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**NASA CONTRACTOR REPORT 166584**

**(NASA-CR-166584) ASTRONOMICAL APPLICATION  
OF IR CID TECHNOLOGY Final Report (Lick  
Observatory) 19 p HC A02/HF A01 CSCL 14B**

**N84-28057**

**G3/35      Unclass  
13992**

Astronomical Application of IR CID Technology  
Final Report

David M. Rank



**CONTRACT NCC2-169**

April 1984

**NASA**

**NASA CONTRACTOR REPORT** 1.66584

**Astronomical Application of IR CID Technology  
Final Report**

David M. Rank  
Board of Studies in Astronomy and Astrophysics  
Lick Observatory  
University of California  
Santa Cruz, California

Prepared for  
Ames Research Center  
under Cooperative Agreement NCC2-169



National Aeronautics and  
Space Administration

**Ames Research Center**  
Moffett Field, California 94035

ORIGINAL PAGE IS  
OF POOR QUALITY

0	0
1	-32.8809219
2	-72.3380262
3	39.4571063
4	32.8809219
5	0
6	13.1523688
7	26.3047375
8	6.57618438
9	-39.4571063
10	-26.3047375
11	-46.0332906
12	-59.1856594
13	6.57618438
14	6.57618438
15	0
16	-59.1856594
17	0
18	92.0665813
19	40154.1818
20	68052
21	65725.8148
22	69728.189
23	70816.3765
24	62345.9884
25	78.9142126
26	144.676056
27	57086.6673
28	51534.1817
29	50149.8153
30	41007.75
31	47957.6025
32	44485.2556
33	38161.2223
34	37715.1045
35	37176.4401
36	36549.4643
37	31678.8847
38	33297.3215
39	29823.5535
40	27505.822
41	29105.7275
42	28128.4593
43	26244.1596
44	24838.6701
45	25985.1691
46	25297.4453
47	26184.6936
48	21671.5823
49	23215.9075
50	24026.8894
51	624.737516
52	414.299616
53	203.861716
54	111.735134
55	-6.57618438
56	-6.57618438
57	-39.4571063
58	-26.3047375
59	13.1523688
60	138.099872
61	0
62	-59.1856594
63	-19.7285531

$\frac{\chi_{Cyg 2}}{\mu Cep 2}$

Figure 1 Baseline division of two stellar spectra at 3.7um

XEN#	CHN	VALUE
	0	394
	1	11
	2	1
	3	3
	4	2
	5	2
	6	6
	7	-100
	8	-12
	9	9
	10	5
	11	9
	12	9
	13	-6
	14	-2
	15	0
	16	0
	17	17
	18	5
	19	43
	20	328
	21	285
	22	140
	23	553
	24	1774
	25	216
	26	32
	27	4
	28	16
	29	7
	30	9
	31	-24
	32	1647
	33	317
	34	147
	35	96
	36	33
	37	-7
	38	237
	39	11883
	40	-123
	41	428
	42	1153
	43	6293
	44	6365
	45	694
	46	285
	47	228
	48	40
	49	37
	50	9
	51	5
	52	12
	53	6
	54	2
	55	-4
	56	-1
	57	-7
	58	-16
	59	0
	60	0
	61	0
	62	11

.....00..... 11883



3.8954

3.679

3.5074

3.3674

Figure 2 Xe lamp calibration for wavelength and focus.

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OF POOR QUALITY

## Appendix A

```

10 SYS]6402
20 POKE52,0:POKE53,64
30 DIM DA(64),DN(64),DD(64),BB(64)
40 POKE ]6586,0
50 DB=5*4096:D2=DB+256:REM.DATA BUFFERSDSAVE"CID]"
55 C]=256:C2=DB+64:C3=256 2:C4=DB+]28:C5=256 3
60 C6=DB+]92:C7=D2+64:C8=D2+]28:C9=D2+]92
100 REM..PARAMETERS
110 A(8)=64:REM..# OF DETECTORS
120 A(7)=]:REM..# OF DET CYCLES
130 INPUT"# OF CHOPS ";NC
135 A(6)=INT(NC/256):A(5)=NC-256*A(6)
140 A(4)=2:REM..A/D DELAY
150 A(3)=0:A(2)=]:REM..CHOPPER DELAY
160 A(1)=250:REM..# OF CHOPS BEFORE DATA BAD SUBSCRIPT
200 PRINT"_"
205 FORJ=]TO]00:NEXT
210 PRINT"_"S COMMAND IRASLDEPC"
215 GET CM$:IF CM$=""THENFORJ=]TO]00:NEXTJ:PRINT"SR COMMAND_"GOSUB]000:GOTO205
217 IF CM$ ""THENPRINT"SQOOLAST COMMAND WAS R"CM$"_":PRINT"_"S"
220 IFCM$="I"THENCM$="S":GOSUB400:CM$=""
240 IF CM$="R" THEN GOSUB 500
245 IFCM$="D"THENGOSUB6000
250 IF CM$="A"THEN GOSUB 500
255 IFCM$="C"THENGOSUB8000
260 IFCM$="L"THENGOSUB4000
265 IFCM$="P"THENGOSUB7000
270 IFCM$="S"THENGOSUB3000
275 IFCM$="B"THENGOSUB5000
290 GOTO 2]0
400 FORJ=]TO8
410 POKE]6384+J,A(J)
415 NEXT J
420 SYS]64]5
430 GOSUB 700
500 POKE]6394,ASC(CM$)+32
510 SYS]6555
520 GOSUB 700
550 RETURN
700 ER=PEEK(]6384)
705 RETURN
710 IF ER=99 THEN PRINT"CHECKSUM ERROR"
720 IF ER=]0] THEN PRINT"ACIA ERROR"
725 A$=""
790 RETURN:REM..SYS]6587:REM..CHECK ACIA
1000 REM..CHECK ACIA
1004 SYS]6587
1005 TE=PEEK(]6586):IFTE=0THEN RETURN
1006 POKE]6586,0
1007 IF TE=32THENCN=0:PRINT"SQOQ)))))))))";" "":RETURN
1008 CN=CN+]
1009 PRINT"SQOQ)))))))))";CN
1010 GOSUB 700
1017 MA=0
1020 FOR J=0TOA(8)-]
1030 DA(J)=PEEK(DB+J)+C]*PEEK(C2+J)+C3*PEEK(C4+J)+C5*PEEK(C6+J)
1040 DN(J)=PEEK(D2+J)+C]*PEEK(C7+J)+C3*PEEK(C8+J)+C5*PEEK(C9+J)

```

```

1050 DD(J)=DA(J)-DN(J)
1051 DD(0)=.]:DD(1)=.]:DD(62)=.]:DD(63)=.]
1052 IF ABS(DD(J)) ABS(MA) THEN MA=ABS(DD(J))
1055 NEXT J
1060 GOSUB 2000
1090 RETURN
2000 PRINT"SQOO" :REM...PLOT ON SCREEN
2002 IFMA=0 THENMA=]0
2003 FORJ=4TO23:PRINT" " :NEXTJ
2004 PRINT" " :S"
2005 SC=20/MA:SO=33728:LL=40
2010 FOR J=0TO62 STEP 2
2015 IJ=INT(J/2)
2020 P]=INT(DD(J)*SC)+20:P2=INT(DD(J+1)*SC)+20:I]=INT(P]/2):I2=INT(P2/2)
2025 IFI] OTHENI]=0:IFI2 OTHENI2=0
2030 IF I]=I2 GOTO 2100
2040 IF I] P]/2 THEN POKE SO+IJ-I]*LL,]26:GOTO 2060
2050 POKE SO+IJ-I]*LL,]23
2060 IF I2 P2/2 THEN POKE SO+IJ-I2]*LL,]24:GOTO 2100
2070 POKE SO+IJ-I2]*LL,]08
2090 GOTO 2300
2100 IFP]=P2ANDI]=P]/2 THENPOKE SO+IJ-I]*LL,98:GOTO2300
2110 IFP]=P2ANDI] P]/2 THENPOKE SO+IJ-I]*LL,226:GOTO2300
2120 IF P] P2 THEN POKE SO+IJ-I]*LL,255:GOTO2300
2130 POKE SO+IJ-I]*LL,]27
2300 NEXT J
2302 PRINT"SQ))))))))))))))))))))))))))", " "
2303 IFTE=]0 THENPRINT"SQOO","INTEGRATION OVER " :"))","*":A(]),"CPS"
2305 PRINT"SQ))))))))))))))))))))))))))","MAX":MA
2310 RETURN
3000 REM...SAVE DATA
3003 PRINT"S", "
3005 PRINT:INPUT"FILE NAME":FL$
3020 DOPEN#8,(FL$),W:IF DS 0 THEN9]00
3030 FORJ=20480TO20992
3040 A$=STR$(PEEK(J))
3050 PRINT#8,A$:CHR$(]3):IFDS ]9 THEN9]00
3060 NEXTJ
3070 DCLOSE#8
3080 GOTO2]0
4000 REM LOAD DATA
4002 GOSUB4005
4003 GOTO]0]7
4005 PRINT"S", "
4010 PRINT:INPUT"FILE NAME":FL$:IF FL$="S" THEN8500
4015 IFFL$="E" THEN8320
4030 DOPEN#8,(FL$): IF DS 0 THEN 9000
4040 FORJ=20480TO20992
4045 INPUT#8,A$:IFDS ]9 THEN9000
4060 POKEJ,VAL(A$)
4070 NEXTJ
4080 DCLOSE#8
4090 RETURN
5000 REM SET BB
5010 FORJ=0TOA(8)-]:BB(J)=DD(J):NEXTJ
5020 RETURN
6000 FORJ=0TOA(8)-]:IFBB(J)=0 THENBB(J)=]00000
600] NEXT J
6005 FORJ=27TO52:DD(J)=DD(J)*C2/BB(J)
6010 IFMA DD(J) THENMA=DD(J)
6020 NEXTJ
6023 FORJ=0TO26:DD(J)=.]:NEXT
6025 FOR J=53TOA(8)-]:DD(J)=.]:NEXT
6030 GOTO2000

```

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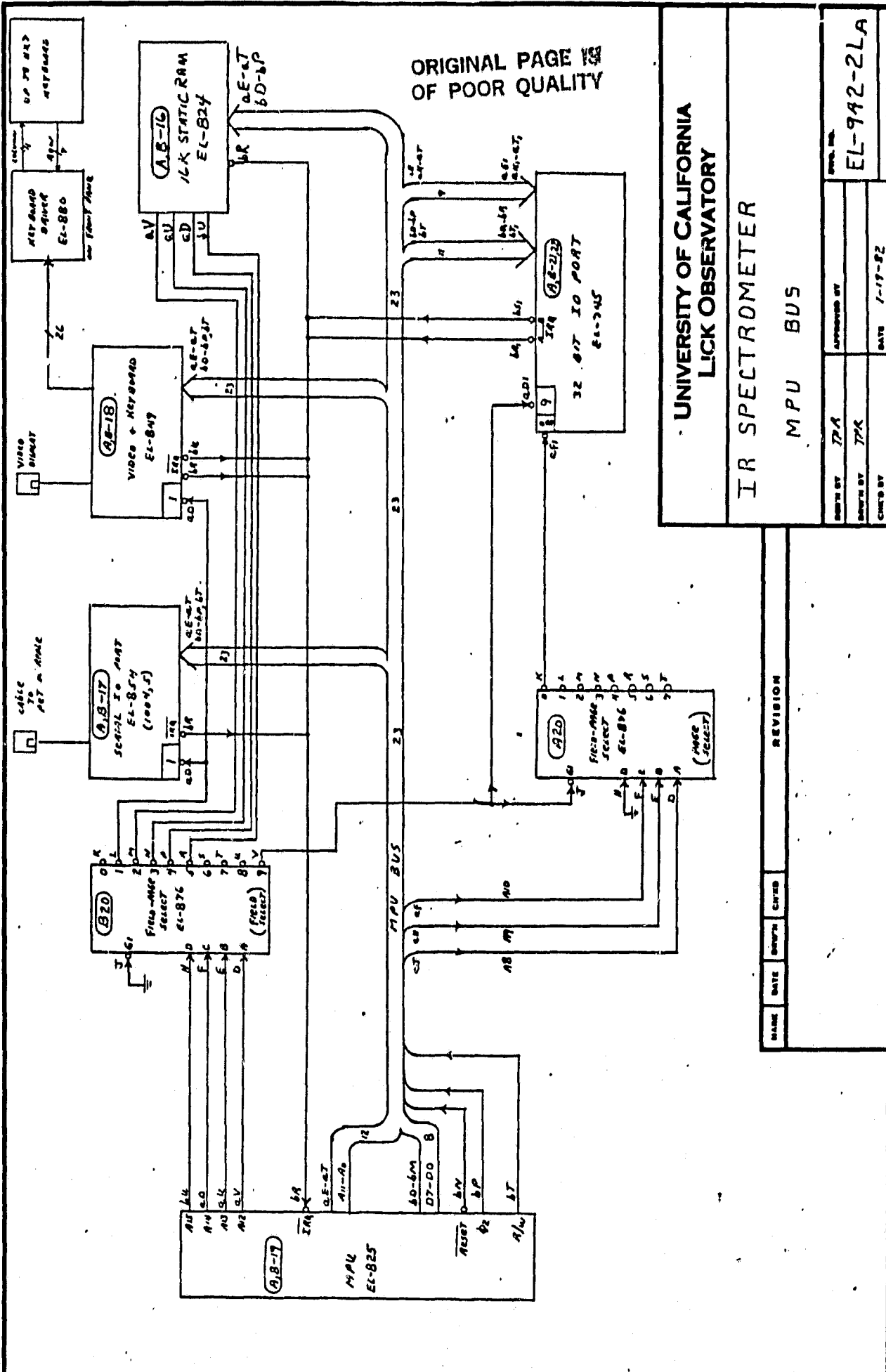
```

7000 IFMA=0 THEN RETURN
7010 OPEN 4,4:CMD4
7015 AS=""
7020 PRINT FL$
7025 PRINT "CH#          VALUE          ).....00.....).....";MA
7040 FORJ=0 TO A(8)-1:SC=40/MA:LL=DD(J)*SC+80:LL=INT(LL)
7045 PRINTJ,DD(J);CHR$(14);LEFT$(AS,LL/2);
7048 IF LL/2=INT(LL) THEN PRINT"5"
7050 PRINT"6"
7055 NEXTJ
7060 CLOSE 4
7070 RETURN
8000 REL: COADD SCANS
8005 FORJ=0 TO A(8)-1:DD(J)=0:DA(J)=0:DN(J)=0:NEXTJ:MA=0:ER=0
8010 GOSUB 4005
8020 PRINT" S +,-,E,S,D..?
8022 FORJ=1 TO 500:NEXTJ
8024 PRINT" S +,-,E,S,D..
8026 GETCM$:IFCM$="" THEN FORJ=1 TO 500:NEXTJ:GOTO 8020
8040 IFCM$="+ THEN PRINT"q))))))))))))) +":GOTO 8000
8050 IFCM$="- THEN PRINT"q))))))))))))) -":GOTO 8200
8060 IFCM$="E" THEN 8300
8070 IFCM$="S" THEN PRINT"q))))))))))))) S":GOTO 8500
8080 IFCM$="D" THEN 8600
8090 GOTO 8026
8100 MA=0:FORJ=0 TO A(8)-1
8105 DA(J)=DA(J)+PEEK(DB+J)+C)*PEEK(C2+J)+C3*PEEK(C4+J)+C5*PEEK(C6+J)
8110 DN(J)=DN(J)+PEEK(D2+J)+C)*PEEK(C7+J)+C3*PEEK(C8+J)+C5*PEEK(C9+J)
8120 DD(J)=DA(J)-DN(J)
8130 IF ABS(DD(J)) ABS(MA) THEN MA=ABS(DD(J))
8140 NEXTJ
8150 GOSUB 2000
8155 ER=ER+1
8160 GOTO 8010
8200 MA=0:FORJ=0 TO A(8)-1
8205 DN(J)=DN(J)+PEEK(DB+J)+C)*PEEK(C2+J)+C3*PEEK(C4+J)+C5*PEEK(C6+J)
8210 DA(J)=DA(J)+PEEK(D2+J)+C)*PEEK(C7+J)+C3*PEEK(C8+J)+C5*PEEK(C9+J)
8220 DD(J)=DA(J)-DN(J)
8230 IF ABS(DD(J)) ABS(MA) THEN MA=ABS(DD(J))
8240 NEXTJ
8250 GOSUB 2000
8255 ER=ER+1
8260 GOTO 8010
8300 IF ER/2=INT(ER/2) THEN 2]0
8310 PRINT"NOT EVEN # SCANS":FORJ=1 TO 1000:NEXTJ:GOTO 8010
8320 PRINT"SAVE SUM BUFFER ? Y/N
8330 GETCM$
8340 IFCM$="Y" THEN 8500
8350 IFCM$="N" THEN 2]5
8360 GOTO 8330
8400 GOTO 2]5
8500 FORJ=0 TO A(8)-1
8510 P1=INT(DA(J)/C5):POKE(C6+J),P1
8515 P2=INT((DA(J)-P1)*C5)/C3):POKE(C4+J),P2
8520 I1=INT((DA(J)-P1)*C5-P2*C3)/C):POKE(C2+J),I1
8530 I2=INT((DA(J)-P1)*C5-P2*C3-I1*C):POKE DB+J,I2
8540 P1=INT(DN(J)/C5):POKE(C9+J),P1
8545 P2=INT((DN(J)-P1)*C5)/C3):POKE(C8+J),P2
8550 I1=INT((DN(J)-P1)*C5-P2*C3)/C):POKE(C7+J),I1
8560 I2=INT((DN(J)-P1)*C5-P2*C3-I1*C):POKE D2+J,I2
8570 NEXTJ
8580 GOTO 3000
8600 DIRECTOR VDD

```



```
8610 PRINT"ANY KEY TO RETURN"  
8620 GETCM$:IFCM$=""THEN8620  
8630 GOTO8024  
9000 REM DISK INPUT ERR..  
9010 PRINT"S";DS$  
9020 DCLOSE#8;GOTO4010  
9100 REMDISK OVERFLOWPUT ERROR  
9110 PRINT"S";DS$  
9120 FORJ=1TO2000:NEXTJ  
9130 DCLOSE#8;GOTO3000  
READY.
```



UNIVERSITY OF CALIFORNIA  
LICK OBSERVATORY

IR SPECTROMETER  
MPU BUS

DESIGNED BY	TKA
APPROVED BY	
DRAWN BY	TKA
CHECKED BY	
DATE	1-17-82
PARTIAL NO.	EL-942-2LA

REVISION		
NAME	DATE	BY

ORIGINAL PAGE IS  
OF POOR QUALITY

FUNCTION	PAGE		
	0,8	1,9	2, A
RAM	9000-90FF	9100-91FF	9200-92FF
IO PORTS PA0 (TO PORT DIRECT. A06 PA0) (TO PORT DIRECT. A06 PA0)	9800	9900	9A00
	9801	9901	9A01
	9802	9902	9A02
	9803	9903	9A03
	9804	9904	9A04
	9805	9905	9A05
	9806	9906	9A06
	9807	9907	9A07
	9810	9910	9A10
	9818	9918	9A18
	9814	9914	9A14
	9815	9915	9A15
	9816	9916	9A16
	9817	9917	9A17
	CARD #1	CARD #2	CARD #3

RAM

IO PORTS

PA0 (TO PORT DIRECT. A06 PA0) (TO PORT DIRECT. A06 PA0)

ENABLE WITH INTERRUPT INDEPENDENT

DISABLE

ENABLE

STATUS

TIMER INTERRUPT STATUS

READ

WRITE TRIC +

BEFORE EVERY 02

" " 8 42

" " 4 64 02

" " 1024 02

INTERUPT FLAGS

T = TIMER FLAG

P = PORT FLAG

7 6 5 4 3 2 1 0

7 0 0 0 0 0 0 0

RAM

PORTS

PULSE DETECT ON PA7

TIMERS

1) WRITE MUST BE ON  
DATA ON BUS IS IGNORED

2) ADD 0020 TO OBTAIN PA(2)-7

1) ADD 0008 TO ENABLE INTERRUPT

2) ADD 0020 TO OBTAIN TIMER (2)

NOTE:  
ADDRESSING ASSUME PORTS  
ARE IN FIELD 9 +  
SELECTED NORMALLY.

UNIVERSITY OF CALIFORNIA  
LICK OBSERVATORY

IO PORT ADDRESSING

DATE MONTH YEAR REVISION

APPROVED BY: TPA

DATE: 12-4-80

UNIV. NO. EL-745-2DB

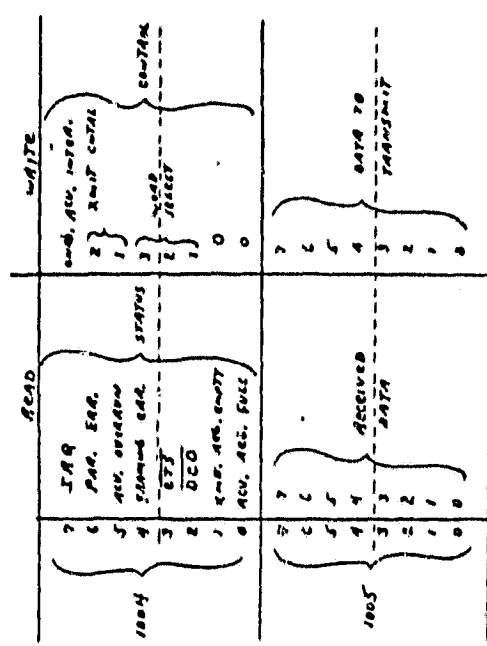
ORIGINAL PAGE 19  
OF POOR QUALITY

BIT	BIT	PAGE 8	ADDRESS
D2	7	CIO CLOCK	7800 D.A. = 7801
E2	6	CIO SELECTED	
F2	5		
H2	4	AOC START	
J2	3	MSB	
K2	2		
L2	1		
M2	0		
N2	0		
O2	0		
P2	7		7802 D.A. = 7803
Q2	6		
R2	5		
S2	4	12 BIT AOC	
T2	3		
U2	2		
V2	1		
W2	0	LSB	
X2	0		
Y2	0		
Z2	7	CIO DEF. #1	7820 D.A. = 7821
AA2	6	TOUACH STAN	
AB2	5	SRAC	
AC2	4	STARTER IN	
AD2	3	SRAC	
AE2	2		
AF2	1	AMPLIFIER GAIN	
AG2	0		
AH2	0		
AI2	0		
AJ2	7	FWD STEERING MOTOR	7822 D.A. = 7823
AK2	6	REV PULSES	
AL2	5		
AM2	4	CARD SELECT	
AN2	3		
AO2	2		
AP2	1	CHANNEL SELECT	
AQ2	0		
AR2	0		

1,8-21,22

NOTE:  
PAC-7 P/AD-9  
CAN CAUSE INTERACTIONS  
ON BIT/CH TRANSITION  
AS INPUTS.

DIA. ACC. BITS:



ACIA

WORD SELECT		LIMIT	
MSB	LSB	INTERRUPT	COMMAND
0	7	0	off
1	7	1	enable
2	7	2	1
3	7	3	0
4	7	0	off
5	7	0	off
6	7	0	off
7	7	0	off

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LICK OBSERVATORY

IR SPECTROMETER  
PORT DESCRIPTIONS

DATE: 1-17-82  
APPROVED BY: [Signature]  
DRAWN BY: TPA  
CHECK BY: [Signature]  
DIA. ACC. BITS: EL-942-20A

NAME	DATE	REVISED	REVISION

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13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	
			824	854	849	821	876	745				364	483	483		572	441	483		
			RAM 80	SCREEN I/O PART	VIDEO + ATTEND	MPU	FIELD SYNC SELECT (876)	32 BIT IO PORT				12 BIT ADC	CALC	CALC	CALC	STCA MOTOR DRIVE	STORING DRIVE	CALC		
										7070										

A B

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LICK OBSERVATORY

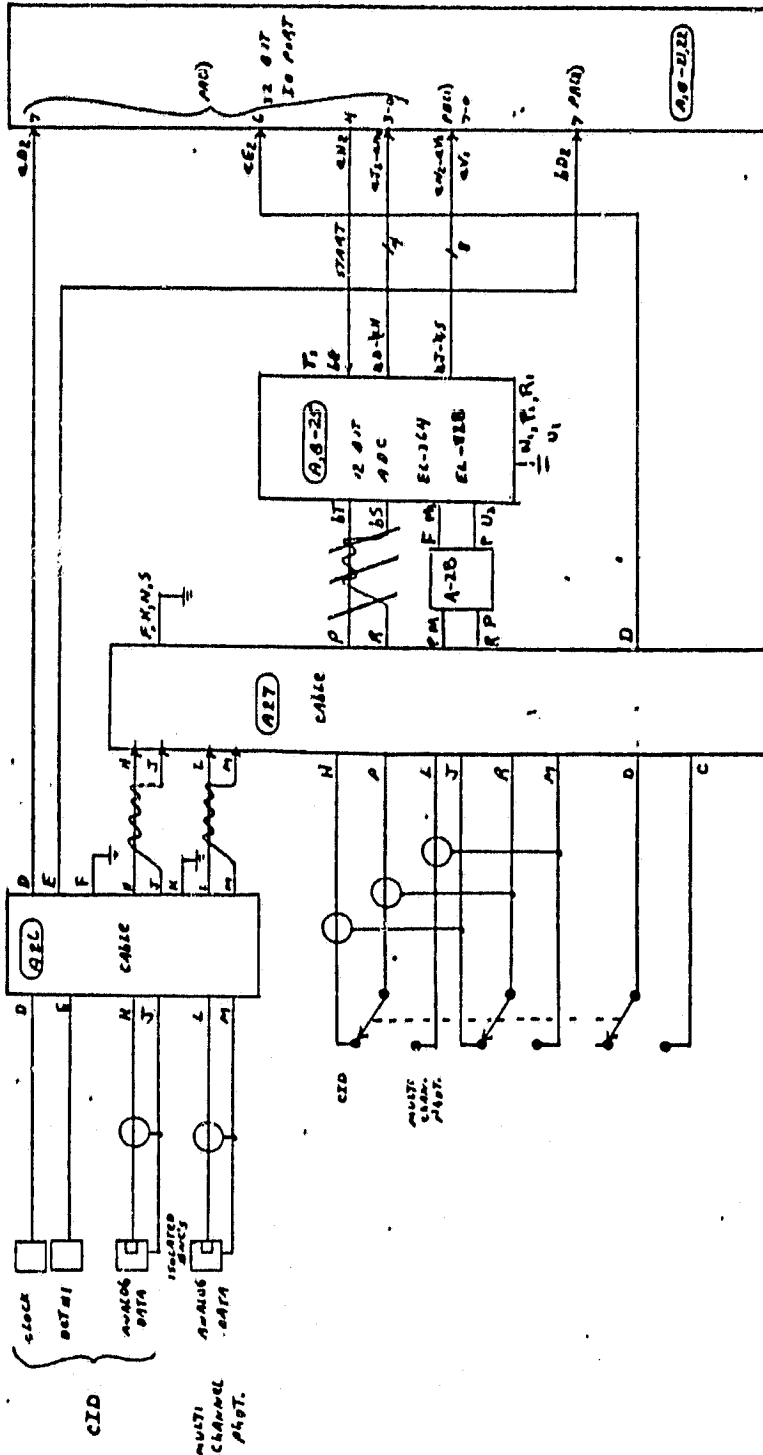
IR SPECTROMETER  
MODULE UTILIZATION

APPROVED BY	DATE
7PA	1-19-82
APPROVED BY	DATE
7PA	1-19-82
CREATED BY	DATE

NAME	DATE	DEPT	CHG	REVISION

REV. NO.  
EL-942-2 M

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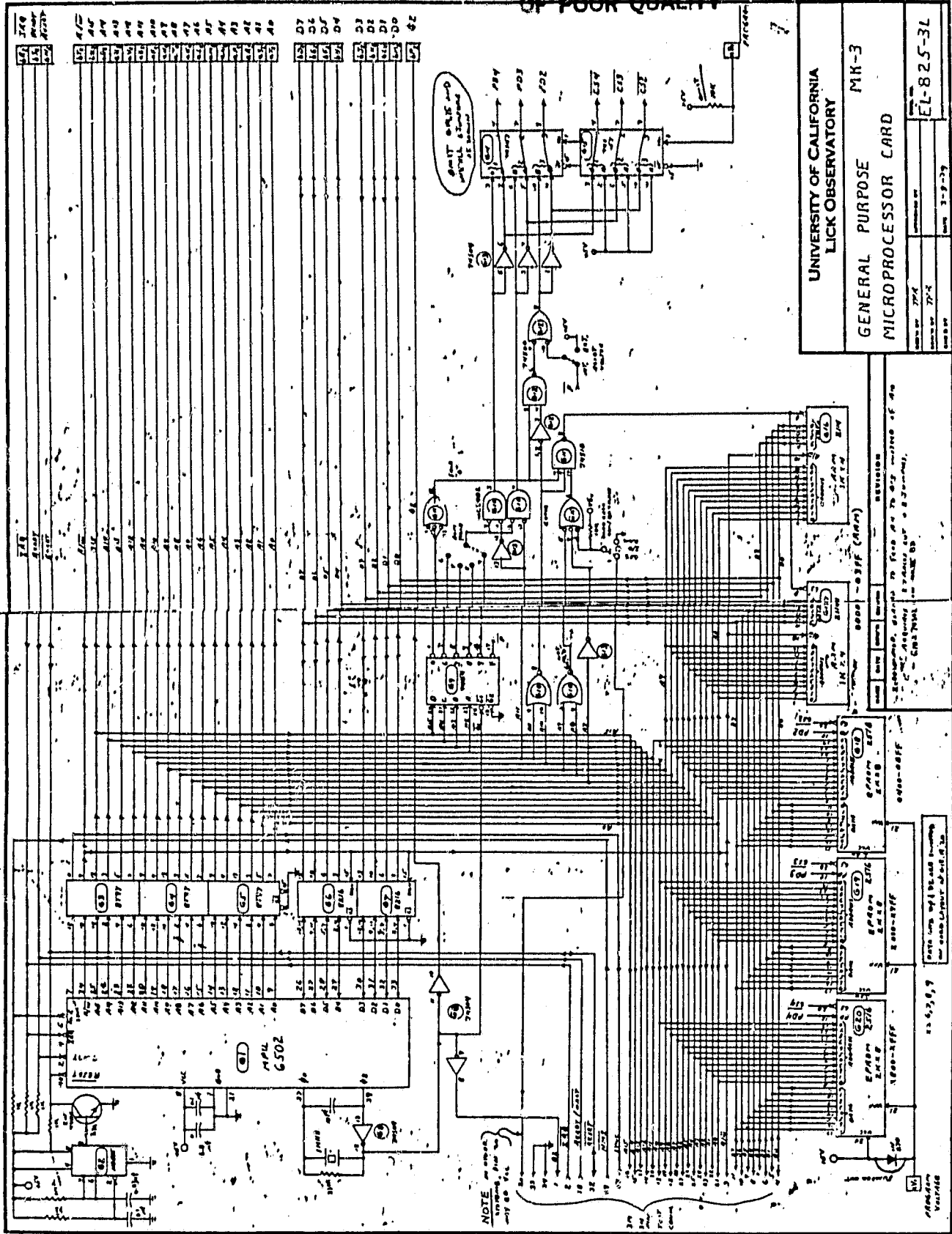


**UNIVERSITY OF CALIFORNIA  
LICK OBSERVATORY**

**IR SPECTROMETER  
ANALOG CONTROL**

DATE BY	APPROVED BY	PART. NO.	SERIAL NO.
7/78	7/78		EL-942-2LB
DATE BY	DATE		
1-17-82			

REVISION	
NO.	DATE



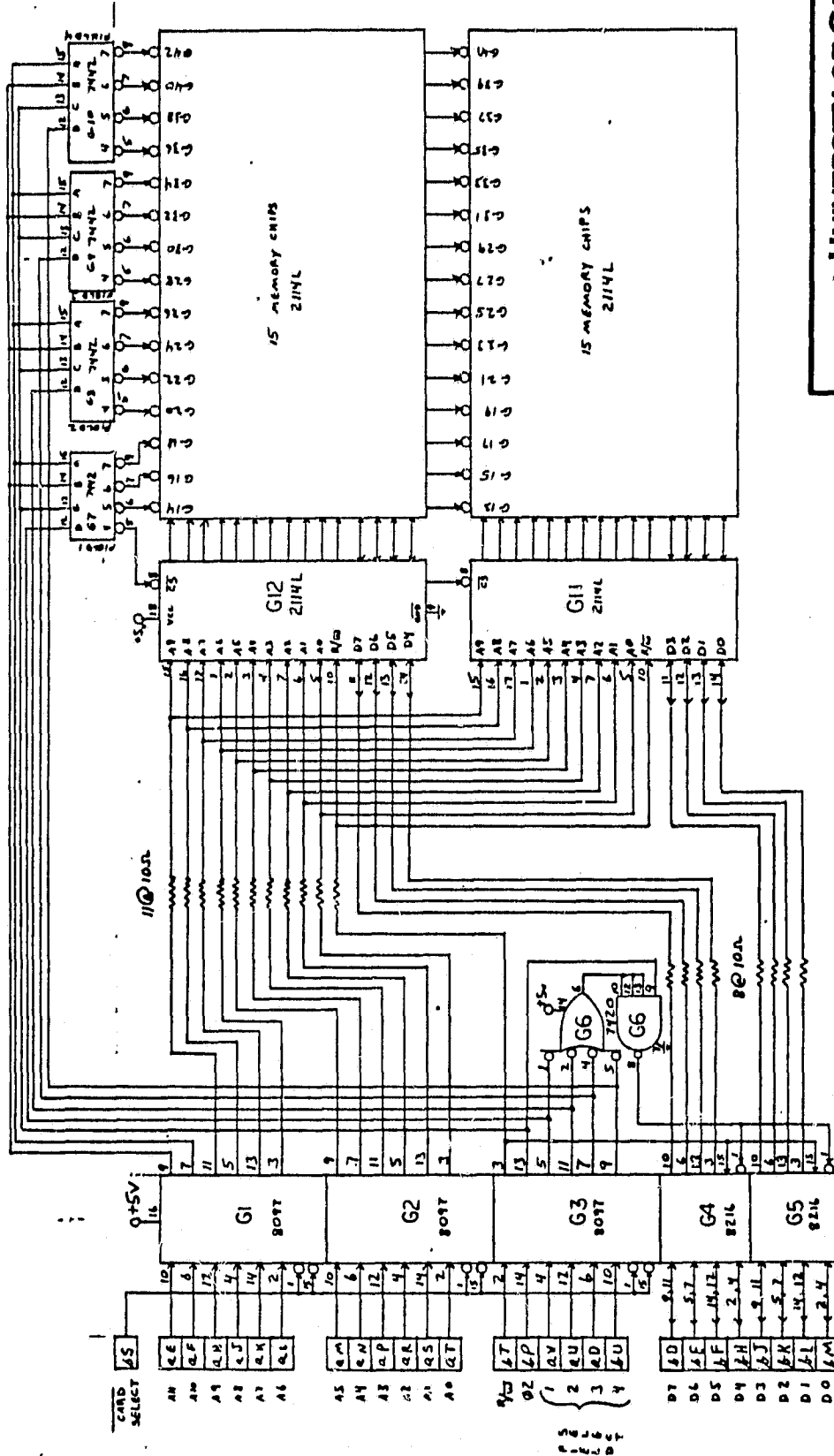
UNIVERSITY OF CALIFORNIA  
LICK OBSERVATORY  
MK-3  
GENERAL PURPOSE  
MICROPROCESSOR CARD

EL-825-3L  
REV. 3-9-79

REVISIONS  
1. ORIGINAL DESIGN BY FIELD AT THE LICK OBSERVATORY OF UC  
2. ALL ADDITIONAL CHANGES BY S. J. JONES  
3. CMOS TRAIL IN PLACE OF BS

NOTE: 1. ALL COMPONENTS ARE TO BE MOUNTED ON THE FRONT OF THE BOARD.  
2. ALL COMPONENTS ARE TO BE MOUNTED ON THE FRONT OF THE BOARD.

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LICK OBSERVATORY

16K STATIC RAM

DATE 3-2-79

APPROVED BY TC

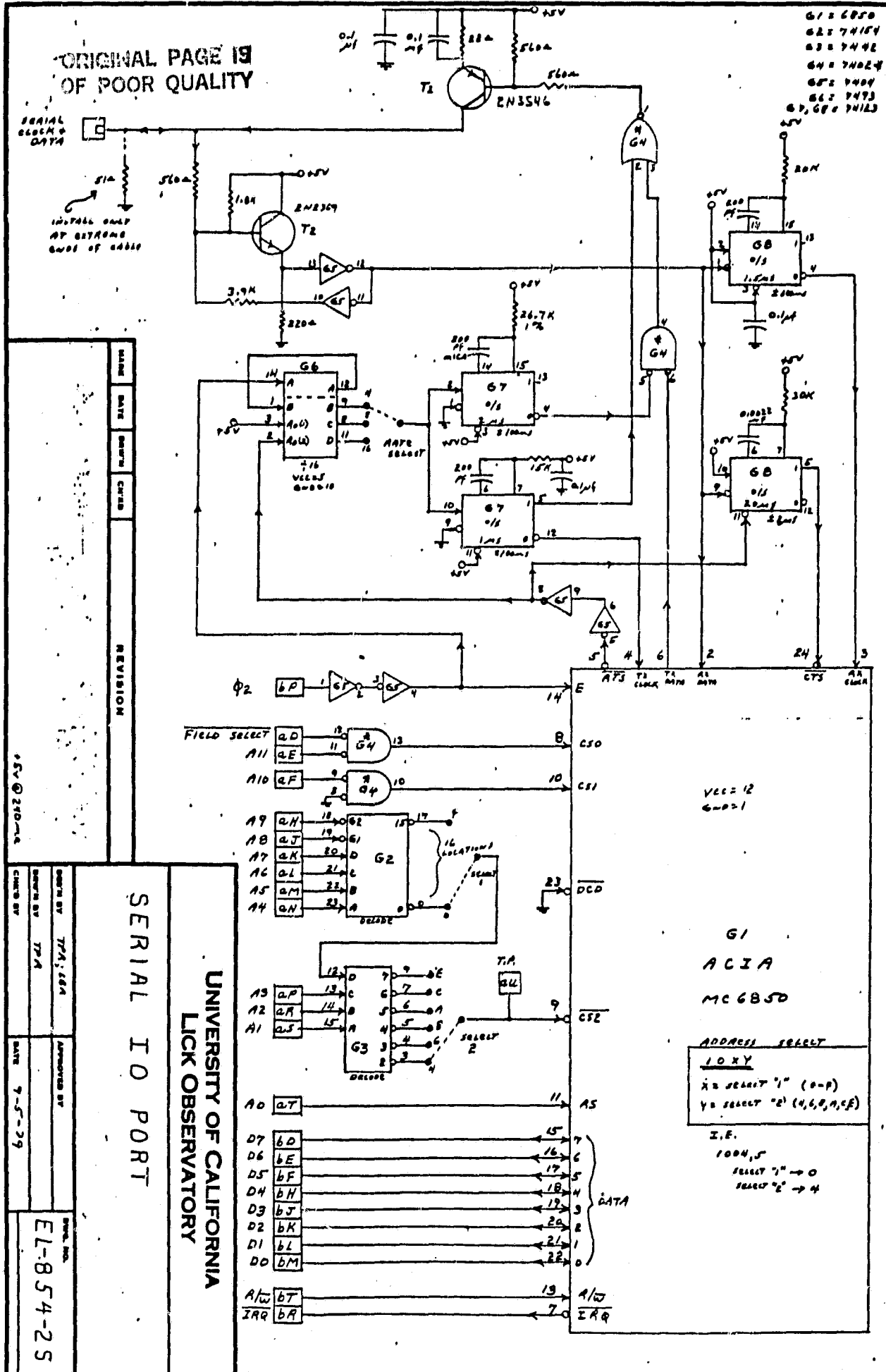
EL-824-2 S

MARK	DATE	BY	REVISION



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G1 2 6850  
G2 2 74154  
G3 2 7442  
G4 2 74024  
G5 2 7404  
G6 2 7473  
G7, G8 74123



REVISION

5V @ 200-1-6

DESIGNED BY: TPA, GEM  
 DRAWN BY: TPA  
 CHECKED BY: [ ]  
 DATE: 7-5-79

EL-854-25

SERIAL I/O PORT  
 UNIVERSITY OF CALIFORNIA  
 LICK OBSERVATORY

VCC = 12  
GND = 1

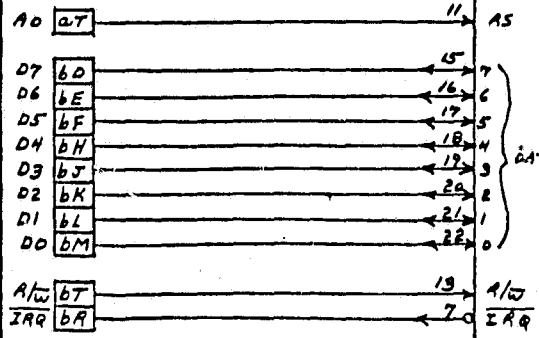
G1  
 ACIA  
 MC6850

ADDRESS SELECT

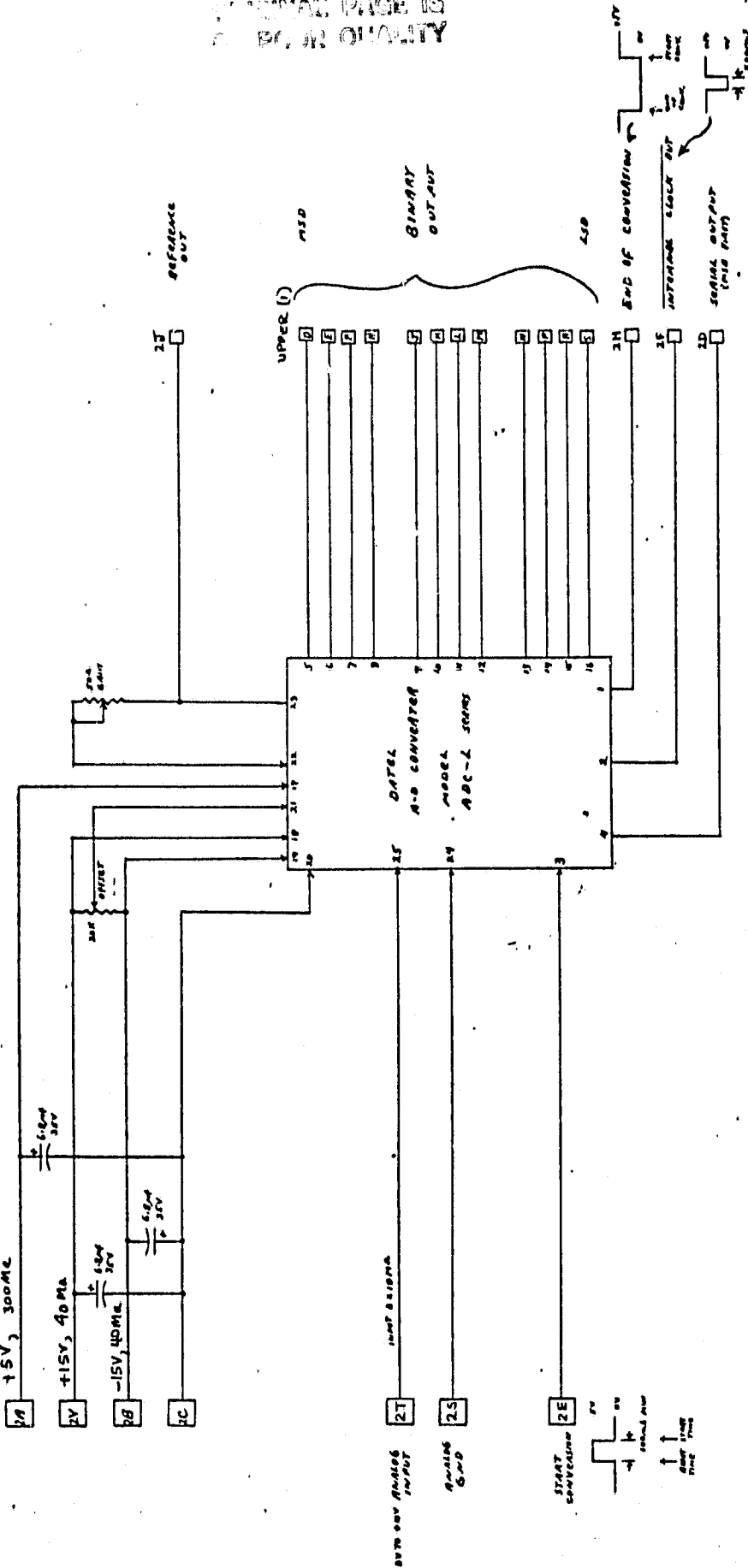
IO XY
X = SELECT '1' (0-P)
Y = SELECT '2' (4,6,8,CF)

I.E.  
 1004,5  
 SELECT '1' → 0  
 SELECT '2' → 4

DATA



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UNIVERSITY OF CALIFORNIA  
LICK OBSERVATORY  
ANALOG TO DIGITAL  
CONVERTER

THROUGHPUT TIME IS 20µS.

REVISION

MARK	DATE	BY	CHK'D

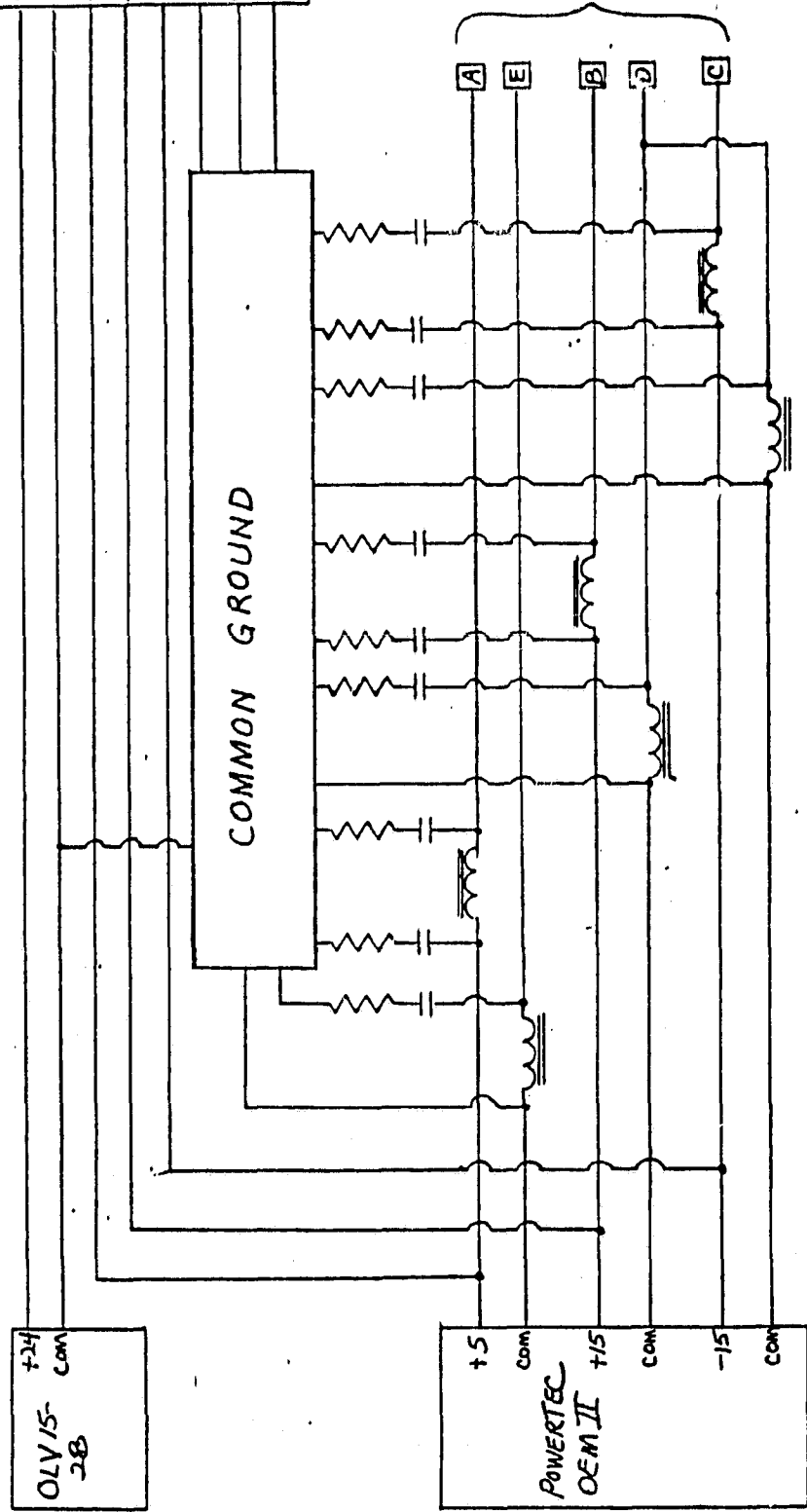
DESIGNED BY	77A	APPROVED BY	
DRAWN BY	77A	DATE	3-22-72
CHECKED BY		SER. NO.	EL-364-2L

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BACK PLANE

+24 COM  
+5  
+15  
-15  
COM  
COM  
COM

AMPLIFIER  
POWER



+24 COM  
OLV 15-2B

+5 COM  
POWERTEC  
OEM II  
+15 COM  
-15 COM

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POWER SUPPLY FILTERING  
& DISTRIBUTION

DATE	APPROVED BY	DATE
3-29-82	TPR	EL-942-WA
DATE	DRAWN BY	DATE
	LP	
DATE	CHECKED BY	

REVISION

MARK DATE DOWNS CHECKED

R = 10-ohm  
C = 1-uf  
L = 1/4" TOROID