

PTV0136-1
1 REQUIRED

NOTE:
R0 = ZERO OHMS (JUMPER)
R1 = 1500 OHMS ± 1% 1/8 W FILM RESISTOR
R3 = 121 OHMS ± 1% 1/8 W FILM RESISTOR
R4 = 15,000 OHMS ± 5% 1/4 W CARBON COMP.
R5 = 57.6 OHMS ± 1% 1/8 W FILM RESISTOR

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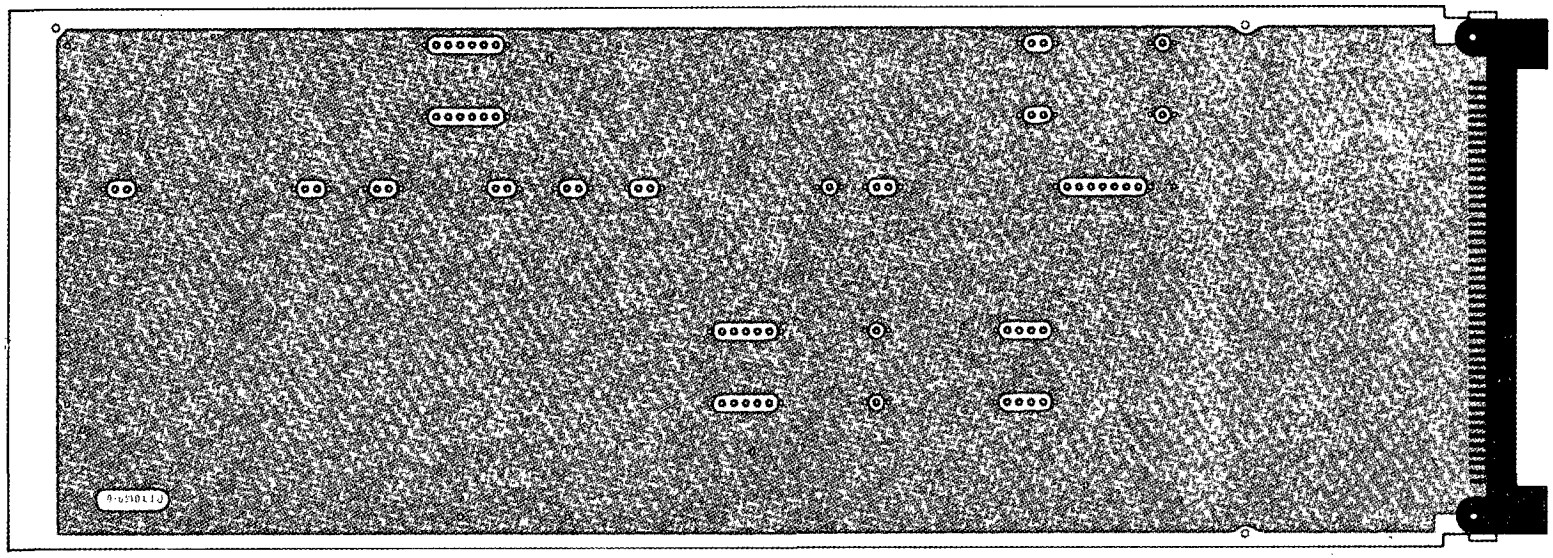
MACROMODULAR PROJECT

TITLE: PARTS LIST
FUNCTION CALLER: MULTIPLEXER BOARD
PART NO. 218.4

APPROVED BY	FOR	DATE	ENG	DRAWING NO.
Chua	PSCD	11/18/72	MLP	218.4D2
			DRAWN BY CAH	
			CHECKED dls	DATE 8/4/72

CHANGE NO.	DATE	DESCRIPTION



NOTE 1: SEE DRAWING NUMBER 200.50D26 FOR CONNECTOR MOUNTING ORIENTATION

NOTE 2: MALE AMP MODU CONNECTORS MUST BE INSTALLED FROM THIS SIDE IN ALL LOCATIONS PRECISELY AS SHOWN IN DRAWINGS 200.50D2 AND 200.50D3 (111 PLACES)

CHANGE NO.	DATE	DESCRIPTION

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
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MACROMODULAR PROJECT

TITLE: COMPONENT IDENTIFICATION
FUNCTION CALLER: TOP MOTHER BOARD
PART NO. 218.5

APPROVED BY	FOR	DATE
Cerm	PROD	11/18/72

ENG. MLP
DRAWN BY CSP
CHECKED dls

DRAWING NO. 218.5D1
DATE 10-25-72

CONNECTORS

MALE AMP MODU NO. 85931-5
111 REQUIRED

AMP NO. 1-202 845-5
1 REQUIRED

PRINTED CIRCUIT BOARD

PTT0139-0
1 REQUIRED

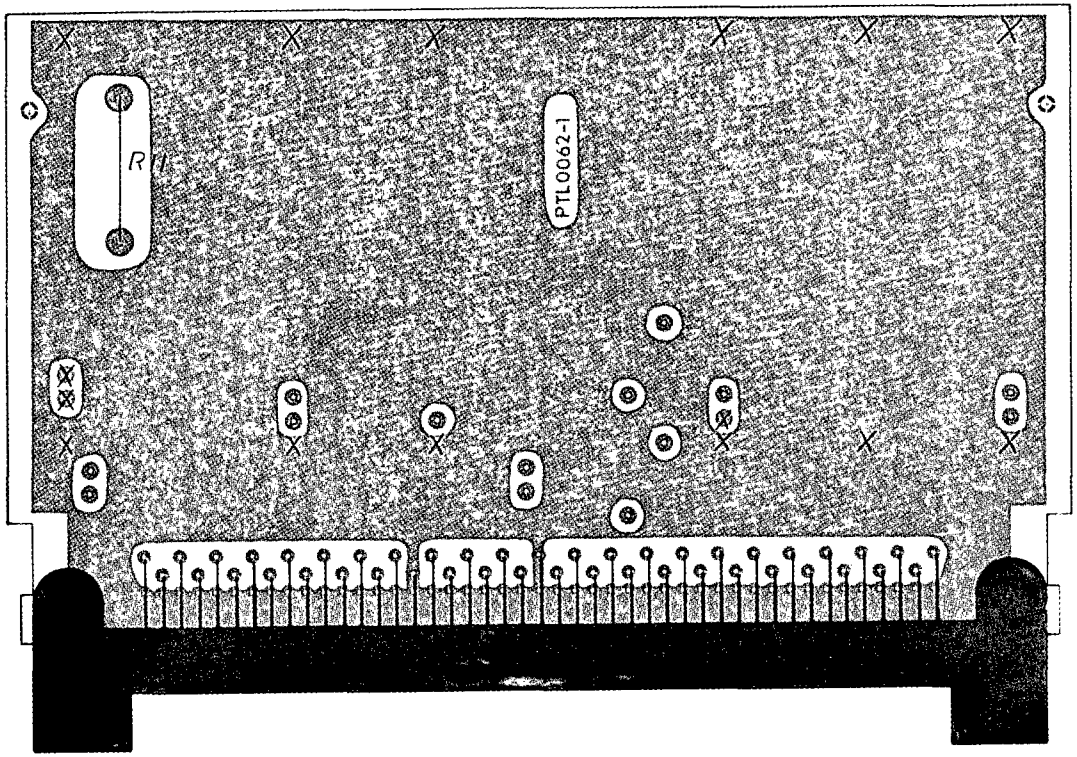
COMPUTER SYSTEMS LABORATORY WASHINGTON UNIVERSITY ST. LOUIS, MISSOURI	**MACROMODULAR PROJECT**	
	TITLE: PARTS LIST FUNCTION CALLER: TOP MOTHER BOARD 218.5D2	
	APPROVED: BY: Com; FOR: PROD.; DATE: 11/18/72	ENG: MLP; DRAWN BY: CAH; CHECKED: dla
		DRAWING NO.: 218.5D2.; DATE: 10-25-72

CHANGE NO.	DATE	DESCRIPTION

NOTE 1: MALE AMP MODU PINS MUST BE INSTALLED FROM THIS SIDE IN LOCATIONS MARKED X PRECISELY AS SHOWN IN DRAWINGS 200.50D2 AND 200.50D3

(15 PLACES)

NOTE 2: SEE DRAWING NUMBER 200.50D28 FOR CONNECTOR ORIENTATION



CHANGE NO.	DATE	DESCRIPTION

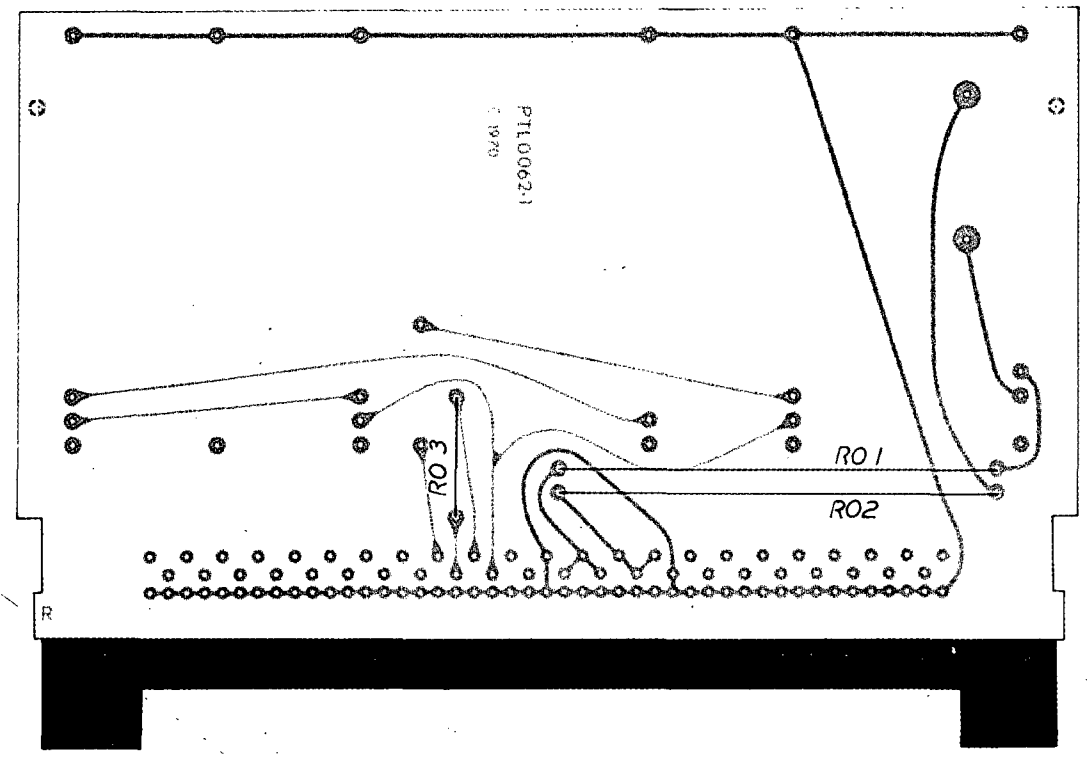
COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

MACROMODULAR PROJECT

TITLE COMPONENT IDENTIFICATION
FUNCTION CALLER: LATERAL MOTHER BOARD COMPONENT
SIDE PART NO. 218.6

APPROVED BY	FOR	DATE
Cem	PROD	11/18/72

ENG. MLP
DRAWN BY CSP
CHECKED dls
DRAWING NO. 218.6D1
DATE 10-25-72



CHANGE NO.	DATE	DESCRIPTION

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WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

MACROMODULAR PROJECT

TITLE: COMPONENT IDENTIFICATION
FUNCTION CALLER: LATERAL MOTHER BOARD SIGNAL SIDE
PART NO. 218.6

APPROVED BY	FOR	DATE
cem	PROD.	11/18/72

ENG. MLP
DRAWN BY CSP
CHECKED dls
DRAWING NO. 218.6D2
DATE 10-24-72

RESISTORS

R01 = JUMPER

R02 = JUMPER

R03 = 42,200 OHMS

CONNECTORS

MALE AMP MODU NUMBER 85931-5
15 REQUIRED

AMP CONNECTOR NUMBER 583 464-1
1 REQUIRED

FUSE

R11 = BUSSMAN GFA 3/4 AMP

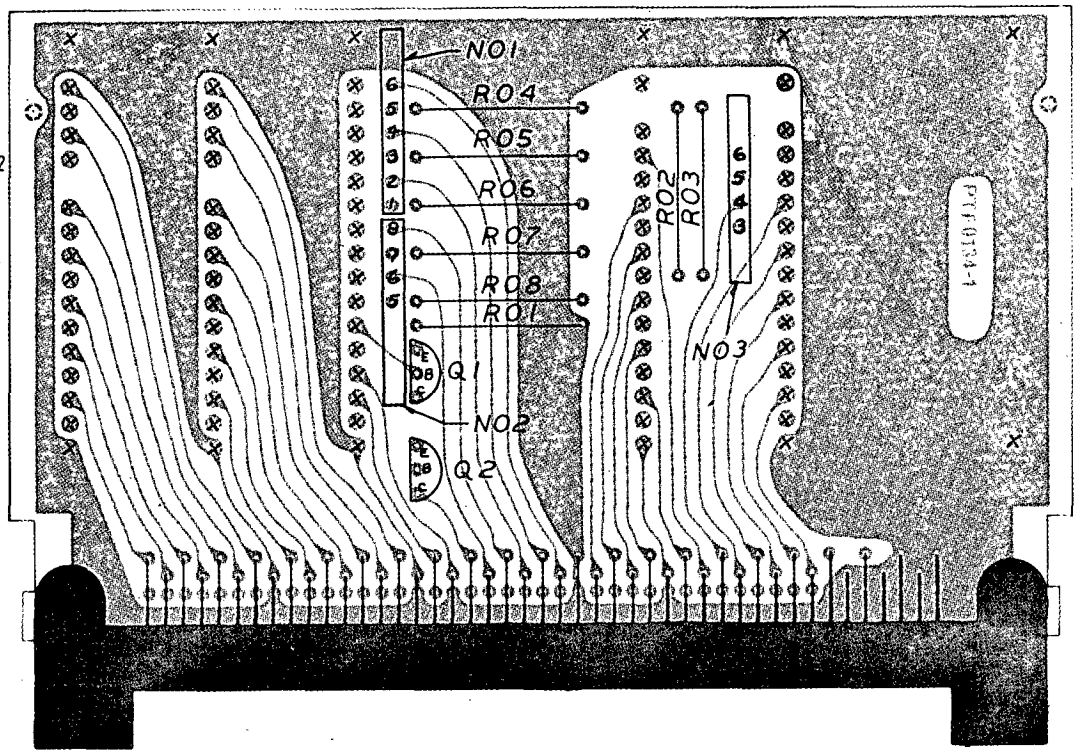
PRINTED CIRCUIT BOARD

PTL0062-1
1 REQUIRED

COMPUTER SYSTEMS LABORATORY WASHINGTON UNIVERSITY ST. LOUIS, MISSOURI			MACROMODULAR PROJECT				
			TITLE PARTS LIST FUNCTION CALLER: LATERAL MOTHER BOARD PART NO. 218.6				
			APPROVED			ENG MLP	DRAWING NO. 218.6D3
			BY	FOR	DATE	DRAWN BY CAH	
				PROD	11/18/72		
CHANGE NO.	DATE	DESCRIPTION				CHECKED	DATE 10-25-72

NOTE 1: MALE AMP MODU CONNECTORS MUST BE INSTALLED FROM THIS SIDE IN LOCATIONS MARKED "X" PRECISELY AS SHOWN IN DRAWINGS 200.50D2 AND 200.50D3 (83 PLACES)

NOTE 2: SEE DRAWING NUMBER 20050D29 FOR CONNECTOR MOUNTING ORIENTATION.



NOTE 3:

NO1	CUT PINS 7,8
NO2	CUT PINS 1,2,3,4
NO3	CUT PINS 1,2,7,8

CHANGE NO.	DATE	DESCRIPTION

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

MACROMODULAR PROJECT

TITLE: COMPONENT IDENTIFICATION
FUNCTION CALLER: FACEPLATE MOTHER BOARD
PART NO. 218.7

APPROVED BY	FOR	DATE
Cem	PROD	11/18/72

ENG.	MLP
DRAWN BY	CSP
CHECKED	dls
DRAWING NO.	218.7D 1
DATE	10-25-72

RESISTORS

TYPE	REQUIRED	LOCATION
R5 = 57.6 OHMS ± 1% 1/8 W FILM	1	R01
R4 = 15,000 OHMS ± 5% 1/4 W CARBON COMPOSITION	7	R02 thru R08
LTN-2 (SPRAGUE)	3	N01 N02 N03

TRANSISTORS

TYPE	REQUIRED	LOCATION
MPS3640 (MOTOROLA)	2	Q1 Q2

CONNECTORS

MALE AMP MODU NO. 85931-5
83 REQUIRED

AMP NO. 583464-1
1 REQUIRED

PRINTED CIRCUIT BOARD

PTF0134-1
1 REQUIRED

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

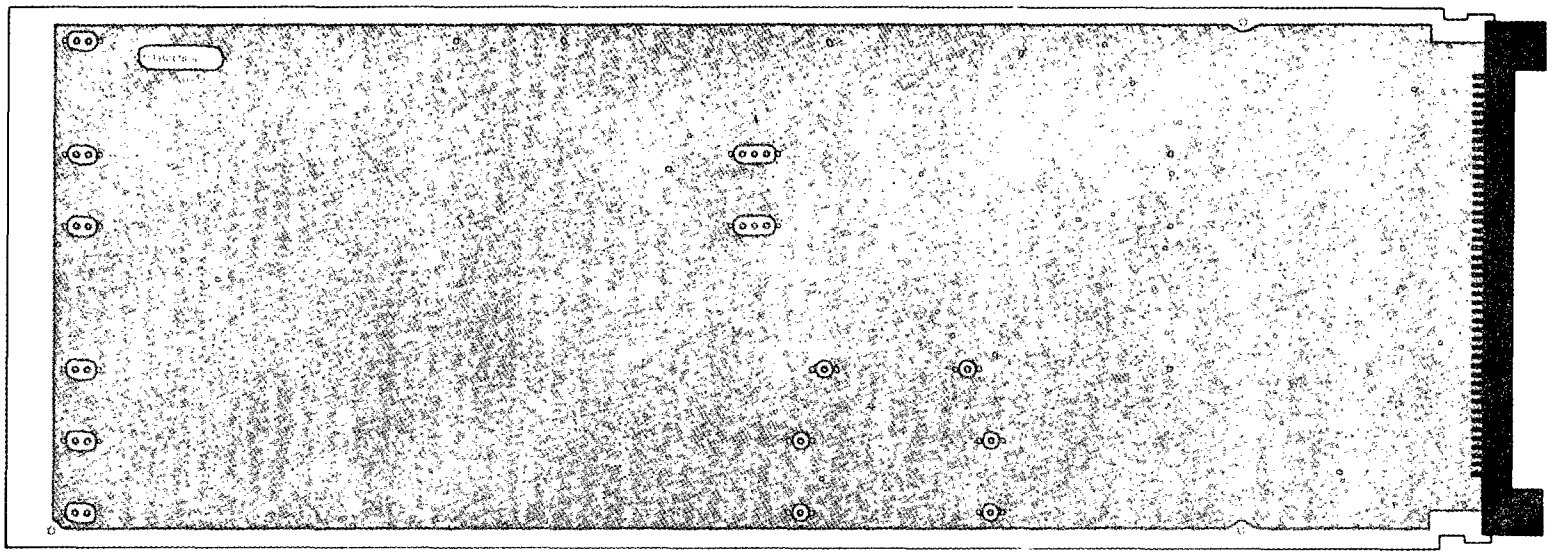
MACROMODULAR PROJECT

TITLE: PARTS LIST
FUNCTION CALLER: FACEPLATE MOTHER BOARD PART NO. 218.7

CHANGE NO.	DATE	DESCRIPTION

APPROVED BY	APPROVED FOR	APPROVED DATE
Clem	PROD	11/18/72

ENG: MLP
DRAWN BY: CAH
CHECKED: dls
DRAWING NO.: 218.7D2
DATE: 10-25-72



NOTE 1: SEE DRAWING NUMBER 200.50D27 FOR CONNECTOR MOUNTING ORIENTATION.

NOTE 2: MALE AMP MODU CONNECTOR MUST BE INSTALLED FROM THIS SIDE, IN ALL LOCATIONS, PRECISELY AS SHOWN IN DRAWINGS 200.50D2 AND 200.50D3. (57 PLACES)

CHANGE NO.	DATE	DESCRIPTION

COMPUTER SYSTEMS LABORATORY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

MACROMODULAR PROJECT

TITLE: COMPONENT IDENTIFICATION
FUNCTION CALLER: BOTTOM MOTHER BOARD
PART NO. 218-8

APPROVED BY	FOR	DATE
Clm	PROD	11/16/72

ENG. MLP
DRAWN BY CSP
CHECKED dls

DRAWING NO. 218.8D1
DATE 10-25-72

CONNECTORS

MALE AMP MODU NUMBER 85931-5
57 REQUIRED

AMP NO. 1-202 845-5
1 REQUIRED

PRINTED CIRCUIT BOARD

PTB0138-0
1 REQUIRED

COMPUTER SYSTEMS LABORATORY WASHINGTON UNIVERSITY ST. LOUIS, MISSOURI		**MACROMODULAR PROJECT**
	TITLE	PARTS LIST FUNCTION CALLER: BOTTOM MOTHER BOARD PART NO. 218.8
	APPROVED BY: cam / FOR: PROD. / DATE: 11/18/72	ENG: MLP DRAWN BY: CAH CHECKED: dls
		DRAWING NO.: 218.8D2 DATE: 10-25-72

CHANGE NO.	DATE	DESCRIPTION

UNCLASSIFIED

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10. DISTRIBUTION STATEMENT

Distribution of this document is unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
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13 ABSTRACT

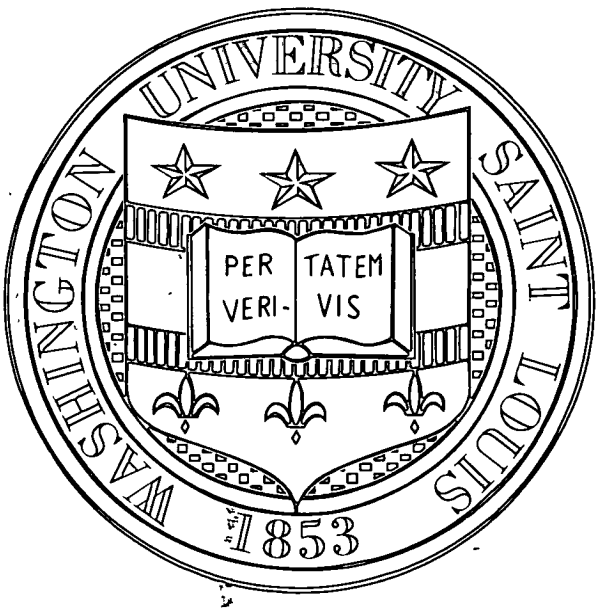
Manufacturing documents, including parts lists, assembly pictorials, and adjustment procedures for the MEMORY, GENERAL MEMORY CONTROLLER, INTERLOCK, MULTIPLY, D/A and FUNCTION CALLER macromodule electronic subassemblies are given.

DD FORM 1 NOV 68 1473 REPLACES DD FORM 1473, 1 JAN 64, WHICH IS OBSOLETE FOR ARMY USE.

UNCLASSIFIED

Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
MEMORY Macromodule						
GENERAL MEMORY CONTROLLER Macromodule						
INTERLOCK Macromodule						
MULTIPLY Macromodule						
D/A Macromodule						
FUNCTION CALLER Macromodule						
Macromodule						
Emitter-Coupled Logic						
Asynchronous Logic						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1853