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FEASIBILITY STUDY OF THE DESIGN OF BI RA SYSTEMS, INC.
MODEL 5301, 5101, AND 3222 CAMAC MODULES FOR SPACE USE.

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BI RA SYSTEMS, INC.
3520 D PAN AMERICAN N.E.
ALBUQUERQUE, NM 87107

APRIL 9, 1976
TYPE III FINAL REPORT-FEBRUARY/MARCH 1976

PREPARED FOR
GODDARD SPACE FLIGHT CENTER
GREENBELT, MARYLAND 20771

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16. Abstract

This report contains a summary of results of redesign of Bi Ra Systems, Inc. Model 5301, 5101, and 3222 commercial modules for space use. Power requirements, operating temperature in space environment of 50°C, parts lists and pricing for 10 and 100 of each module are included.

17. Key Words Suggested by Author	18. Distribution Statement

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
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PREFACE

Objective:

The object of this contract is to conduct a feasibility study of the design of Bi Ra Systems Model 5301, 32 Channel Analog Data System, Model 5101 32 Channel Expender Module, and Model 3222 Dual 24 Bit TTL Output Register.

Scope Of Work:

The intent of the study is not to fabricate completely redesigned modules but to estimate the cost of redesigned modules. The study is conducted with respect to incorporation of NASA approved components, component screening and documentation as well as toward reducing power consumption while maintaining performance as much as possible.

Conclusions:

The study results show that redesigned modules will function reliably in a space environment of 50°C and withstand greater than 15G's of random vibration between 40Hz and 400Hz.

Some problems relating to $\pm$ 15 V power and the signal interconnections between the 5301 and 5101 modules are not completely resolved. This is discussed in the Technical section.

TECHNICAL

Introduction

This third and final report contains a summary of the results of the feasibility study. Included is a discussion of the rear panel interconnections for the 5301/5101, mechcanical design, power consumption steady-state operating temperature, parts list, schematics, and pricing for 10 and 100 each space-worthy 5301, 5101, and 3222 modules.

A meeting was held at NASA, Greenbelt, March 3, 1976. Those present were Dr. J. H. Trainor and Mr. T. Comenski of NASA and Mr. R. McElderry of Bi Ra. Several questions which have arisen during the investigation were answered by NASA. A copy of the items discussed has been forwarded to Dr. Trainor.

Copies of the rough draft Heat Transfer and Vibration analysis were presented to Dr. Trainor at the March 3, 1976 meeting. By instruction of Dr. Trainor, no other copies are required and are not included in this report. It is noted that the Resonant Frequency Analysis Calculations for the Model 5101 were used to predict the mechanical stresses of all redesigned modules; separate calculations were not made for the 5301 and 3222.

The March 3, 1976 meeting authorized removal of the series +6V to +5 dropping diodes and $\pm$ 24V to $\pm$ 15V regulators where applicable. The +5 will be available at the dataway; the $\pm$ 15V will be supplied by a NASA furnished DC to DC converter. The $\pm$ 15V shall be coupled to the 5301 module by a rear panel connector. Signal interconnections between the 5301 and 5101 modules shall also be coupled by a rear panel connector. The type of connector for signal and power shall be a Royal D or DD.

Problem Area:

Some mechanical complications are created due to the size of the Royal D or DD connectors and the available space for mounting at the module rear panel. The smallest connector of this type is a nine (9) pin which is used for power. Signal interconnects require the next smallest which is a fifteen (15) pin. These connectors must be mounted side-by-side on the 5301 which removes considerable metal from the back plate for mounting. The 5101 is a single-wide module. Therefore, all interconnections, signal and ± 15V, must be contained in the single rear connector selected for this module. Distribution of signals and power must be daisy-chained to the next 5101 module.

It is requested that NASA investigate the rear panel interconnects using the Royal D or DD connectors. A solution may be a smaller type connector.

Power Consumption:

With the removal of the +6V to 5V dropping diodes and the ± 24V to ± 15V regulators where applicable and redesigning the logic of the Micro Networks MNA 7000 Data Acquisition Unit, the power dissipated by each module is as follows:

5301 Module

Commercial		Redesign		
Vin	Power	Vin	Board 1 Pwr.	Board 2 Pwr.
+6	4.87W	+5	0.440W	0.371W
-24	2.06W	-15	0.678W	0.000W
+24	1.58W	+15	0.630W	0.000W
Total	8.51W	Total	1.748W*	0.371W

*Typical (Max. 2.1W)

5101 Module

Commercial	396MW	Total
Redesign	144MW	Total

3222 Module

Commercial	5.5W
Redesign	2.2W*

*5406 buffers dissipate 1.45W

Design Changes:

5301 Module

The commercial design utilizes A15, provides a separate additional OVP circiuts for inputs, provides range select by X1 or X2 amplifier gain, allows adjustment for 10.24 or 10.00V full scale and has strap selection for offset binary, one's compliment, two's complement, and unipolar binary.

The redesigned module replaces A15 with A2, OVP provided by specifications of HI-506 A multiplexer, provides range select by X1 or X0.5 amplifier gain, has full scale of 10.00V, and has offset binary code.

5101 Module

Commercial version provides separate addition OVP circuits; redesign utilizes OVP circuits within HI-506 A multiplexer.

3222 Module

Redesign has deleted F8 A15 to test LAM, deleted low or high-true output option; redesign has low-true only.

The redesigned modules have no indicators and operate directly from +5V and $\pm$15 where applicable.

Enviromental

No recalculations have been made to determine the reduction of steady-state operating temperatures of the modules after the removal of the dropping diodes and regulators from the boards where applicable. With these elements on the boards, the original Thermal Analysis and

Resonant Frequency calculations indicate that the modules will function reliably in a space environment of 50°C with a random vibration from 40-400Hz. The worse-case temperature of each board is as follows:

	5301	5101	3222
Board 1	80°C	58.4°C	85°C
Board 2	75.2°C		

Mechanical Design

The 3222 and 5101 are single-wide modules; the 5301 is dual-wide. Pictorials of the modules are shown in Figures 1, 2A, and 2B.

A five (5) point mounting system mechanically links the top and bottom aluminum covers to the PC board through spacers. The top and bottom cover edges are secured to the PC board guide rails with five (5) each 4-40 screws. Spacers located in the plane of the PC board and on the top and bottom surfaces are compressively loaded from the aluminum covers with 4-40 screws torqued to a minimum of 8 inch-lbs.

The 5301 contains three aluminum covers; the 5101 and 3222 utilize two covers. In addition to stiffening, the covers provide heat transfer paths from the PC board through the spacers to the guide rails.

Schematics and Parts Lists

The 5301, 5101, and 3222 drawings are enclosed. The type of circuit is specified. The designs are subject to change as the result of PC board layout which may result in circuit addition for ease of conductor routing.

Fabrication Costs

Estimates of NASA quality 5301, 5101, and 3222 modules in quantities of 10 and 100 are presented. The pricing includes Category I recurring cost which includes costs related to all modules. This category includes special equipment, training, procedure preparation and definition, etc.

Category II non-recurring costs for each module includes one-time

costs such as PC board layout for the specific module. Reocurring costs for each module include parts, board fabrication, assembly, checkout, etc.

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED

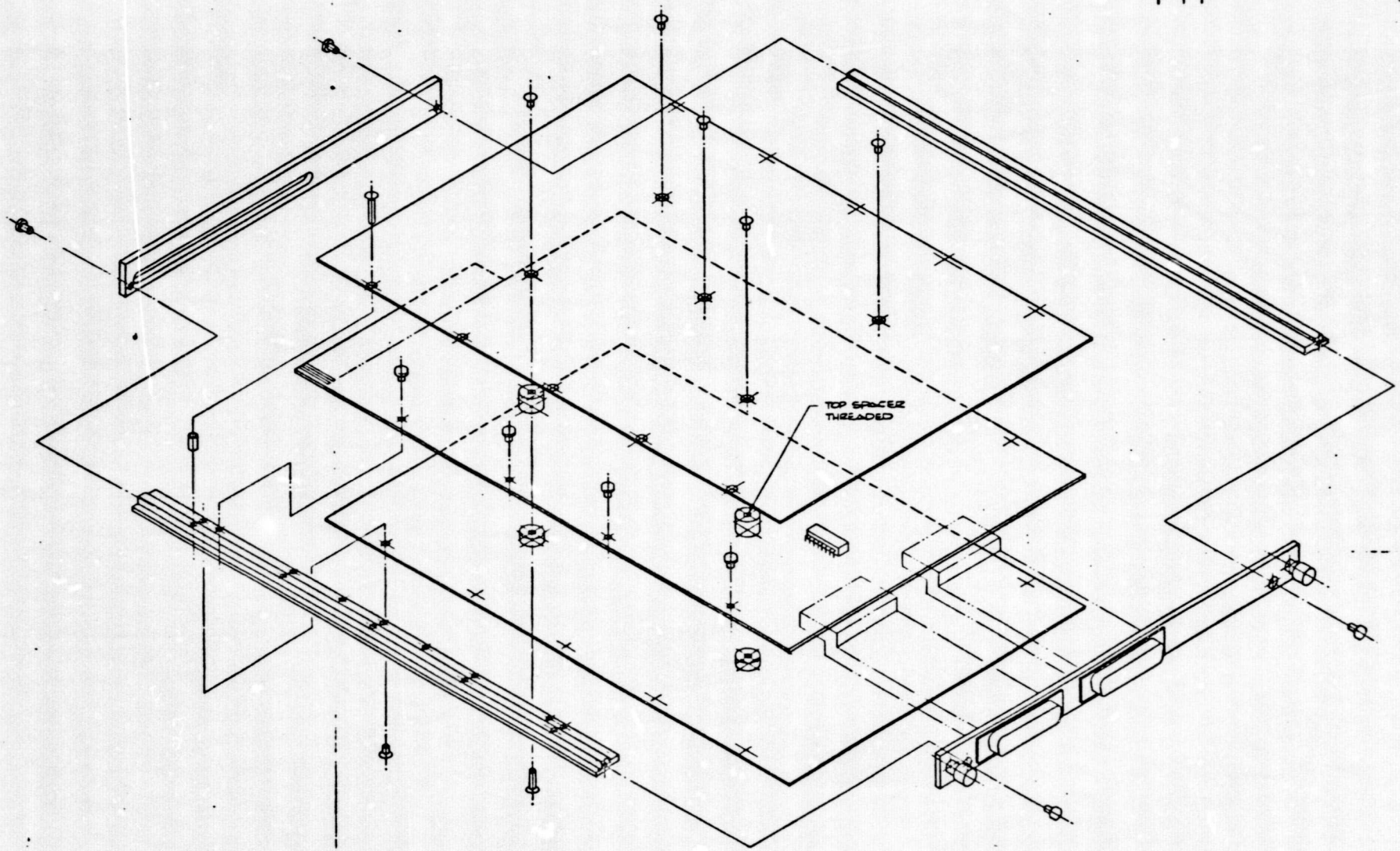


FIG. 1 MODULE № 3222 & № 5101

SIZE	CODE IDENT NO	DRAWING NO
D		F
SCALE		SHEET

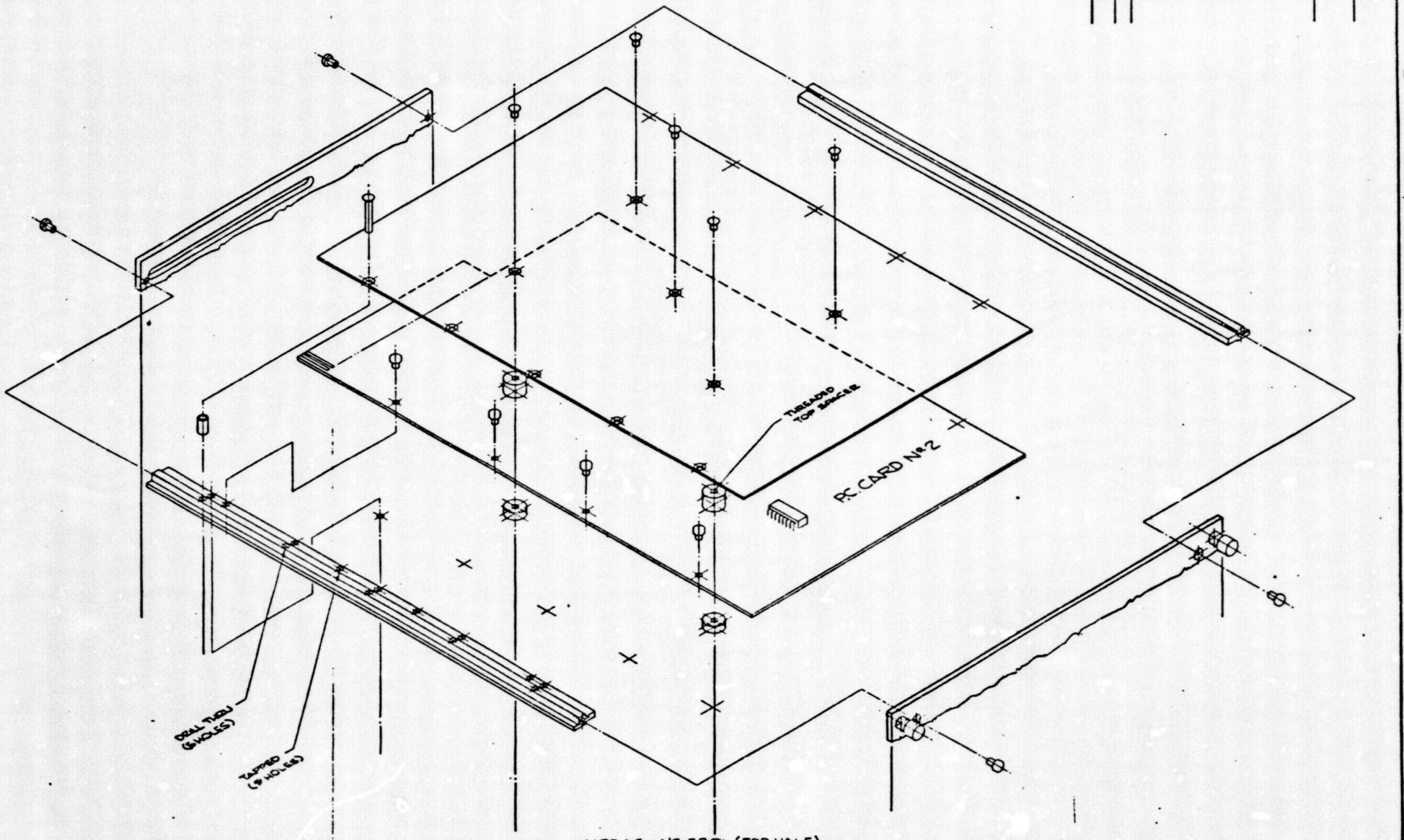


FIG. 2A MODULE Nº 5301 (TOP HALF)

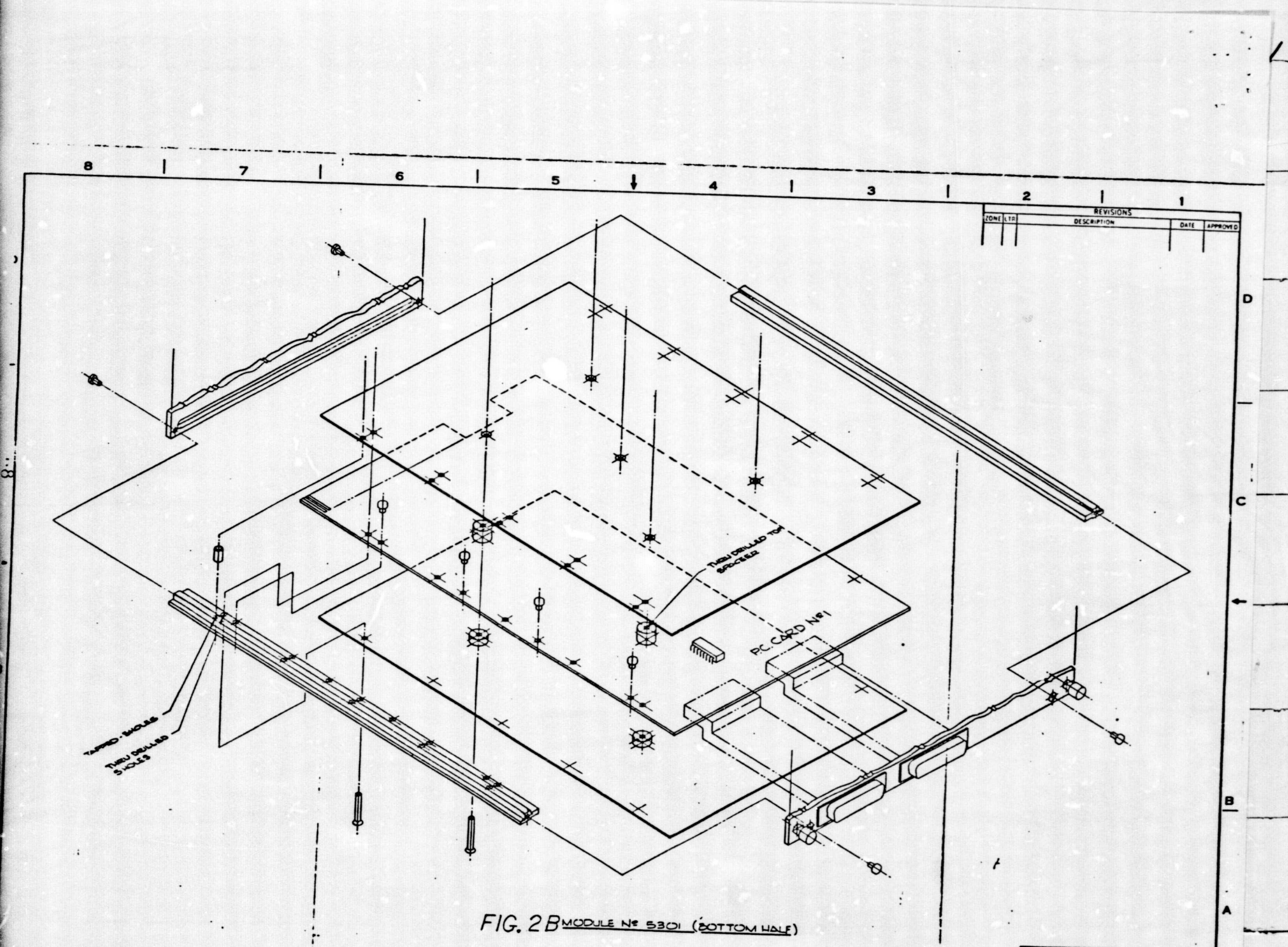


FIG. 2B MODULE Nº 5301 (BOTTOM HALF)

Parts List 5301

Note: All 54LSXX IC's class B

Part	Description	Quantity
54LS00W	Quad 2 input pos NAND	2
02W	Quad 2 input pos NOR	1
04W	Hex inverters	4
08W	Quad 2 input pos AND	2
20W	Dual 4 input pos NAND	1
30W	8 input pos NAND	1
32W	Quad 2 input pos OR	2
38W	Quad 2 input pos NAND open col.	5
42W	BCD to Decimal Decoder	3
73W	Dual J-K Flip-Flop	2
74W	Dual D Flip-Flop	1
85W	4-Bit Comparator	1
93W	4-Bit Binary Counter	1
122W	Retriggerable Monostable Multivibration	1
158W	Quad 2 line to 1 line Multiplexer	1
197W	Presettable Binary Counter	1
1200 pf	GCMV6 1%	1
.01 uf	CKR11 50v	10
4.7 uf	CSR13 50v	3
10 uf	CSR13 50v	1
1 K	RCR05 solid core	5
5 K	RTR12 trimmer	1
20 K	RLR05 2% solid core	1
HI 506 A8	16 Channel Analog Mux Mil 883 class B	2
DG 508-2	8 Channel Analog Mux Mil 883 class B	1
DG 509-2	4 Channel Diff Analog Mux Mil 883 class B	1
MN 343H-B	Micro Networks S/H Mil 883 class B	1
MN 368H-B	" " Amp " " " "	1
MN5212H-B	" " ADC " " " "	1
M24308/2-4 *	Cinch Royal D Mark III 37 pin connector	2
M24308/2-2 *	" " " " " 15 pin connector	1
M24308/4-1 *	" " " " " 9 pin connector	1
275001	1 Amp Picofuse per 204 A/D	4
E-26	Wire Mil-W-16878	AR

* per GSFC S311-P4/9,10

Parts List 5101

Part	Description	Quantity
HI-506-A8	16Channel Analog Mux, Mil 883 class B	2
M23408/2-4	Cinch Royal D Mark III 37 pin conn.*	2
M23408/2-2	" " " " " 15 pin conn.*	1
1 K	RC05 solid core	1
275001	1 Amp Picofuse per 204 A/D	2
.01 uf	CKR11 50v 20%	2
E-26	Wire Mil-W-16878	AR

* per GSFC S311-P-4/9,10

Parts List 3222

Note: All IC's Mil-883 Class B

Part	Description	Quantity
54LS00W	Quad 2 input pos NAND	1
02W	" " " " NOR	1
04W	Hex Inverters	7
5406W	Hex Buffer Open Collector	8
08W	Quad 2 input pos NAND	1
30W	8 input pos NAND	2
32W	Quad 2 input pos OR	2
38W	Quad 2 input pos NAND open col.	1
42W	BCD to Decimal Decoder	2
73W	Dual J-K Flip-Flop	1
74W	Dual D Flip-Flop	2
174W	Hex D-Type Flip-Flop	8
1 K	RCR05 solid core	1
.01 uf	CKR11 50v	1
4.7 uf	CSR13 25v	1
275001	1 Amp picofuse per 204 A/D	1
E-26	Wire Mil-W-16878	AR
M23408/3-5*	Cinch Royal D Mark III 50 pin Conn.	2

*per GFSC S311-P-4/9,10

Cost Estimates-Category I, Non recurring

		Est. Cost	Total
1.	Direct Material		
	a. Subcontract-Clean area	$1500.00	$1500.00
2.	Direct Labor		
	a. Trainning-Assy/Insp.	500.00	
	b. Liaison-Engineer at NASA	1200.00	1700.00
3.	Labor Overhead	1020.00	1020.00
4.	Special Equipment		
	a. Oven/Fixture	2000.00	2000.00
5.	Travel		
	a. Air-Training/Liaison 5 round trips, Albu. to Greenbelt	1325.00	
	b. Per Diem	540.00	
	c. Auto	195.00	2060.00
6.	Total Direct Costs and Overhead		8280.00
7.	G and A		2584.00
8.	Total Estimated Cost		10864.00
9.	Fee		1086.00
10.	Total Estimated Cost and Fee		$11940.00

Cost Estimates-Category II, Non recurring, Model 5301

		Est. Cost	Total
1.	Direct Material		
	a. Purchased Parts	$1840.00	$1840.00
2.	Direct Labor		
	a. PC Circuit Layout	1200.00	
	b. Design, Breadboard, Schem., Dif.	3000.00	
	c. Assembly	300.00	
	d. Testing	500.00	5000.00
3.	Labor Overhead	3000.00	3000.00
4.	Total Direct Cost and Overhead		9840.00
5.	G and A		2952.00
6.	Total Estimated Costs		12792.00
7.	Fee		1279.00
8.	Total Estimated Costs and Fee		$14,071.00

Cost Estimates-Recurring, Model 5301, 10 Units

		Est. Cost	Total
1.	Direct Material		
	a. Purchased Parts	$24254.00	
	b. Subcontract	1200.00	$25454.00
2.	Direct Labor		
	a. Assembly	1500.00	
	b. Testing	1500.00	
	c. Silk Screen/Machining	200.00	3200.00
3.	Labor Overhead		1920.00
4.	Other Direct Costs		
	a. Manuals/Schematics	100.00	
	b. Shipping	50.00	150.00
5.	Total Direct Cost and Overhead		30724.00
6.	G and A		9217.00
7.	Total Estimated Cost		39941.00
8.	Fee		3994.00
9.	Total Estimated Cost and Fee		$43,935.00

Cost Estimates-Recurring, Model 5301, 100 Units

		Est. Cost	Total
1.	Direct Material		
	a. Purchased Parts	$150,000.00	
	b. Subcontract	10,000.00	$160,000.00
2.	Direct Labor		
	a. Assembly/Inspection	11,800.00	
	b. Testing	8,000.00	
	c. Silk Screen/Machining	800.00	20,600.00
3.	Labor Overhead		12,360.00
4.	Other Costs		
	a. Manuals/Schematics	900.00	
	b. Shipping	500.00	1,400.00
5.	Total Direct Cost and Overhead		194,360.00
6.	G and A		58,308.00
7.	Total Estimated Cost		252,668.00
8.	Fee		25,267.00
9.	Total Estimated Cost and Fee		$277,935.00

Cost Estimated-Single Unit Costs for 10 and 100 Quantities of Model 5301

Total Non recurring Costs

Category I	$11,940.00
Category II	$14,071.00
Total	$26,011.00

	10 Unit Quan.	100 Unit Quan.
Cat. I, II	$26,011.00	$26,011.00
Recurring	$43,935.00	$277,935.00
Total	$69,946.00	$303,946.00
Per Unit	$6,995.00	$3,039.00

Cost Estimates-Category II, Non Recurring, Model 5101

		Est. Cost	Total
1.	Direct Material		
	a. PC Layout	$150.00	$150.00
2.	Direct Labor		
	a. Schematics, Def	200.00	200.00
3.	Labor Overhead	120.00	120.00
4.	Total Direct Costs and Overhead		470.00
5.	G and A		141.00
6.	Total Estimated Costs		611.00
7.	Fee		61.00
8.	Total Estimated Cost and Fee		$672.00

Cost Estimates-Recurring, Model 5101, 10 Units

		Est. Cost	Total
1.	Direct Material		
	a. Purchased Parts	$7,333.00	$7,333.00
	b. Subcontract	400.00	400.00
2.	Direct Labor		
	a. Assembly/Inspection	240.00	
	b. Testing	300.00	
	c. Silk Screen/Machining	100.00	640.00
4.	Other Direct Costs		
	a. Manuals	80.00	
	b. Shipping	50.00	130.00
5.	Total Direct Costs and Overhead		8,487.00
6.	G and A		2,546.00
7.	Total Estimated Costs		11,033.00
8.	Fee		1,103.00
9.	Total Estimated Cost and Fee		$12,136.00

Cost Estimates-Recurring Model 5101, 100 Units

		Est. Cost	Total
1.	Direct Material		
	a. Purchased Parts	$49,165.00	
	b. Subcontract	3,500.00	$52,665.00
2.	Direct Labor		
	a. Assembly/Inspection	2,200.00	
	b. Testing	2,800.00	
	c. Silk Screen/Machining	985.00	5,985.00
3.	Labor Overhead		3,591.00
4.	Other Direct Costs		
	a. Manuals	700.00	
	b. Shipping	500.00	1.200.00
5.	Total Direct Cost and Overhead		63,441.00
6.	G and A		19,032.00
7.	Total Estimated Costs		82,473.00
8.	Fee		8,247.00
9.	Total Estimated Cost and Fee		$90,720.00

Cost Estimates-Single Unit Costs for 10 and 100 Quantities of Model 5101

Total Non Recurring Costs

Category I	$11,940.00
Category II	672.00
Total	$12,612.00

	10 Unit Quan.	100 Unit Quan.
Category I, II	$12,612.00	$12,612.00
Recurring	12,136.00	90,720.00
Total	$24,748.00	$103,332.00
Per Unit	$2,475.00	$1,033.00

Cost Estimates-Category II, Non-Recurring, Model 3222

1.	Direct Material	Est. Cost	Total
	a. Subcontract	$750.00	$750.00
2.	Direct Labor		
	a. Schematics, Def.	$800.00	$800.00
3.	Labor Overhead	$480.00	$480.00
4.	Total Direct Costs and Overhead		$2,030.00
5.	G and A		609.00
6.	Total Estimated Costs		2,639.00
7.	Fee		264.00
8.	Total Estimated Costs and Fee		$2,903.00

Cost Estimates-Recurring, Model 3222, 10 Units

		Est. Cost	Total
1.	Direct Material		
	a. Purchased Parts	$6,226.00	
	b. Subcontract	500.00	$6,726.00
2.	Direct Labor		
	a. Assembly/Inspection	850.00	
	b. Testing	500.00	
	c. Silk Screen/Machining	100.00	1,450.00
3.	Labor Overhead	870.00	870.00
4.	Other Direct Costs		
	a. Manuals/Schematics	100.00	
	b. Shipping	50.00	150.00
5.	Total Direct Costs and Overhead		9,196.00
6.	G and A		2,758.00
7.	Total Estimated Cost		11,954.00
8.	Fee		1,195.00
9.	Total Estimated Cost and Fee		$13,149.00

Cost Estimates-Recurring, Model 3222, 100 Units

		Est. Cost	Total
1.	Direct Material		
	a. Purchased Parts	$43,659.00	
	b. Subcontract	4,500.00	$48,159.00
2.	Direct Labor		
	a. Assembly/Inspection	8,000.00	
	b. Testing	4,500.00	
	c. Silk Screen/Machining	800.00	13,300.00
3.	Labor Overhead	7,980.00	7,980.00
4.	Other Direct Costs		
	a. Manuals/Schematics	800.00	
	b. Shipping	500.00	1,300.00
5.	Total Direct Costs and Overhead		70,739.00
6.	G and A		21,222.00
7.	Total Estimated Cost		91,961.00
8.	Fee		9,196.00
9.	Total Estimated Cost and Fee		$101,157.00

Cost Estimates-Single Unit Costs for 10 and 100 Quantities of Model 3222

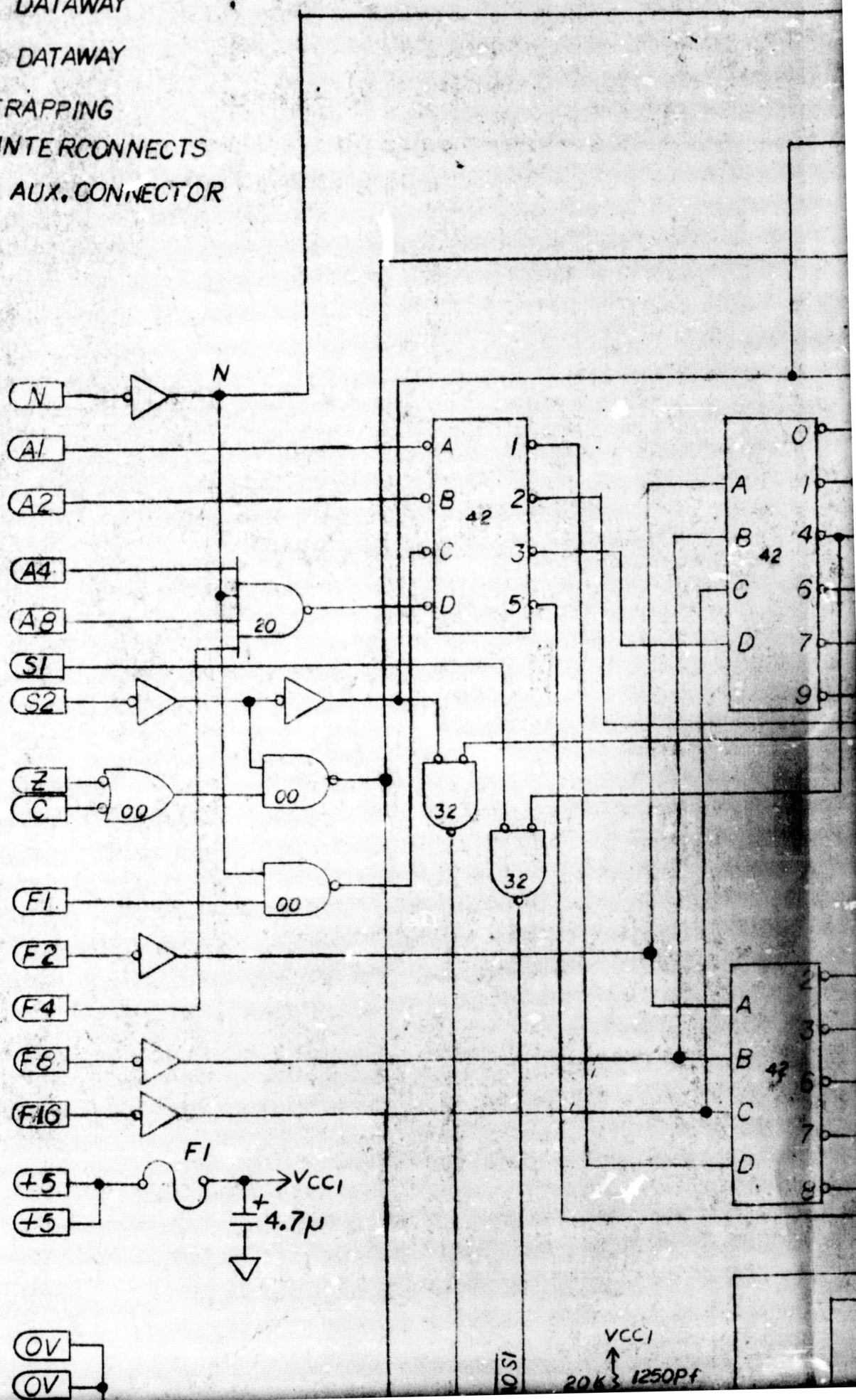
Total Non Recurring Costs

Category I	$11,940.00
Category II	2,903.00
Total	$14,843.00

	10 Unit Quan.	100 Unit Quan.
Category I, II	$14,843.00	$14,843.00
Recurring	13,149.00	101,157.00
Total	$27,992.00	116,000.00
Per Unit	$2,799.00	$1,160.00

SYMBOLS

- BOARD 1 DATAWAY
- BOARD 2 DATAWAY
- PROG. STRAPPING
- BOARD INTERCONNECTS
- BOARD 2 AUX. CONNECTOR



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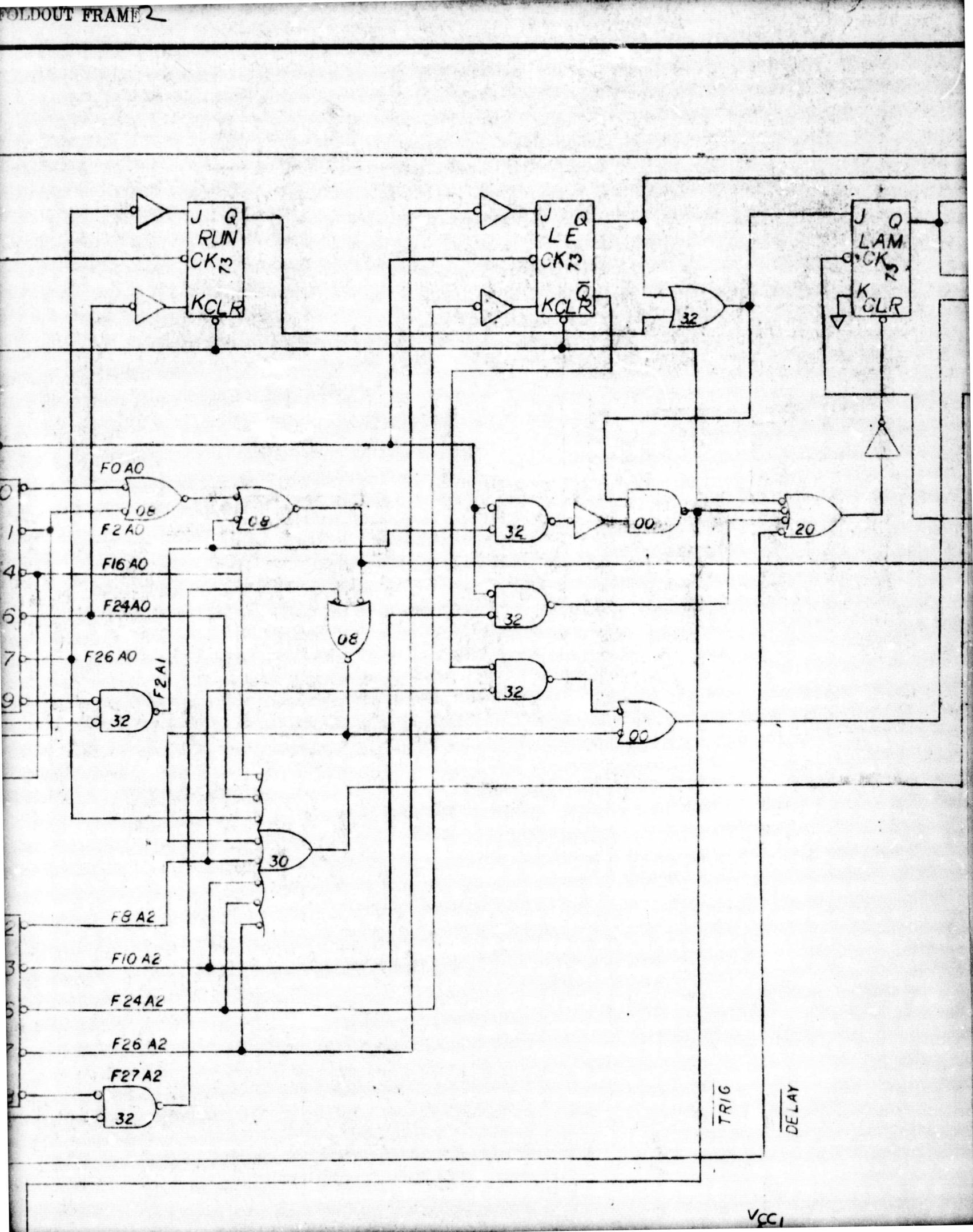

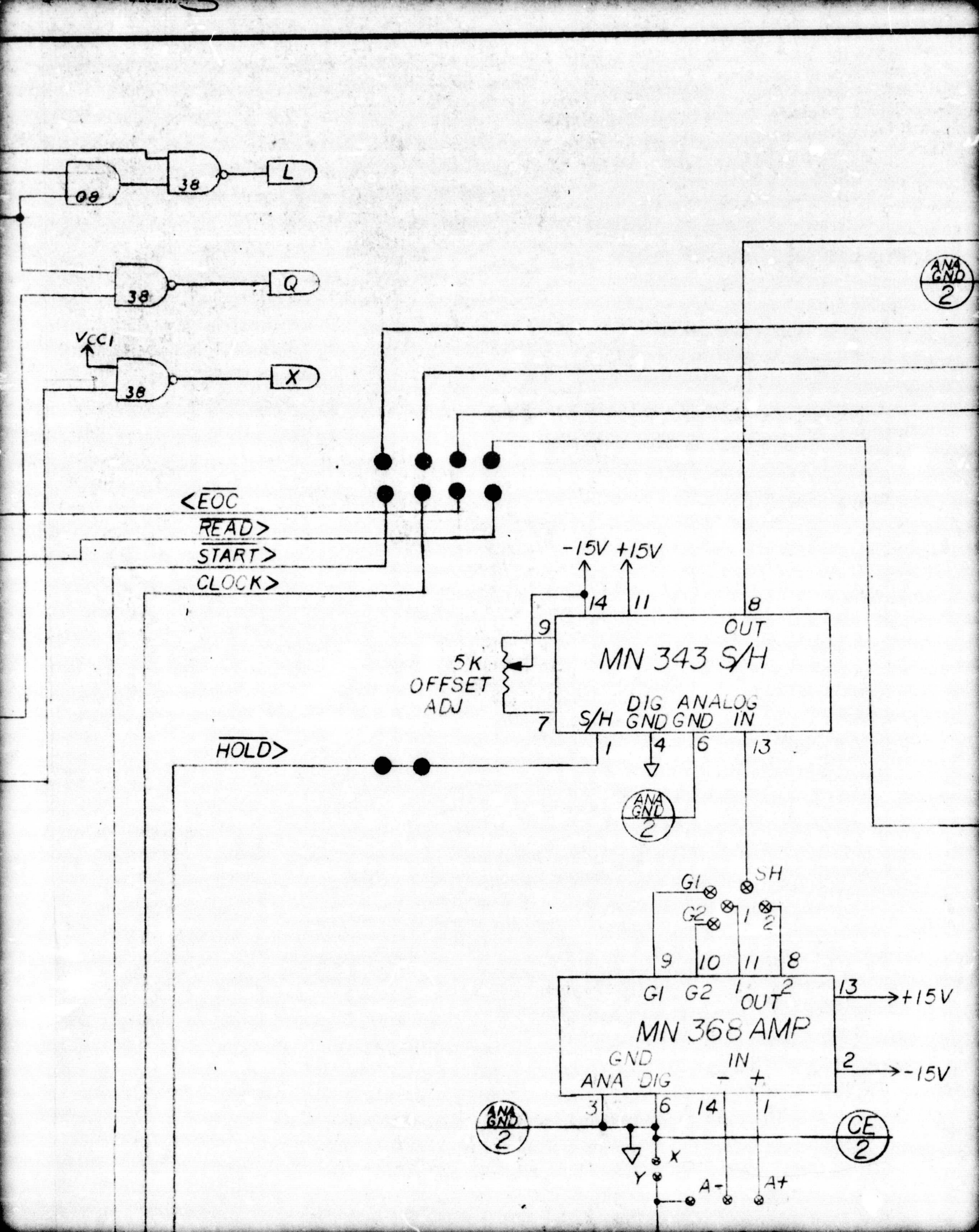
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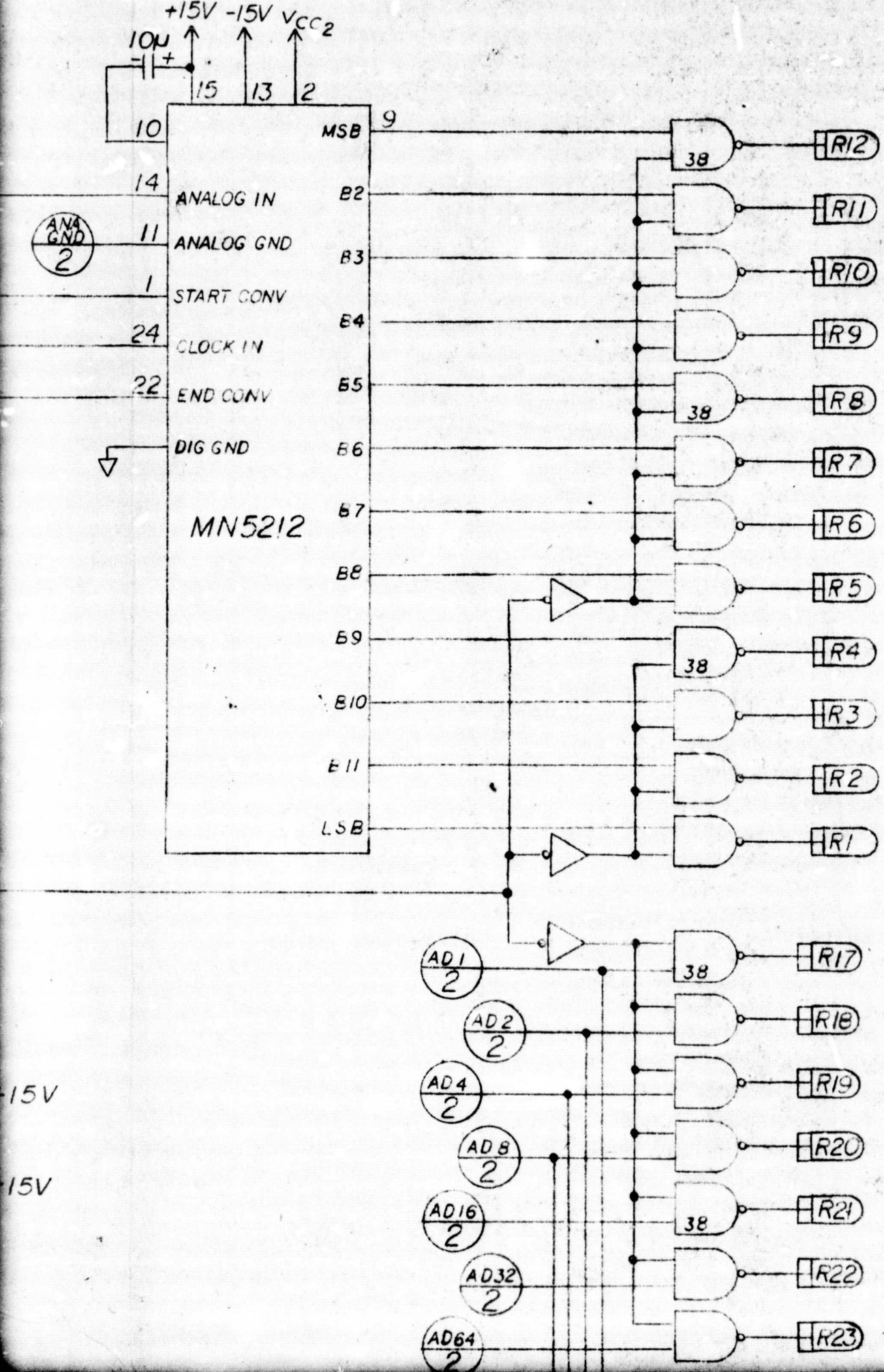
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B2
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B7
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B9
B10
B11
LSB
9
ANA GND 2
38
R12
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AD1 2
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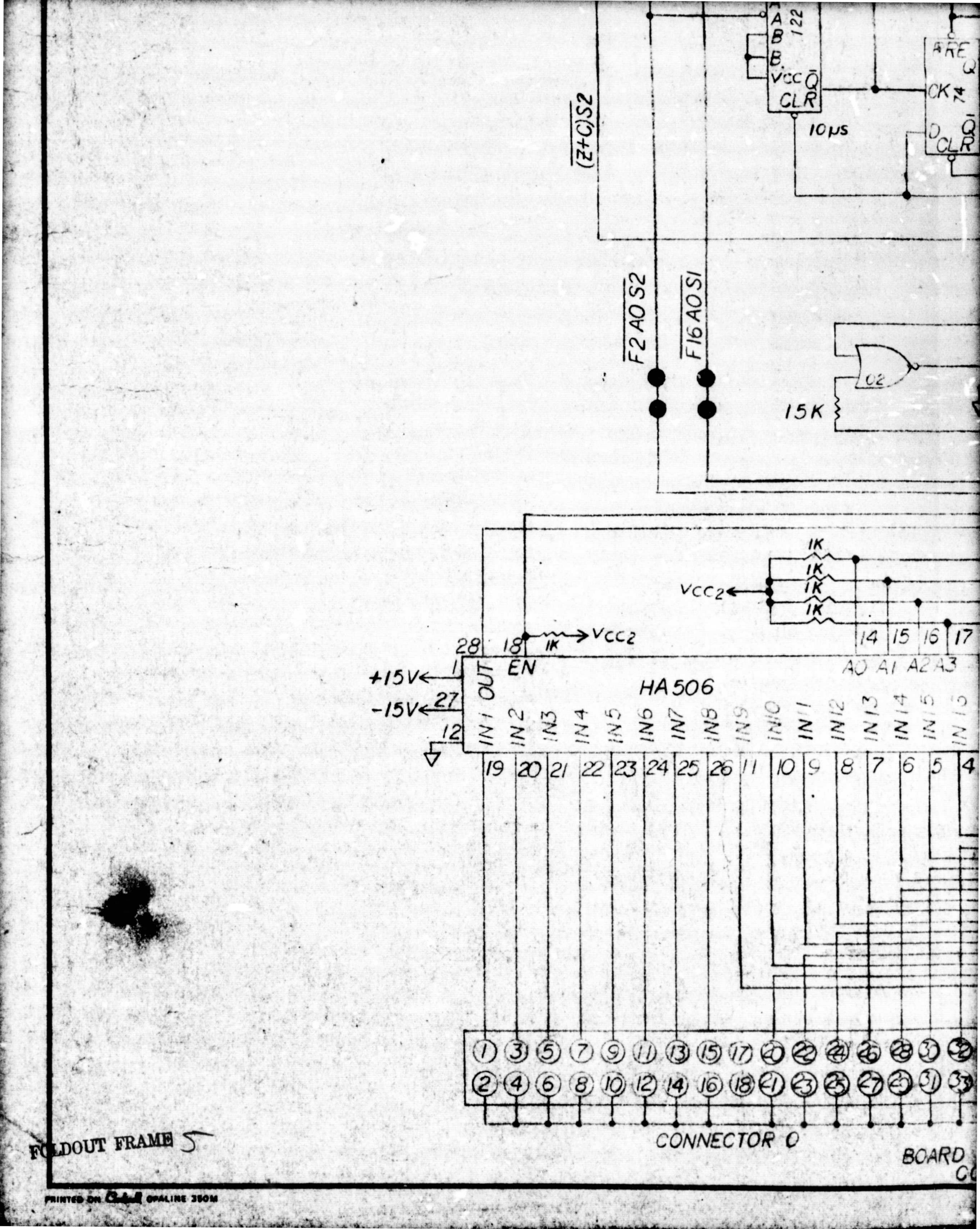
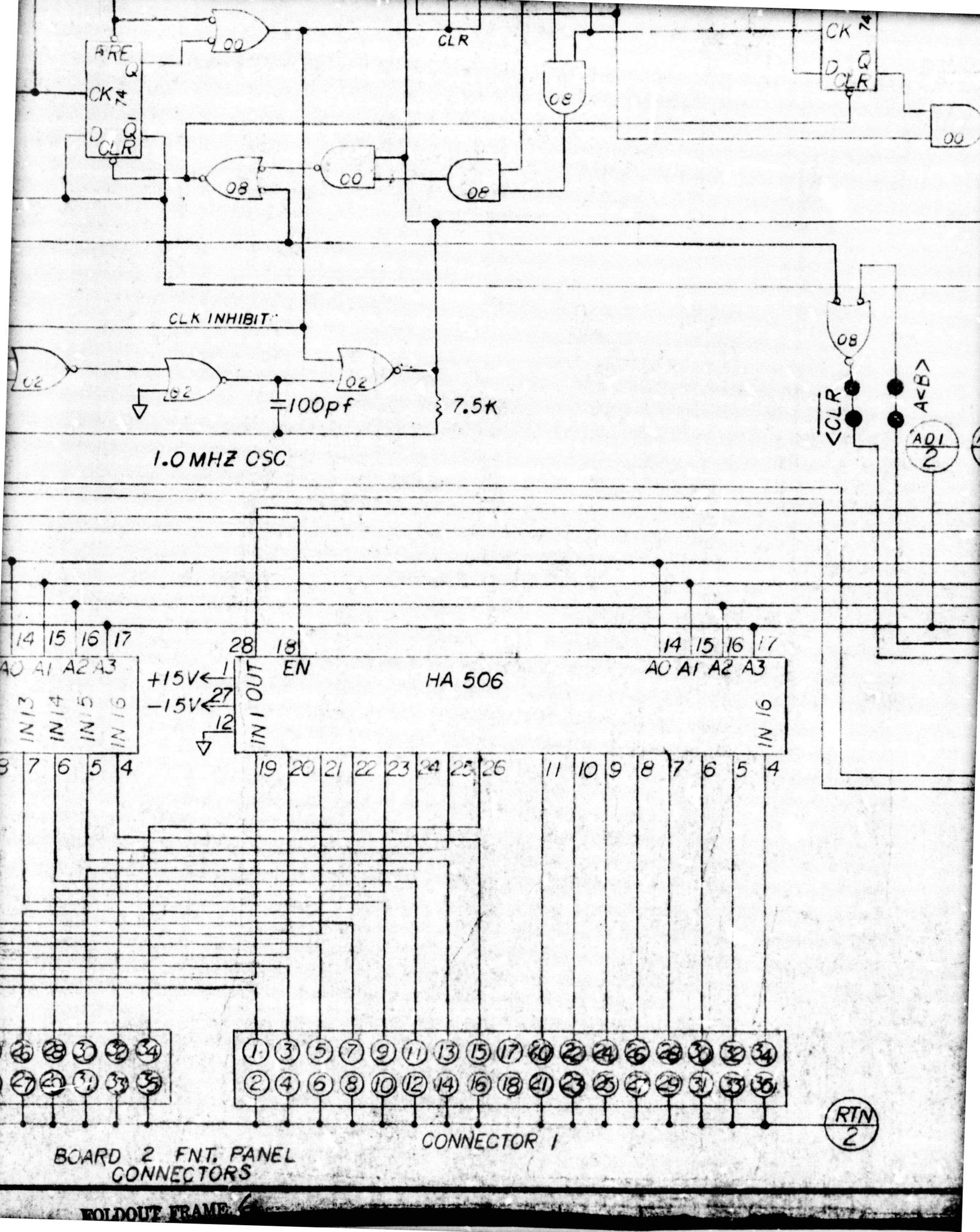


FOLDOUT FRAME 5



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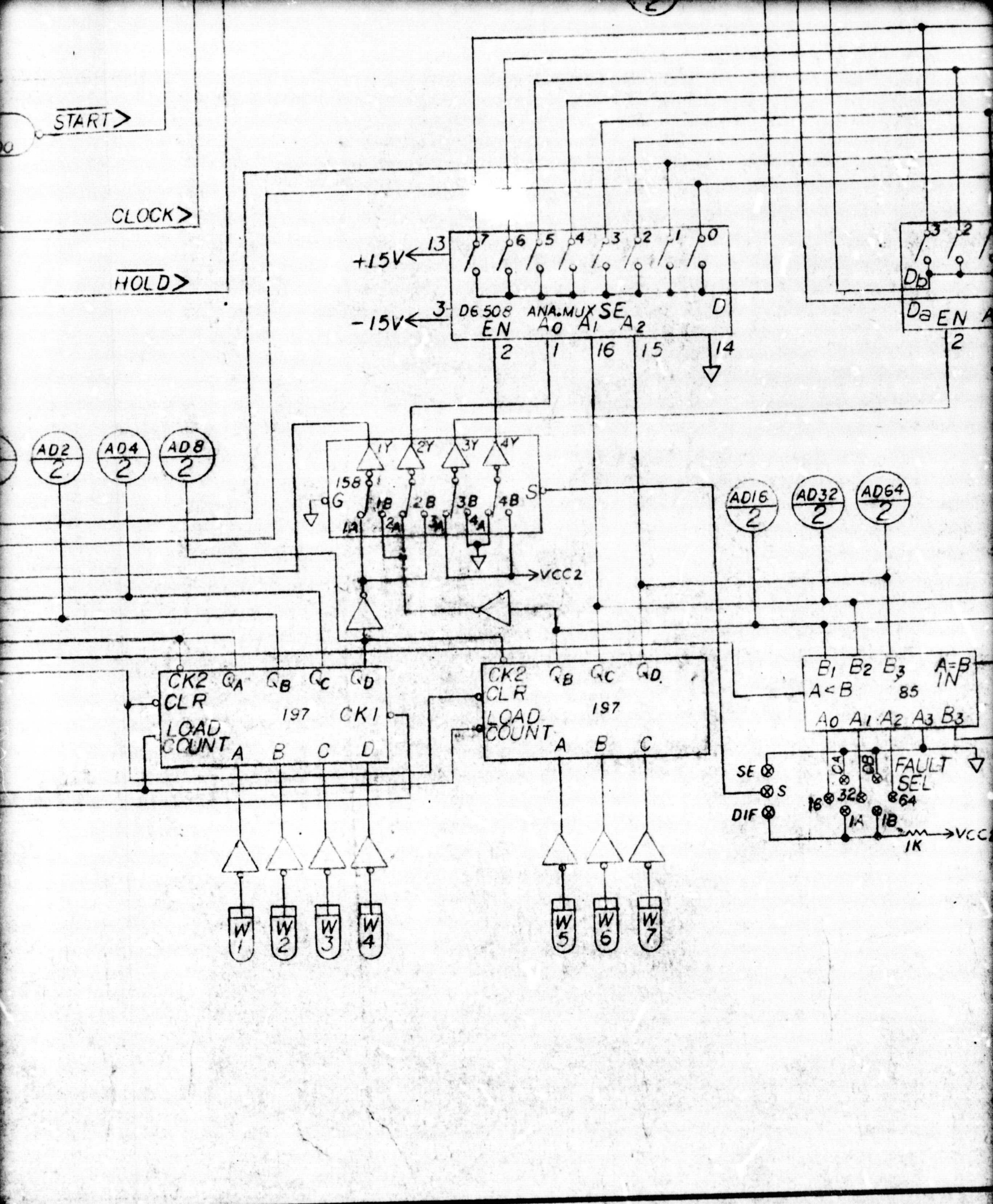
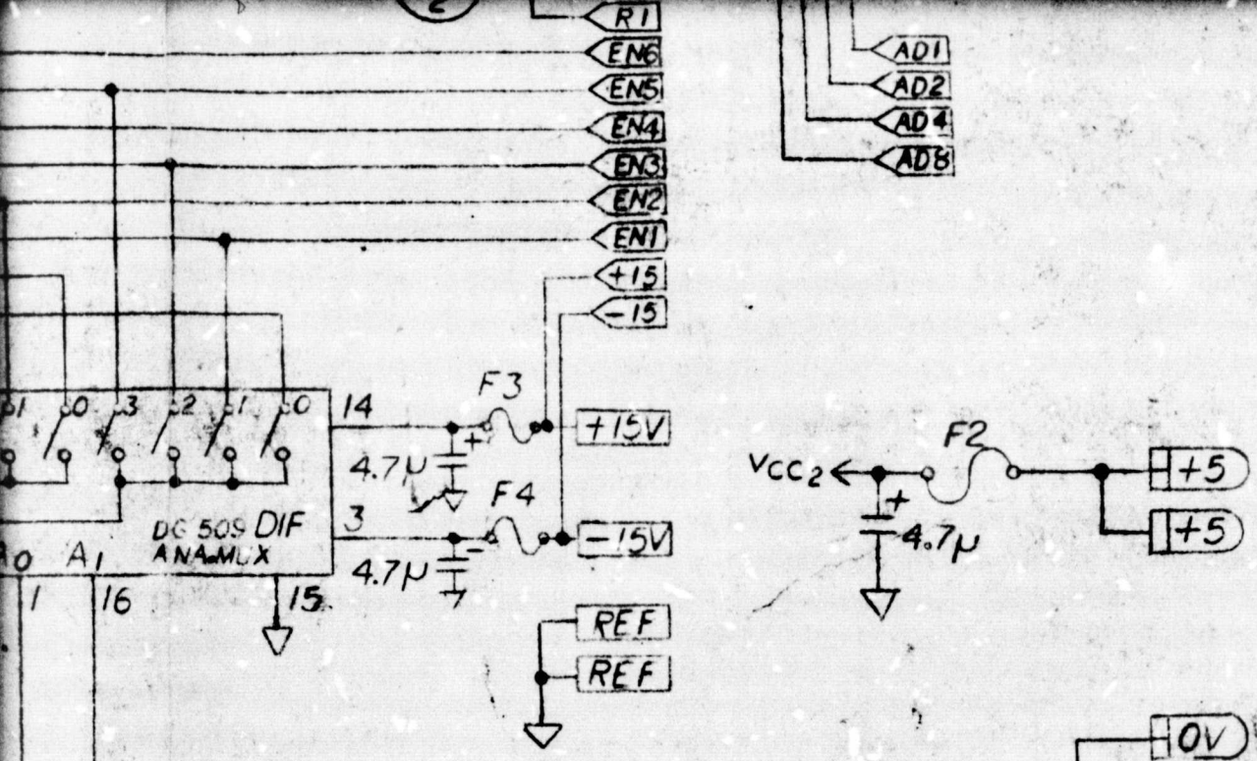
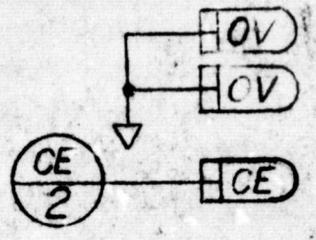

START>
CLOCK>
HOLD>
+15V
-15V
13
3
D6 508 ANA. MUX
EN A0 A1 SE A2
D
7 6 5 4 3 2 1 0
2 1 16 15 14
AD2 2
AD4 2
AD8 2
AD16 2
AD32 2
AD64 2
158
1Y 2Y 3Y 4Y
G
1B 2B 3B 4B
1A 2A 3A 4A
S
VCC2
CK2 QA QB QC QD
CLR
LOAD
COUNT
197
CK1
A B C D
CK2 QB QC QD
CLR
LOAD
COUNT
197
A B C
B1 B2 B3 A=B IN
A<B 85
A0 A1 A2 A3 B3
SE
S
DIF
FAULT SEL
16 32 64
1A 1B
1K
VCC
W1 W2 W3 W4
W5 W6 W7

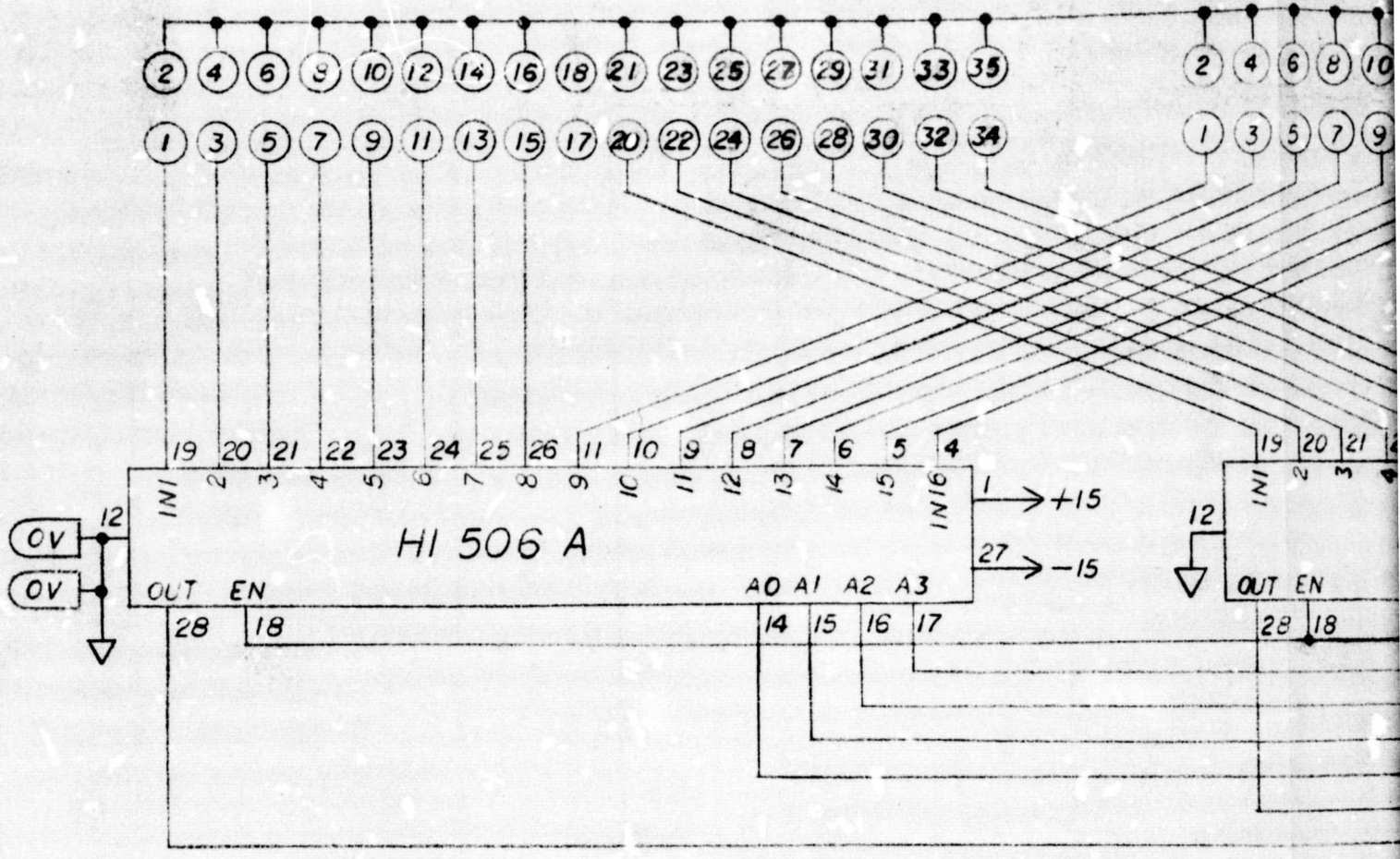




BI RA SYSTEMS INC		
DATE FEB 22, 76	DRAWN BY RCm	APPROVED BY PRELIMINAY
SCALE	REVISED 3/19/76 RCm	
NASA MODEL 5301		
SUBJECT TO CHANGE		DRAWING NUMBER

FOLDOUT FRAME 8

CONNECTOR O



SYMBOLS

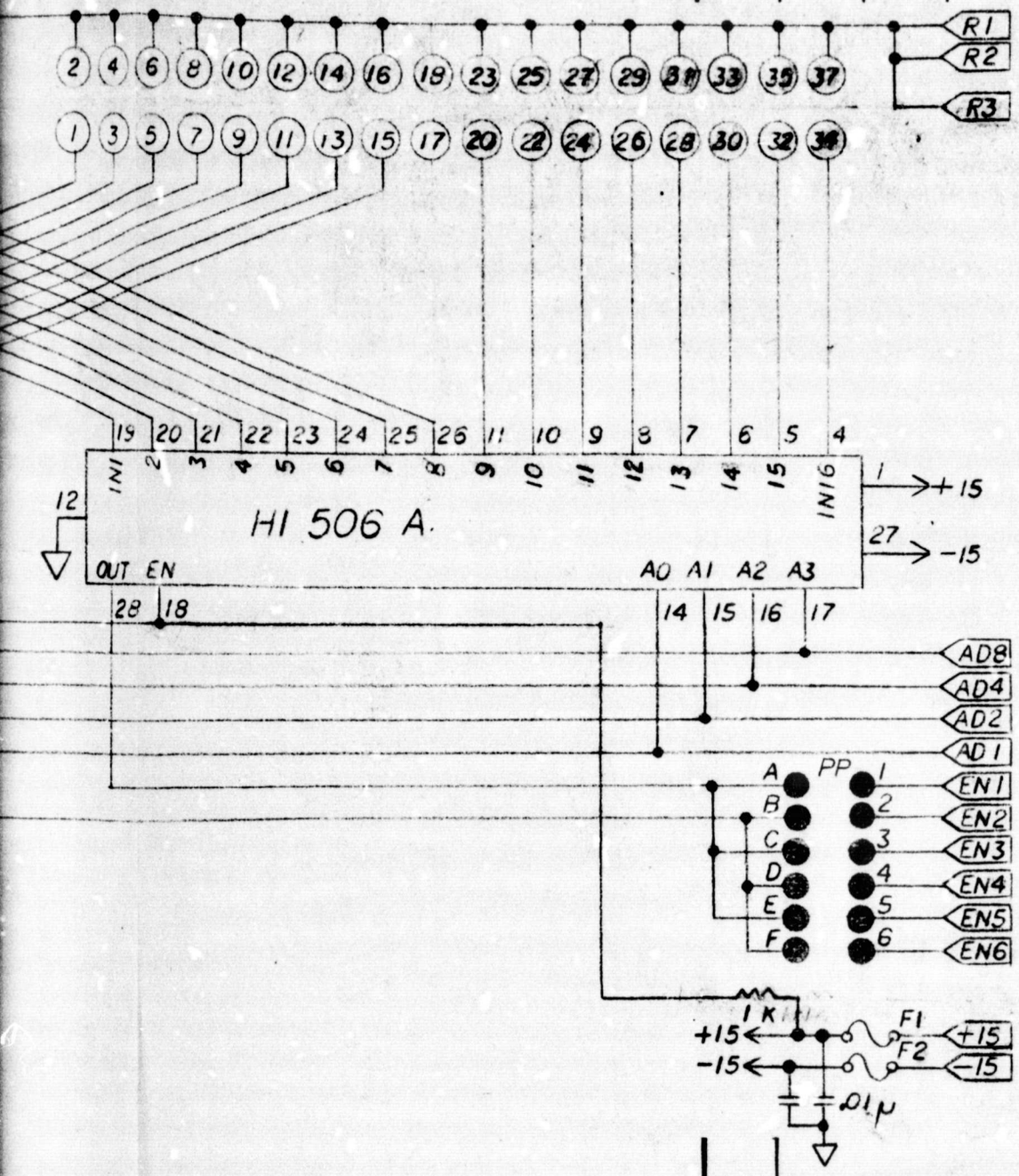
DATAWAY

AUX. CON

PROG. POINTS

FOLDOUT FRAME /

CONNECTOR 1



BILL OF MATERIAL

PART NUMBER	NUMBER REQD.	PER	DESCRIPTION

REV. LET.	CHANGED ITEM WAS	DATE	CHANGED BY	CHECKED BY

REVISIONS

TOLERANCES - UNLESS OTHERWISE NOTED
FRACTIONAL: DECIMAL: ANGULAR:

	SIGNATURE	DATE	GROUP NO. & REPRESENTATIVE	DATE
ORIGINATED	[illegible]	3/10/76		
DRAWN				
CHECKED				
PROJ. ENG.	[illegible]		TOT. SHTS.	SCALE
APPROVED				

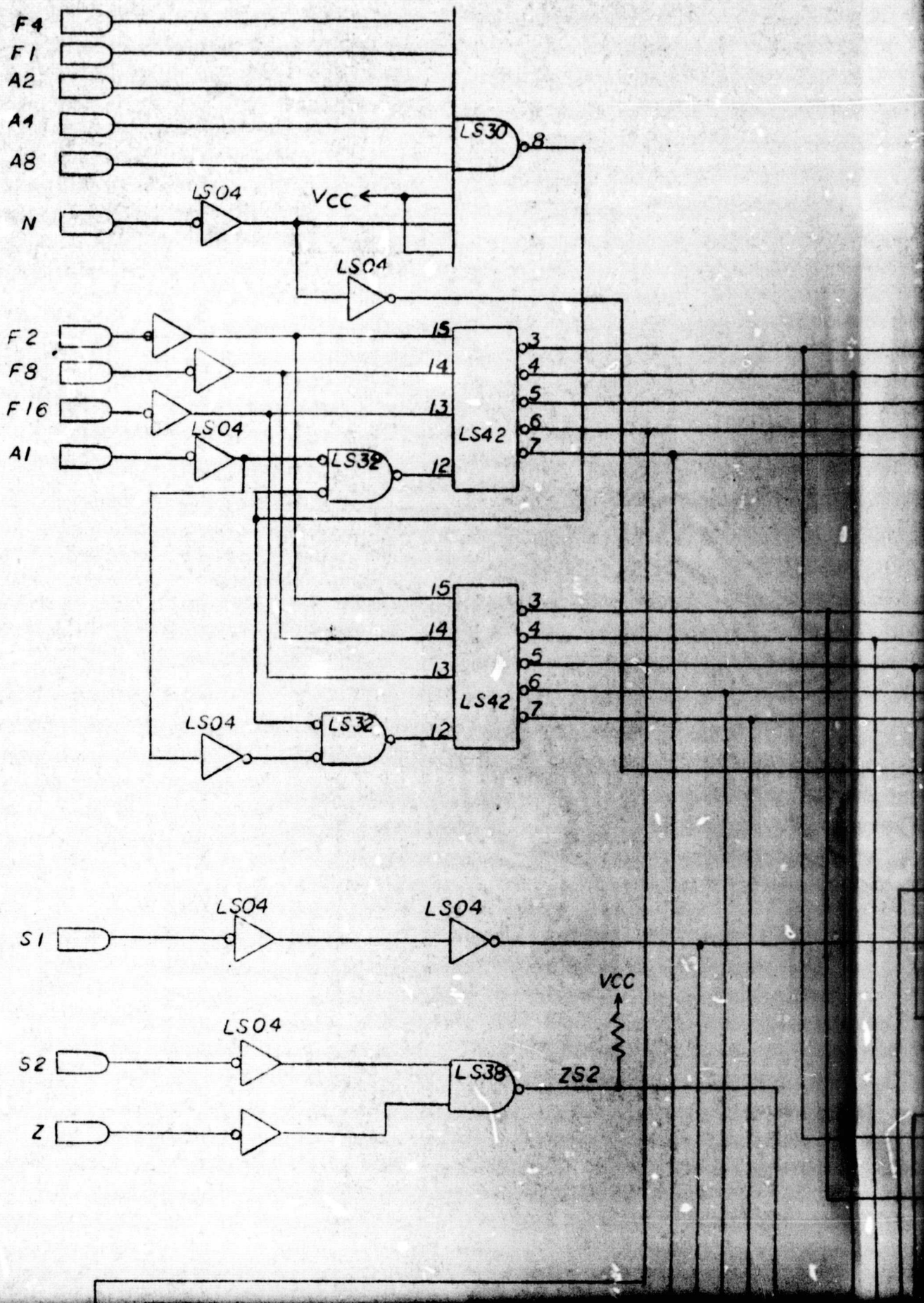
TITLE: BIRA SYSTEMS
NASA MODEL 5101
ANALOG MULTIPLEXER

DRAWING NO. PRELIMINARY SUBJECT TO CHANGE
SHEET SIZE AND NO. B
PART NO.

FOLDOUT FRAME 2

FOLDOUT FRAME

ORIGINAL PAGE IS
OF POOR QUALITY



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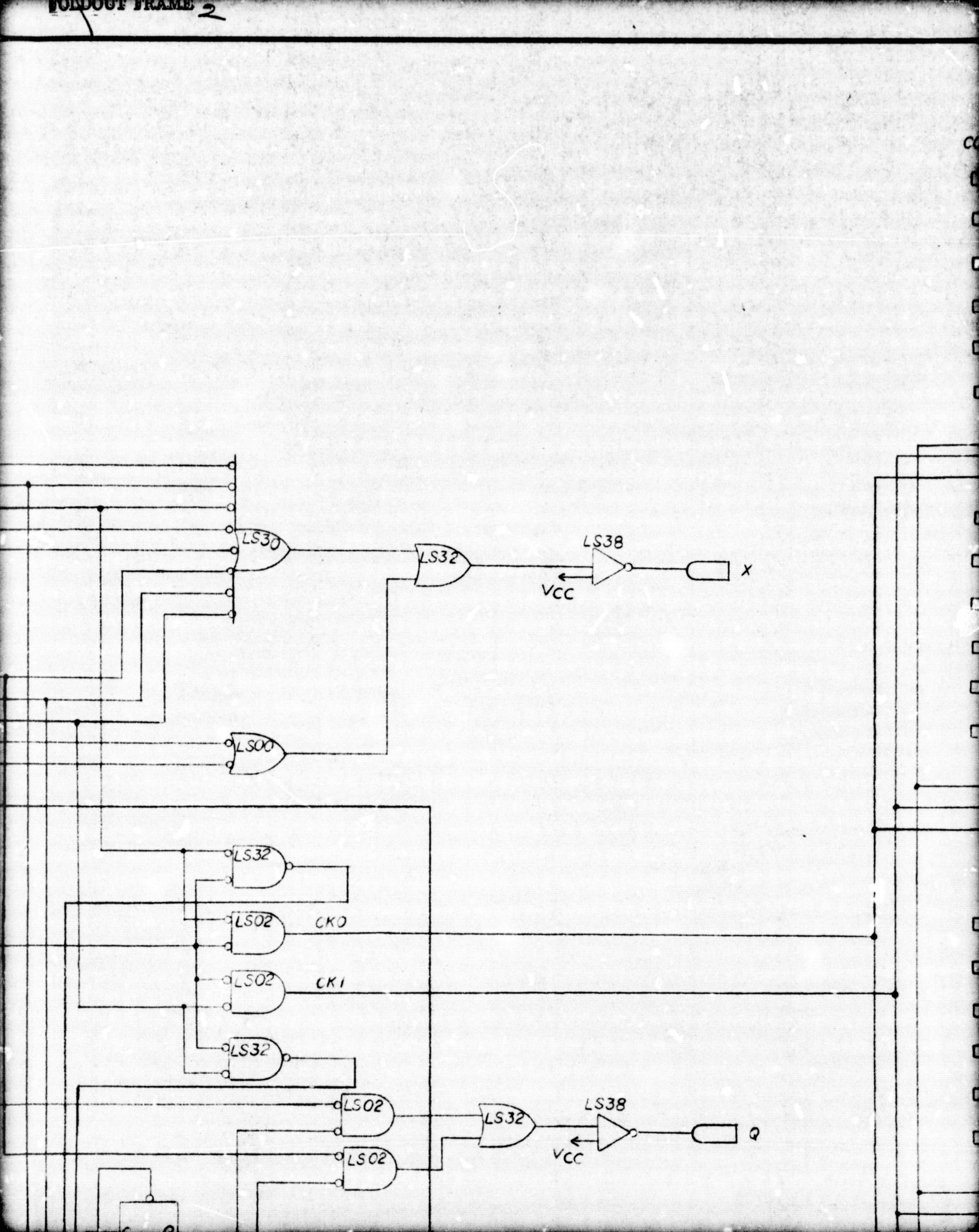

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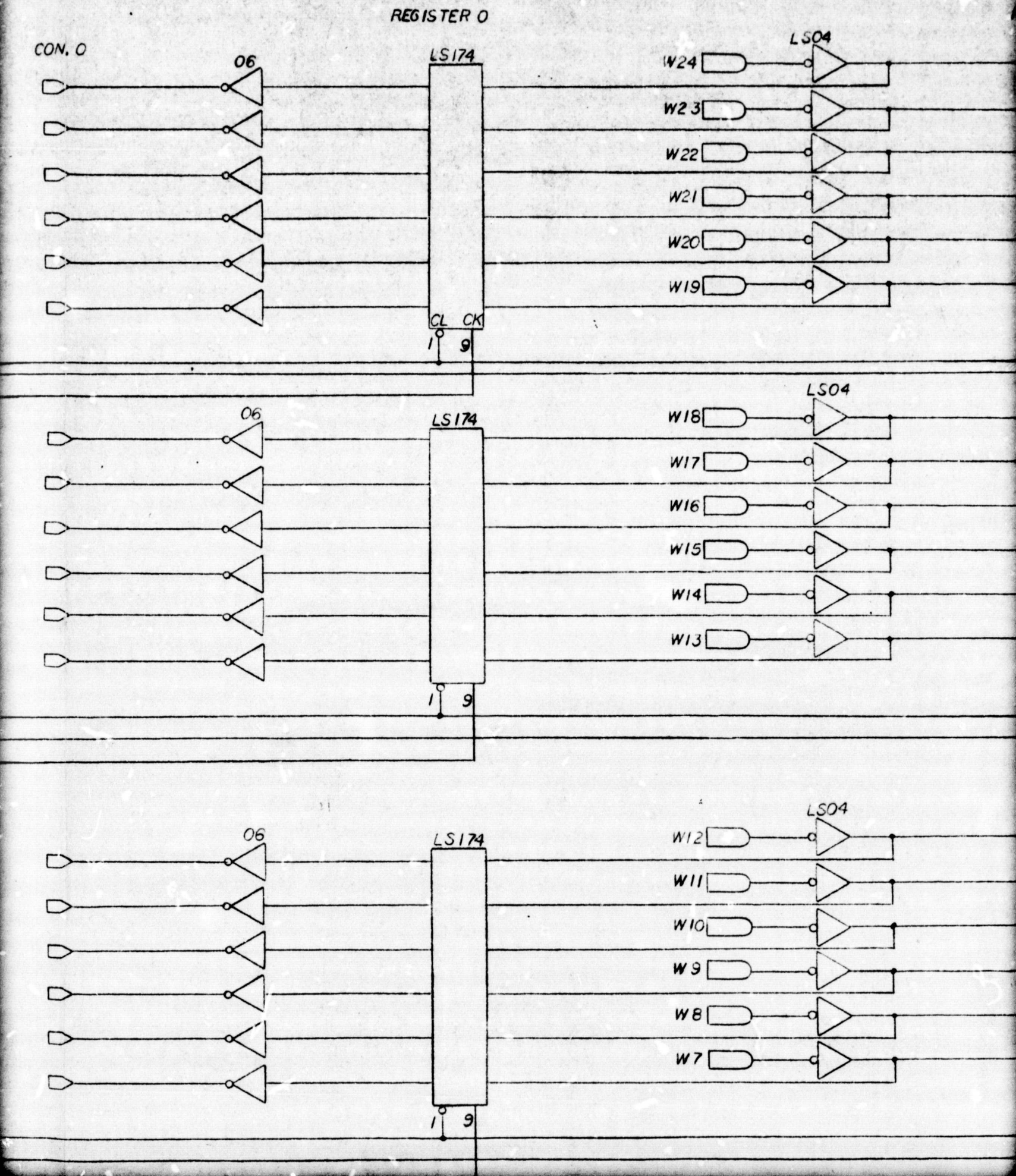
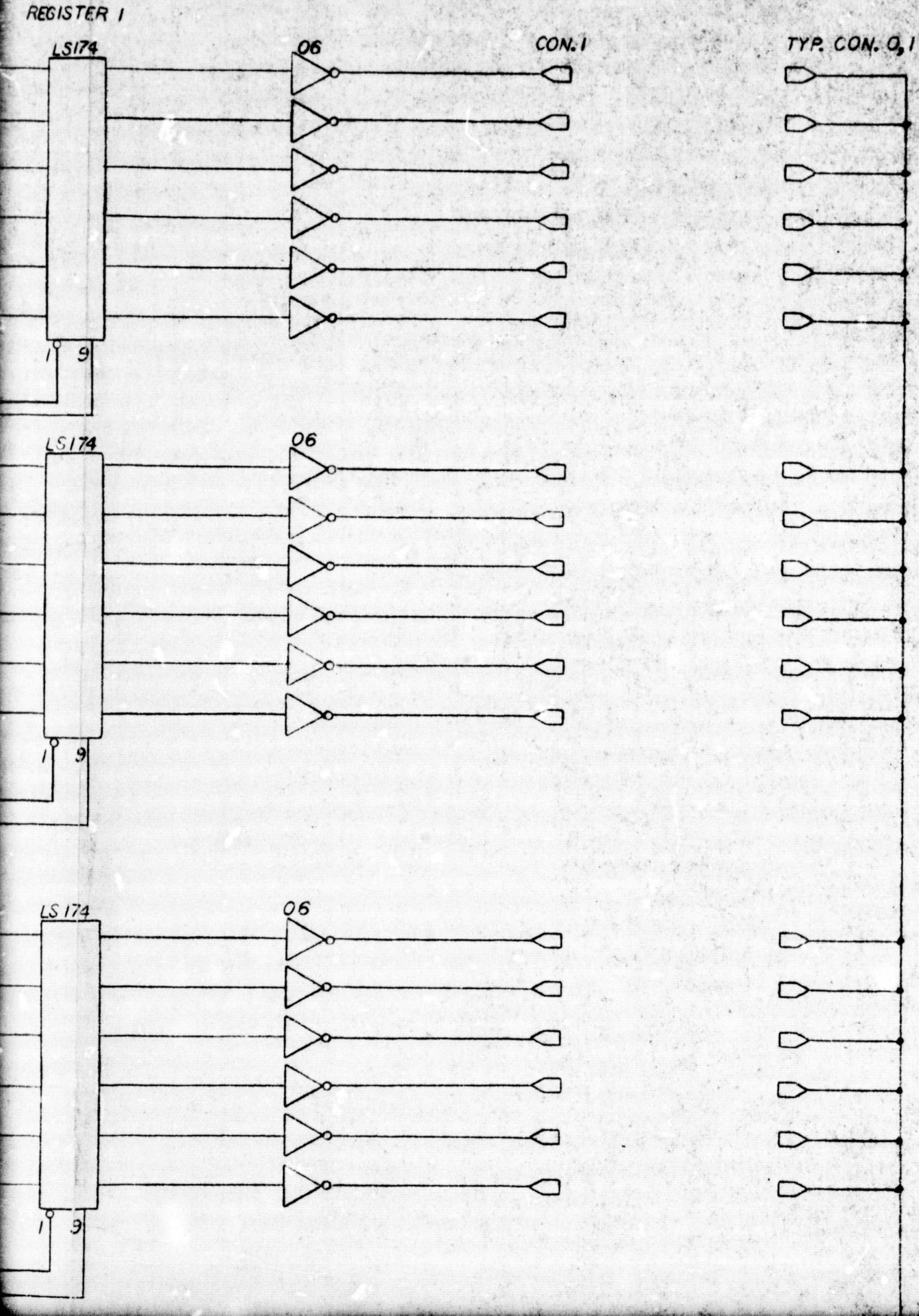
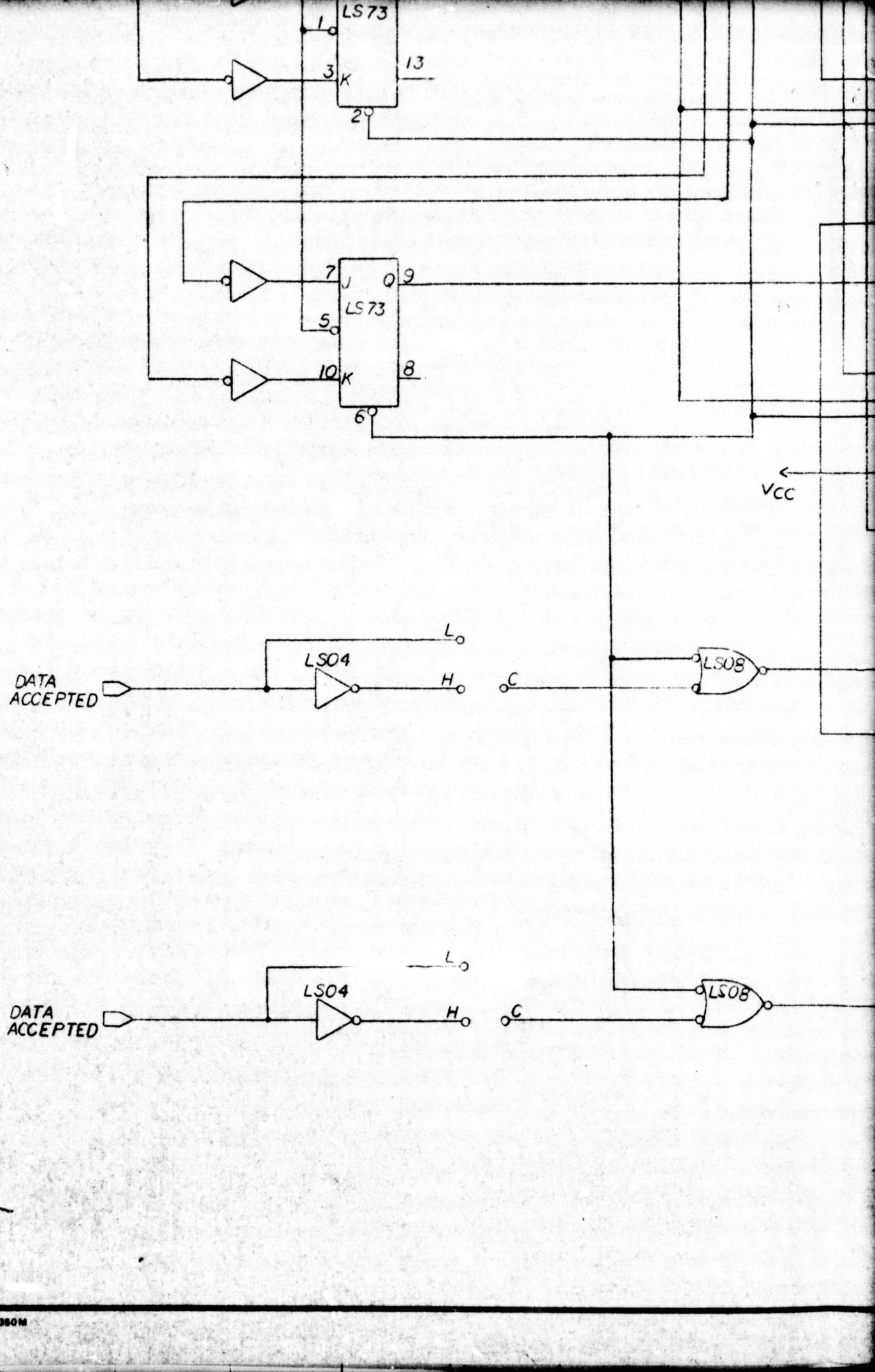
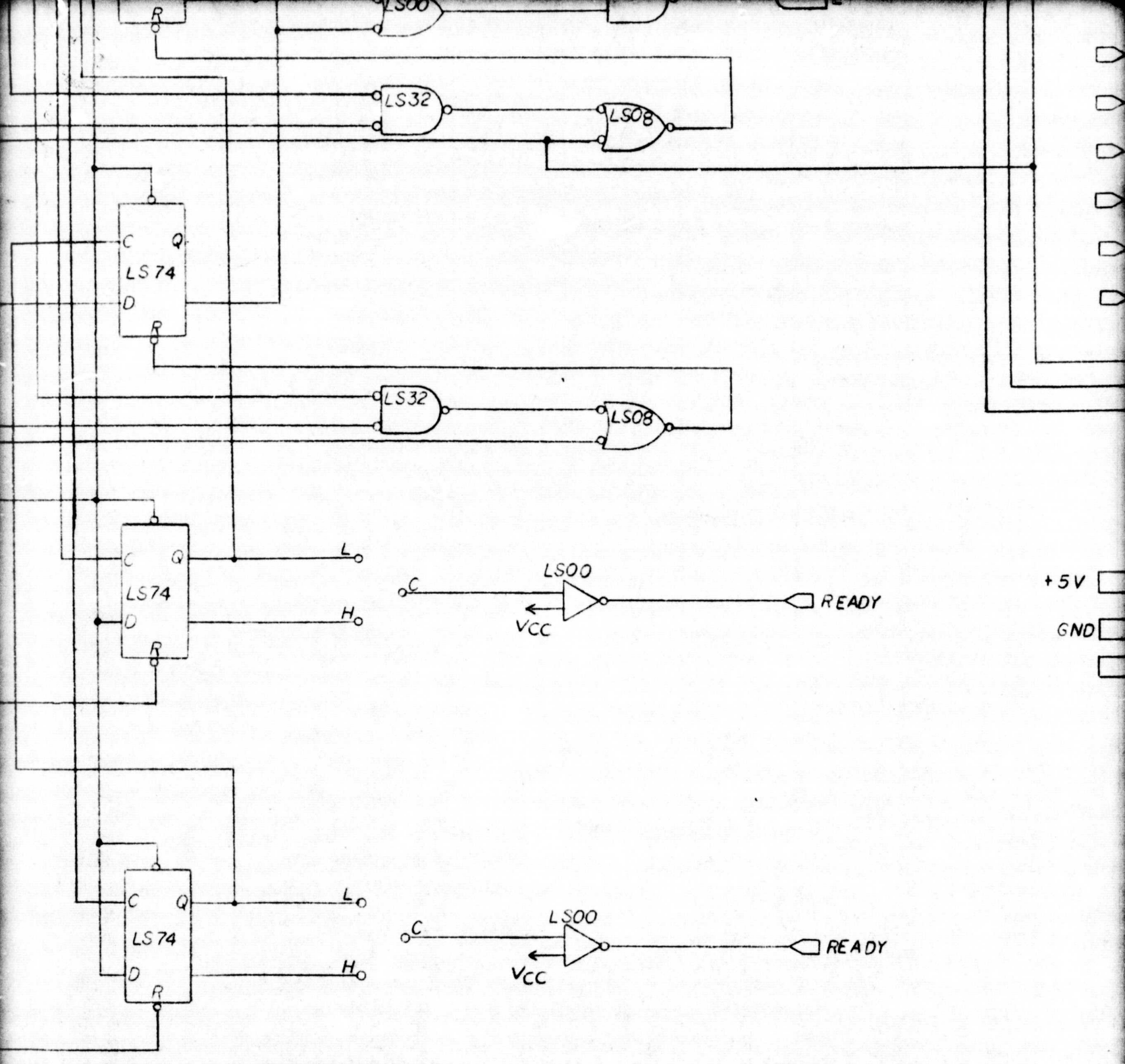
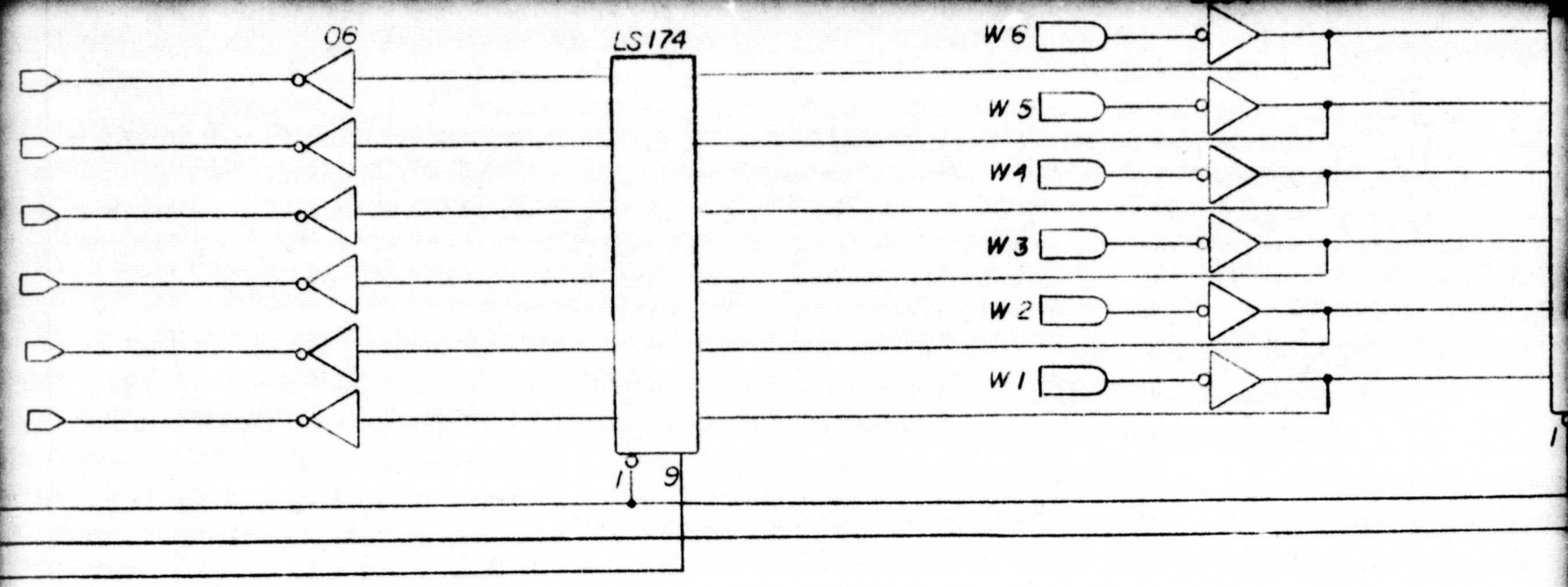


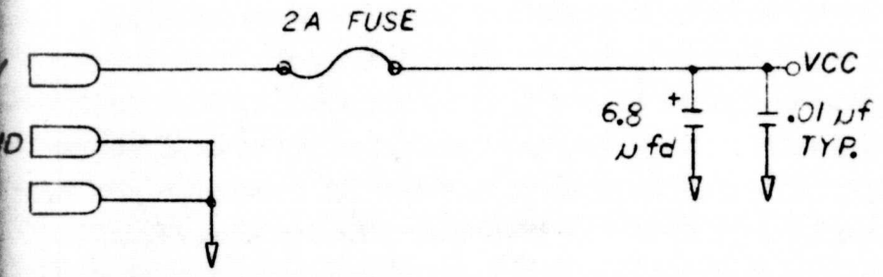

REGISTER 1
LS174
06
CON. 1
TYP. CON. 0, 1
1
9
LS174
06
1
9
LS 174
06
1
9

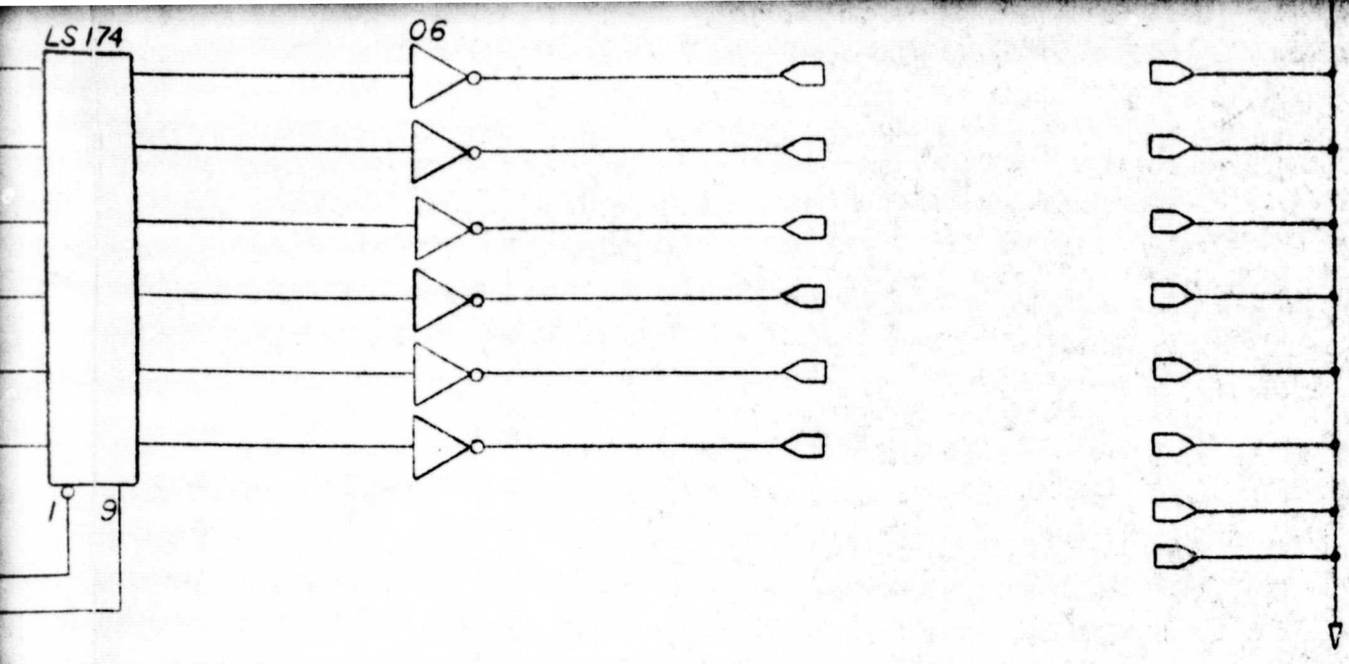


FOLDOUT FRAME 5


R
LS00
LS32
LS08
C
Q
LS74
D
R
LS32
LS08
C
Q
LS74
D
R
L
H
C
LS00
VCC
READY
+5V
GND
C
Q
LS74
D
R
L
H
C
LS00
VCC
READY


06
LS174
W6
W5
W4
W3
W2
W1
1
9


2A FUSE
VCC
6.8 μfd
.01 μf TYP.



DATAWAY

I-O CONNECTOR

BI RA SYSTEMS, INC.		
DATE 3-12-76	DRAWN BY BISWELL	APPROVED BY PRELIMINARY SUB. TO CHANGE
SCALE	REVISED	
DUAL 24 BIT PARALLEL OUTPUT REGISTER		
MODEL 3222		DRAWING NUMBER B 3222

FOLDOUT FRAME