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STANFORD RSL Final Report No. 71-3

The National Aeronautics and Space Administration
Research Contract NAS9-7313

"INFRARED SPECTROMETRY STUDIES"
FINAL REPORT (B) - PHASE IV

STANFORD SPECTRAL DIGITAL DATA ACQUISITION SYSTEM

(1971 Version)

BY

Lee Lu, Research Geophysicist

R. J. P. Lyon, Principal Investigator
School of Earth Sciences
Stanford University
Stanford, California 94305

OCTOBER 31, 1971

REMOTE SENSING LABORATORY
SCHOOL OF EARTH SCIENCES

STANFORD UNIVERSITY • STANFORD, CALIFORNIA

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"Infrared Spectrometry Studies"
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Stanford Spectral Digital Data Acquisition System

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Period: October 1, 1970 to September 30, 1971

The Phase IV Final Report is composed of three sections

(A) Software (Computer Programming) - RSL 71-2

(B) Digital Data Acquisition System - RSL 71-3

(C) Spectral Data from Flights 1 and 3, Mission 108 - RSL 71-6

The Report covers the last twelve month period of the contract.

R. J. P. Lyon
Principal Investigator

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71-3 "Stanford Digital Data System." Final Report (B) -- Phase IV.

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71-5 "Infrared Spectral Emittance in Geological Mapping: Airborne Spectrometer Data from Pisgah Crater, California." Paper submitted to Science, August 1971. pp. 14.

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I. INTRODUCTION

This report deals with the construction of the Stanford Spectral Digital Data Acquisition System. The objective of the system is to record both the spectral distribution of incoming radiation from the rock samples measured by the spectro-radiometer (Exotech Model 10-34 Circular Variable Filter (CVF) Infrared Spectro-radiometer as shown in Fig. 1.) together with other weather information.

This is a versatile and compact system which is designed for both laboratory and field measurement programs. The overall physical layouts are shown in Fig. 2 to Fig. 4.

The multichannel inputs (8 channels) of the system are as follows: Ch 1 the Spectro-radiometer, Ch 2 the radiometer (PRT-5), and Ch 3 to Ch 8 for the weather information. The system records data from channel 1 and channel 2 alternately for 48 times, before a fast sweep across the six weather channels, to form a single scan in the scan counter. The detailed description of the operation is illustrated in the block diagram in Section II and the theory of operation in Section III. The outputs are written on a 7-track magnetic tape with IBM compatible form. The format of the tape and the playback computer programs are included in Section IV and Section V respectively. The μ-PAC digital modules (Honeywell) and a CIPHER model 70 tape recorder (Cipher Data Products) are used. One of the major characteristics of this system is that it is externally clocked by the spectro-radiometer instead of taking data at intervals of various wave lengths by using internal-clocking. The interface between the electronic circuits and the tape recorder of the system also is quite simple.

II. THE BLOCK DIAGRAM

The block diagram of the system (Fig. 5) enables us to understand its overall functions. The encoder of the Exotech CVF infrared spectro-radiometer provides three basic control signals in its function as the

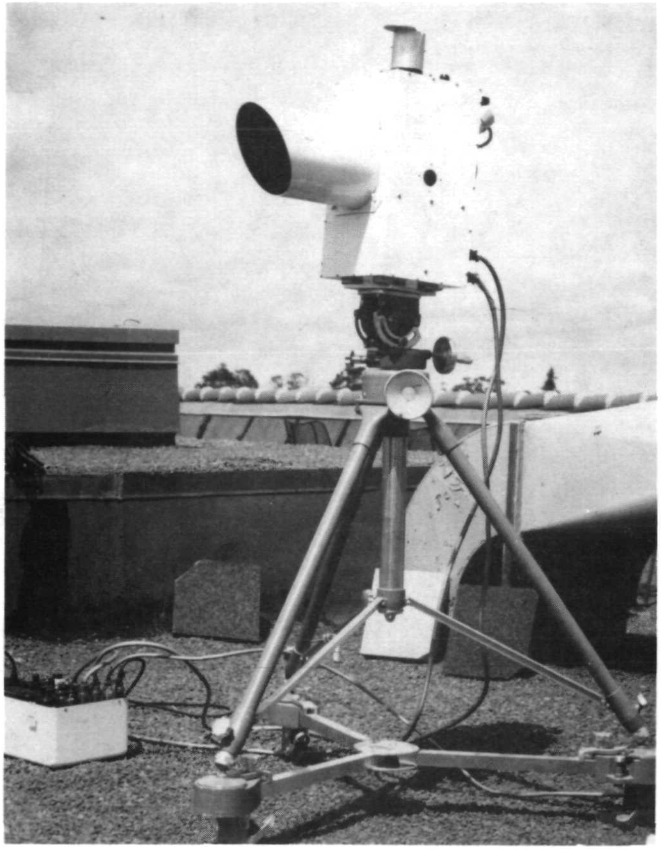

Fig. 1.

Exotech Model 10 Spectroradiometer.

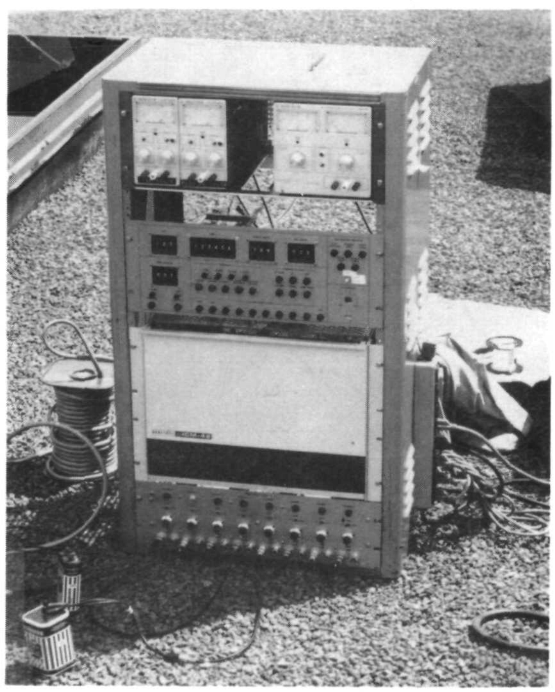

Fig. 2.

Data system operating on roof of Earth Science Bldg. Digital Tape recorder is hidden at rear.

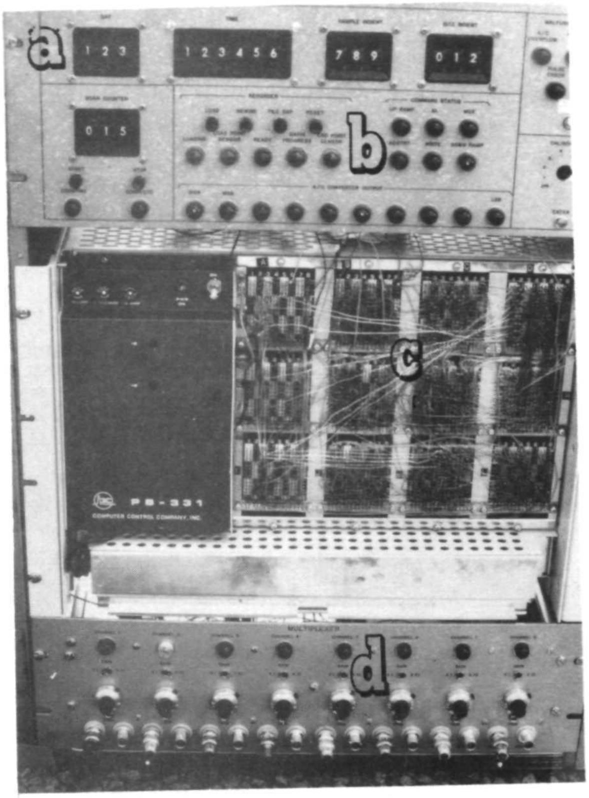

Fig. 3.

Digital Data System showing:

A. Input for ID
B. Status lights
C. Wiring Board
D. Input and monitor channels (8 pairs)
   1. Spectrometer
   2. Radiometer
   3-8. Met. data

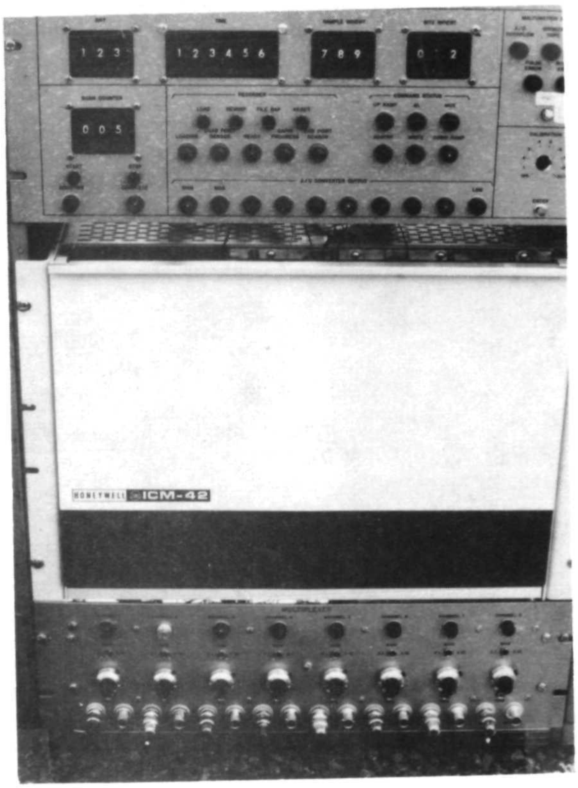

Fig. 4.

Same with cover added. Notice status lights are different.

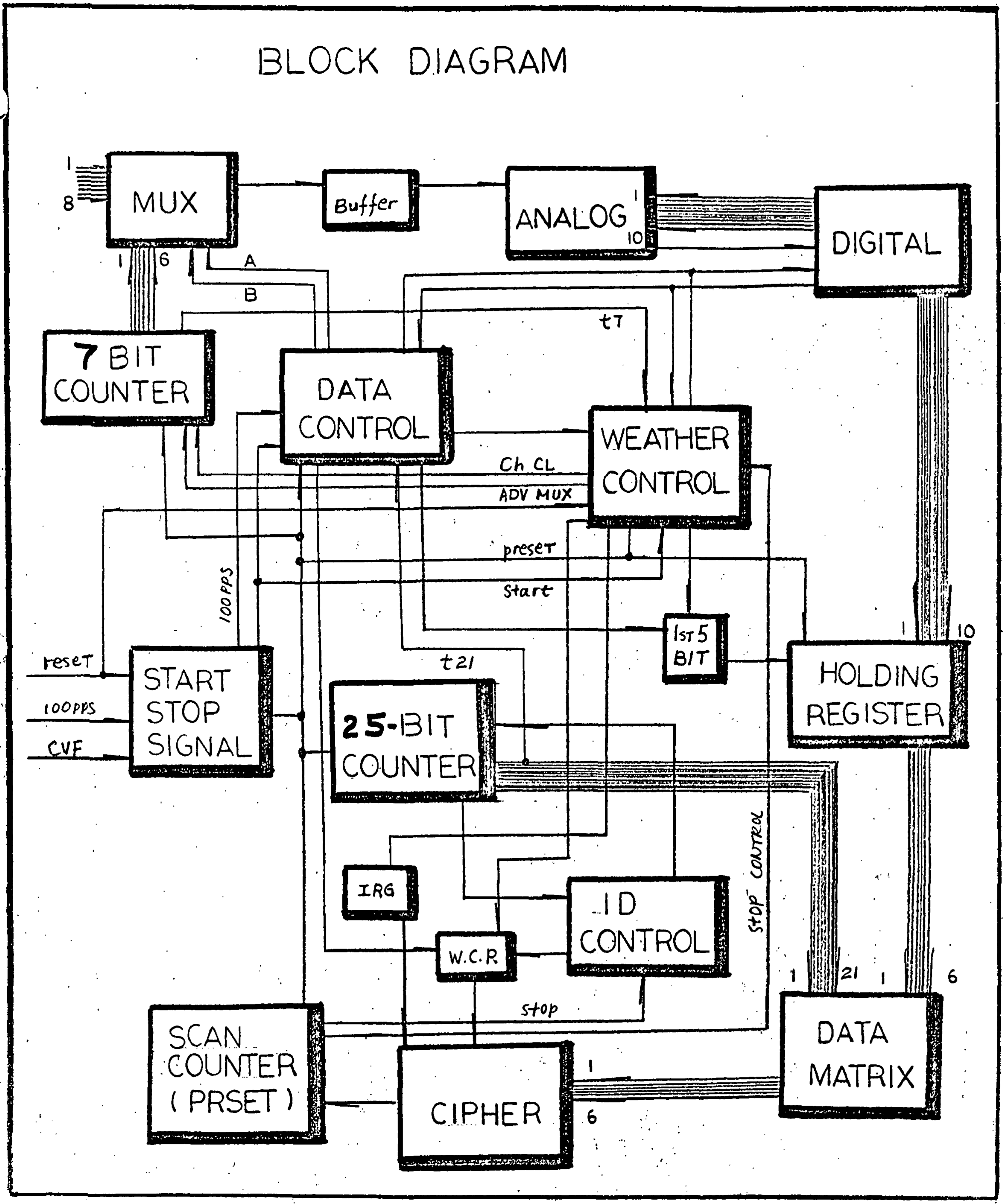

Fig. 5. The block diagram of the system

external clock of the system. These signals are (1) the reset, (2) the 100 PPR , and (3) the ramp function. In the data system the START-STOP SIGNAL controls the start and the initialization (the preset) of the SCAN COUNTER as well as the system. The multiplexer (MUX) switches a single-ended voltage from one of its 8 channel-inputs to its common output without changing the nature of the voltage. Then the common voltage is applied to the buffer amplifier (BUFFER), which is a unit gain noninverting device having high input impedance and low output impedance. The ANALOG and DIGITAL circuit converts the output from the buffer amplifier into 10-bits-word decimal data which are stored on the HOLDING REGISTER in the format of two-6-bits bytes. Those bytes are ready to be written on the 7-track tape of the tape recorder CIPHER through the DATA MATRIX. However, the additional 2 bits in the data matrix serve for the error checking only. The timing is controlled by the ID CONTROL. The DATA CONTROL and the WEATHER CONTROL blocks will be described in detail later in Section III.

First, the ID control gives signal to the 25-BIT COUNTER to write a "header" in the beginning of the tape. The header, providing the number of the scan, the day, the time, the sample number and the site number, is now located in the DATA MATRIX. Secondly, the DATA CONTROL block is responsible for writing Ch 1 and Ch 2 alternately for 48 times. Finally, the WEATHER CONTROL block controls the recording of the six weather channels. Furthermore, the 7-BIT COUNTER is mainly used for the weather channel selections. The circuit diagrams of the above mentioned blocks are shown in Appendicies A to L.

III. THE THEORY OF OPERATION

The theory of operation can be understood by the timing relations in the ID CONTROL, the DATA CONTROL, and the WEATHER CONTROL blocks. Thus, their timing diagrams are discussed separately as follows.

A. The ID Control Signal Sequences

At the release of the START button, a square wave pulse is generated. The negative-going edge of this square wave pulse triggers a 500 μsec write command pulse (W. C. P.) which in turn generates the 4 msec duration byte-time. This byte-time is for the tape recorder to record one data byte. At the same time the 25-bit counter is also advanced once by the negative edge of the W. C. P. The ID sequences will be stopped as soon as the 25-bit counter reaches t_{13}. Meanwhile, the negative output $\overline{(t_{13})}$ is fed back to the enable control of the 500 μsec one shot. Hence, zero input at this enable lead will terminate the one shot from functioning. Fig. 6a shows the timing diagram of the signal sequences.

B. The Spectro-radiometer Data Channel Control Signal Sequences

As shown in Appendix B, the $\overline{\text{100 PPR}}$ gated by $\overline{Q_a}$, $\overline{Q_b}$ and $\overline{\text{WEATHER}}$ will trigger the DRPOT$^+$ signal in the tape recorder. The 1 μsec DRPOT$^+$ will in turn trigger a 12 μsec square wave to account for the "settling time" (S. T.) of the tape recorder. The positive and the negative edges of the 12 μsec S. T. pulse trigger a 1st 4 msec byte-time pulse and a 12 μsec W. C. P. respectively. The negative edge of the 1st W. C. P and the 1st 4 msec byte-time pulse again triggers a second W. C. P. and a 2nd 4 msec byte-time pulse. At the end of the 2nd 4 msec byte-time, the DRPOT$^+$ pulse is triggered. Then the above mentioned cycle repeats. The sample A/D command is a negative-going pulse. This pulse is activated whenever Q_a changes state. Fig. 6b shows the timing diagram of the data control signal sequences.

C. The Weather Channels Control Signal Sequences

During the WEATHER cycle, the negative edge of the inverse "reset" pulse from Exotech triggers the DRPOT$^+$ signal which in turn triggers a 12 μsec S. T. pulse and a W. C. P. The 1st and the 2nd 4 msec byte-time

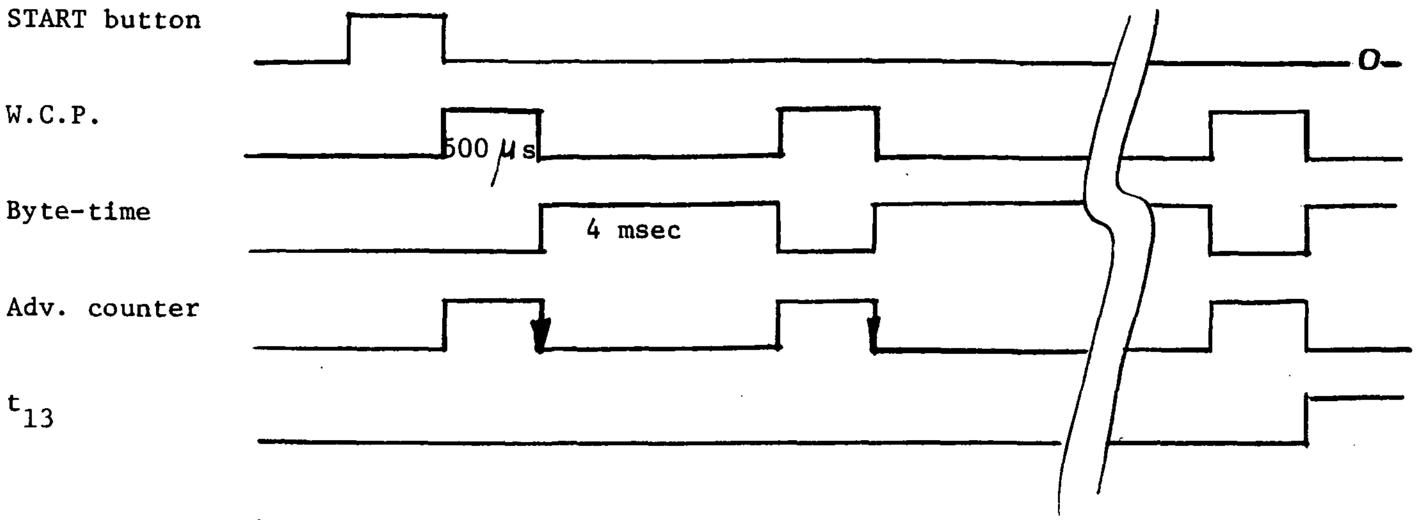

Fig. 6a. The ID control signal sequences

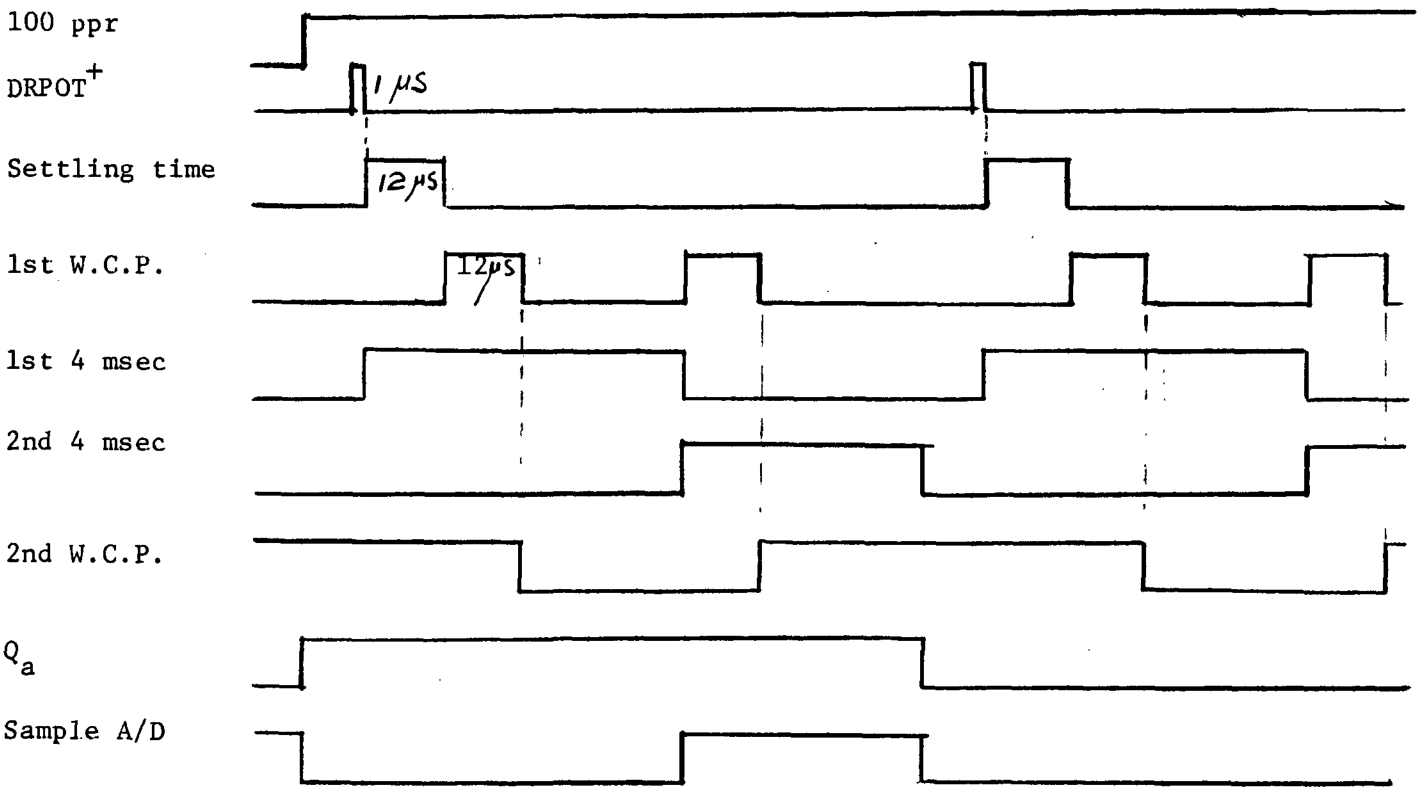

Fig. 6b. The data control timing sequences

pulses are being generated in the same way as in the data control cycle. Now, the negative edge of the W. C. P. also acts as the clock signal for the 7-bit counter and the multiplexer. The weather sequence will stop when the 7-bit counter reaches t_7. At this moment an I. R. G. command is applied to the tape recorder to write a record gap on the tape. Then the tape recorder sends back a return pulse which will activate the scan counter to advance on count. A whole event cycle is now completed and the control sequences go back to the data state. Therefore, it is ready for another new spectro-radiometer recording cycle. The timing diagram of the weather channel control signal sequences is illustrated in Fig. 7.

IV. THE DATA FORMAT AND THE SPECIFICATIONS OF THE SYSTEM

A. The Data Format

The tape recorder CIPHER in the system writes 7-track tapes with density of 200 bpi. These tapes are IBM compatible. The format of the tape is exhibited in Fig. 8. The header (or ID) contains 12 bytes, of which the first two bytes contain 3 BCD digits giving the number of scans; the 3rd and 4th bytes give 3 BCD digits indicating the day in a year; the next four bytes consist of 6 BCD digits showing the time in HH:MM:SS format; the ninth, the tenth bytes and the remaining 11th, 12th are for the sample and the site respectively. Next 96 words are integer*2. Each word contains 10-bits-two's-complement integer and two alternating bits for error checking. The 12 bits of an integer*2 are ordered in the following manner.

Tape channel	First byte	Second byte
1	2**0	2**5
2	2**1	2**6
4	2**2	2**7
8	2**3	2**8
A	2**4	the sign bit
B	1	0

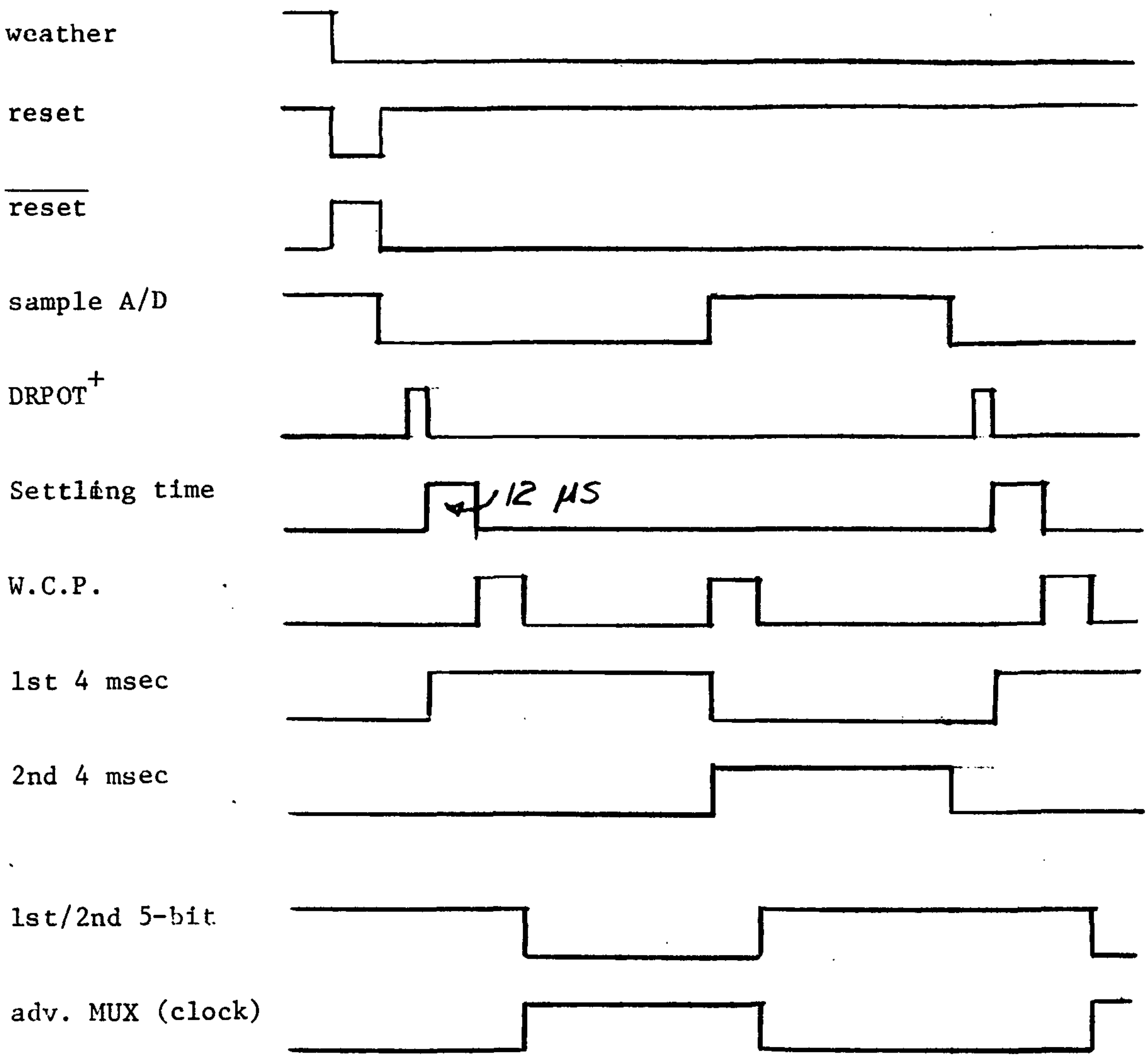

Fig. 7. The timing diagram of the weather control signal sequences.

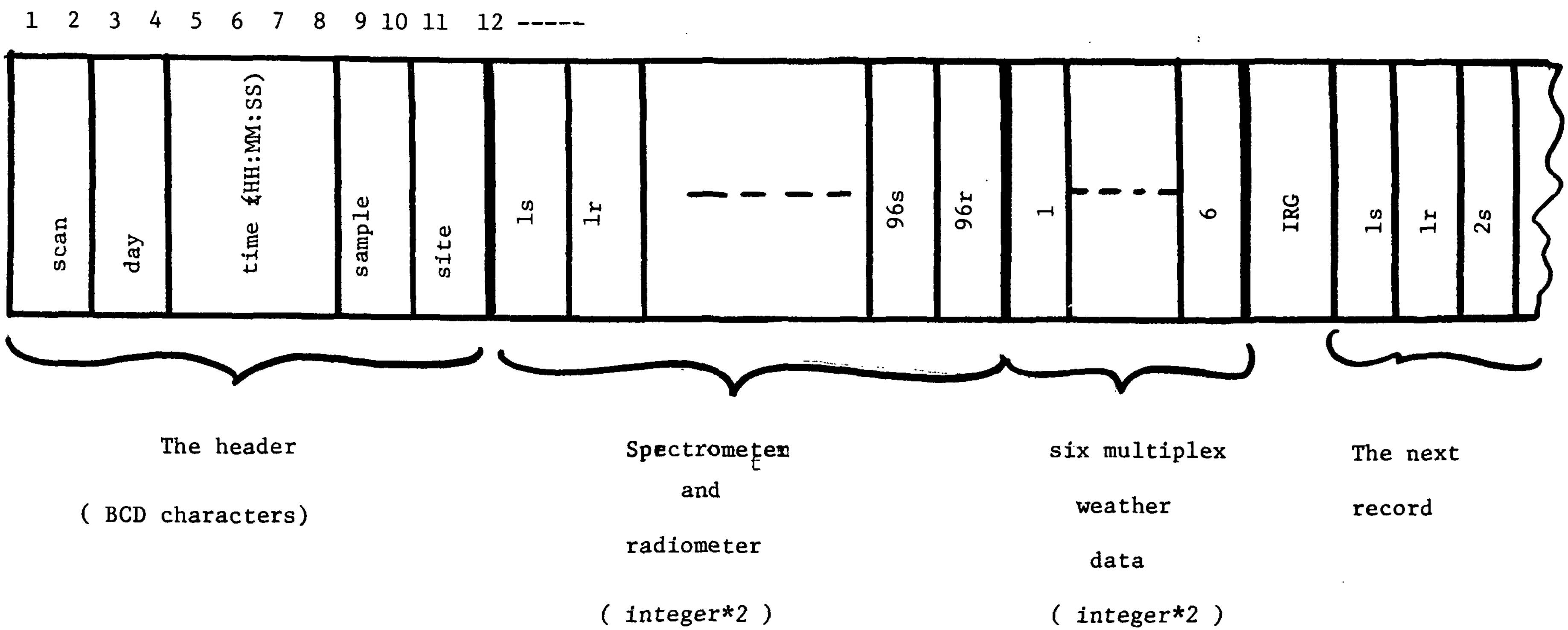

Fig. 8. The tape format (6 bit bytes)

The 96 words contain alternately, (1) the spectral samples over 48 different frequencies and (2) the 48 radiometer samples taken during the spectrum sweep. At the end, there are 6 words supplied from 6 different input channels of the ground meteorological information. An interrecord gap (IRG) is written at the end of the weather data, then, the next sampling cycle follows. After the system completes taking data, a file gap is written by pushing the file gap button on the panel of the system.

B. The Specifications of the Digital Data Acquisition System

This section contains general specifications of the digital data acquisition system. The detailed specifications of the tape recorder CIPHER, the Honeywell μ-PAC I/C Modules, and the Exotech 10 Spectro-radiometer are in References I, II, and V.

1. Logical Levels

logical ZERO	0.00 V to 0.35 V (max)
logical ONE	3.50 V (min) to 6.3 V (max)

2. Temperature Range

0° to 40° C

3. Power Supply Requirements

(a) A/D	$\pm(24 \pm 1)$ volts
(b) other circuits	$\pm(6 \pm 0.3)$ volts
(c) lamp indicators	$+14 \pm 4$ volts

4. Current Requirements

They are listed in the specifications for each individual μ-PAC in reference I.

5. Accuracy of the Outputs

The output accuracy of the digital system is approximately $\pm$ 0.15 volts.

6. Wavelength Region for Exotech 10 Spectro-radiometer

7 to 14 μ

7. Input Requirements

The input voltage of each channel should stay within $\pm$ 10 volts

V. THE TAPE PROGRAMS WITH ILLUSTRATION OF DATA

The computer programs used are the revised tape-dump programs. They are listed later in this section.

To test the digital system, we use constant DC inputs to verify the digitized outputs. An example of those outputs is illustrated in Fig. 9. For the purpose of checking each bit in the output, we printed out the hexadecimal values instead of integers. There are 6 records in Fig. 9 in which the first record is the header (or ID) and the remaining 5 records are data. Because the IBM computer does not read any record less than 18 bytes, we have had to insert 10 redundant bytes in front of the ID. Each bit of the redundant bytes has the logical level ONE. Thus, in the hexadecimal format, one data-word becomes "3F3F". The rest information in the first record is the ID in BCD format. They are interpreted as follows.

ID	Hex	Decimal
day	1419	456
time (HH:MM:SS)	210C 1419	12:34:56
sample	0726	789
site	1008	012

The record Nos. 2 to 6 in Fig. 9 are data. Each of the records has 204 bytes in which the first 192 bytes are from alternating spectrometer and radiometer inputs, the remaining 12 bytes are from 6 weather channel inputs. The relation among the hexadecimal, the decimal data words,

1	20	3F3F3F3F	3F3F3F3F	3F3F1419	210C1419	07261008			
2	204	270F3D12	2C0F3C12	290F3712	270F3A12	2D0F3F12	2B0F3B12	2D0F3E12	2D0F3D12
2	204	2DCF3E12	2B0F3C12	2E0F3F12	2A0F3F12	290F3712	2D0F3F12	2D0F3E12	290F3712
2	204	2ACF3A12	2A0F3F12	2A0F3F12	2A0F3A12	2D0F3F12	2D0F3F12	270F3B12	2A0F3F12
2	204	26CF3B12	2B0F3B12	290F3912	2D0F3E12	270F3A12	290F3712	280F3A12	2D0F3F12
2	204	2CCF3F12	290F3F12	2D0F3E12	2A0F3A12	2B0F3F12	2B0F3B12	280F3B12	2D0F3E12
2	204	2CCF3D12	270F3A12	270F3A12	2B0F3D12	2C0F3C12	2D0F3E12	2A0F3A12	290F3912
2	204	2BCF2918	2A0F2C0F	2CCF2B0F					
3	204	28CF3C12	2E0F3F12	2D0F3F12	290F3712	2A0F3912	2D0F3E12	2A0F3912	2A0F3F12
3	204	2ACF3F12	2ACF3A12	2D0F3E12	290F3912	270F3912	280F3D12	280F3F12	260F3D12
3	204	28CF3D12	2A0F3F12	2D0F3E12	2A0F3912	280F3D12	2D0F3E12	2A0F3912	2B0F3C12
3	204	2CCF3D12	29CF3712	2B0F3D12	2E0F3F12	2D0F3E12	2A0F3F12	2A0F3F12	2D0F3E12
3	204	2F0F2213	2FCF2113	2E0F2213	2D0F3F12	2A0F3912	2B0F3B12	2F0F2113	2F0F2113
3	204	2BCF3C12	2D0F3E12	290F3D12	2A0F3912	2A0F3A12	2F0F2113	2F0F2113	2B0F3B12
3	204	2ECF2818	2FCF2E0F	2CCF2B0F					
4	204	2ECF3D12	2D0F3E12	2B0F3F12	280F3B12	270F3A12	2D0F3F12	260F3D12	280F3F12
4	204	2A0F3F12	290F3712	2D0F3E12	270F3B12	2D0F3D12	2B0F3B12	2B0F3B12	2D0F3E12
4	204	2ACF3F12	2D0F3F12	2B0F3D12	2A0F3F12	2D0F3D12	2E0F3F12	260F3D12	280F3C12
4	204	270F3912	2E0F3F12	2D0F3E12	2A0F3912	2A0F3A12	2A0F3912	2D0F3E12	270F3712
4	204	29CF3712	290F3712	280F3E12	290F3F12	2D0F3E12	2E0F3F12	2A0F3A12	2B0F3B12
4	204	290F3712	2D0F3E12	2DCF3E12	2D0F3F12	280F3B12	280F3B12	270F3B12	290F3712
4	204	28CF2B18	28CF2B0F	2DCF2C0F					
5	204	280F3F12	2D0F3D12	280F3C12	2E0F3F12	2D0F3F12	2A0F3712	2B0F3B12	2B0F3B12
5	204	2CCF3E12	2D0F3D12	27CF3912	290F3F12	2B0F3B12	2A0F3912	2D0F3D12	260F3E12
5	204	29CF3712	290F3F12	2B0F3D12	280F3D12	280F3F12	280F3B12	2B0F3B12	2D0F3E12
5	204	29CF3F12	2A0F3F12	270F3A12	270F3A12	270F3912	2A0F3F12	2A0F3F12	290F3F12
5	204	27CF3712	2D0F3E12	2DCF3E12	270F3712	2A0F3A12	2A0F3912	2D0F3E12	270F3A12
5	204	28CF3F12	290F3F12	2B0F3B12	2B0F3A12	2B0F3B12	2D0F3F12	290F3712	2A0F3F12
5	204	2CCF2818	2D0F2D0F	2BCF2A0F					
6	204	2C0F3B12	2ACF3912	2ACF3F12	280F3F12	2D0F3E12	290F3712	2E0F3F12	2A0F3912
6	204	2BCF3B12	2C0F3B12	280F3F12	270F3D12	280F3A12	270F3A12	2B0F3B12	270F3A12
6	204	2BCF3B12	2B0F3F12	2B0F3D12	2C0F3B12	290F3712	2B0F3B12	290F3F12	2D0F3E12
6	204	27CF3912	2D0F3D12	2D0F3E12	270F3912	2D0F3E12	2D0F3F12	2A0F3912	270F3812
6	204	2C0F3F12	270F3D12	27CF3812	2A0F3912	2D0F3D12	2B0F3D12	2D0F2213	2A0F3A12
6	204	2FCF2113	2C0F2213	2F0F2113	2C0F3B12	2A0F3A12	2F0F2113	2F0F2113	2A0F3912
6	204	2ACF3018	290F2B0F	2FCF2E0F					

Fig. 9. An example of the computer output from the tape playback programs. (The explaination is in Section V.)

and the output voltages is shown in the following example

Hex	Decimal	Output (voltages)
3F3F	1023	+10.00
0000	0	-10.00
0020	0	-10.00
0010	512	0.00
0030	512	0.00
270F	497	-0.29
260F	492	-0.39
3D12	605	+1.82
3C12	604	+1.80
2B0F	491	-0.41
2A0F	490	-0.43
2918	777	+5.18
2D0F	493	-0.37

The accuracy of the outputs is approximately within $\pm$ 0.15 volts, resulting from the variations of the first three bits in the first byte of a data word, that is the system is 10-bit but the accuracy is 7-bits. The computer programs are listed as follows.

```
//RSL JOB (J032,332),TM.TRKLOAD.SOURCE
//FORT EXEC PGM=FORTH,PARM='XREF,MAP,OPT=2'
//SYSUT1 DD UNIT=SYSDA,SPACE=(CYL,(3,3))
//SYSUT2 DD UNIT=SYSDA,SPACE=(CYL,(3,3))
//SYSLIN DD DSN=&PUNCH,UNIT=SYSDA,DISP=(MOD,PASS),
//          SPACE=(CYL,(3,3)),DCB=(RECFM=FB,LRECL=80,BLKSIZE=3200)
//SYSPRINT DD SYSOUT=A
//SYSIN DD *
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C                                                                        C
C               PROGRAM TRKLOAD -- TRUCK TAPE TO DISK                    C
C            TONY MARSHALL -- STANFORD REMOTE SENSING LABORATORY         C
C                                                                        C
C     THIS PROGRAM READS TRUCK TAPES AND CREATES TWO OUTPUT FILES.       C
C     DATA RECORDS ARE STORED IN A DIRECT ACCESS DATASET, AND            C
C     IDENTIFICATION RECORDS ARE STORED IN A SEQUENTIAL DATASET          C
C     WITH POINTERS TO THE CORRESPONDING DATA.                           C
C                                                                        C
C               SPECTAPE -- DDNAME OF TRUCK TAPE.                        C
C                           NO DCB PARAMETERS REQUIRED.                  C
C               DIRECT   -- DDNAME OF DATA OUTPUT FILE.                  C
C                           DCB=(DSORG=DA,BLKSIZE=204)                   C
C               FT10F001 -- DDNAME OF IDENTIFICATION FILE.               C
C                           DCB=(RECFM=FB,LRECL=40,BLKSIZE=3520)         C
C               FT06F001 -- DDNAME OF IDENTIFICATION LISTING FILE.       C
C               FT04F001 -- DDNAME OF DATA LISTING FILE.                 C
C               FT05F001 -- DDNAME OF PARAMETER INPUT FILE.              C
C                           &PARMS LIST=F, ERRCNT=10, TERR=F, &END       C
C                                                                        C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C
      IMPLICIT INTEGER*2 (A-Z)
      INTEGER KEY/1/, COUNT/0/, PRINT/6/, INDEX/10/, DUMP/4/, LRECL
      INTEGER ERRCNT/10/, CARD/5/, NERR/0/, NIDS/0/, NINV/0/, NREADS/0/
      INTEGER JUMP, DATE(5), I, J, K, L, M, N
      INTEGER DTLEN, IDLEN/20/, DTSIZ/48/
      LOGICAL   LIST /.FALSE./,   TERR /.FALSE./
      DIMENSION SAVEID(6)
C
C     RDTRK COMMON DEFINITION
      COMMON /TDATA/ INPA(200), IDENT(6), SPECT(48), RADIO(48), MULT(6)
C
C     DEFINE DIGITIZED (0,1023) TO DECIVOLTS (-100,100) FORMULA
      DVOLT(RAW) = (200*RAW - 102300) / 1023
C
C     DEFINE AND READ NAMELIST
      NAMELIST /PARMS/ ERRCNT, LIST, TERR
      READ (CARD,PARMS,END=2)
2     CONTINUE
C
C     INITIALIZE
      DTLEN = DTSIZ*4 + 12
```

```
      IF (TERR) CALL NOERR
C
      CALL DATER (DATE)
      WRITE (PRINT,65) DATE
C
      ASSIGN 11 TO JUMP
11    CALL RDTRK (LRECL)
      NREADS = NREADS + 1
      IF (LRECL .EQ. IDLEN) GOTO 12
      IF (LRECL .LT. 0) GOTO 80
      IF (LRECL .EQ. 0) STOP
C
      BUFL = LRECL/2
      WRITE (PRINT,61) NREADS, LRECL, (INPA(J), J = 1,BUFL)
      NINV = NINV + 1
      GOTO 11
C
12    DO 10 I = 1,6
10    SAVEID(I) = IDENT(I)
      SAVKEY = KEY
C
C     READ INPUT TAPE
      ASSIGN 20 TO JUMP
20    CALL RDTRK (LRECL)
      NREADS = NREADS + 1
C
      IF (LRECL .EQ. DTLEN) GOTO 30
      IF (LRECL .EQ. IDLEN) GOTO 40
      IF (LRECL .EQ. 0) GOTO 50
      IF (LRECL .LT. 0) GOTO 80
C
C     BAD LRECL IGNORE RECORD
      NINV = NINV + 1
      BUFL = LRECL/2
      WRITE (PRINT,61) NREADS, LRECL, (INPA(J), J = 1,BUFL)
      WRITE (PRINT,67)
      GOTO 20
C
C     DATA RECORD FOUND
30    DO 31 M = 1,DTSIZ
      SPECT(M) = DVOLT(SPECT(M))
31    RADIO(M) = DVOLT(RADIO(M))
      DO 32 M = 1,6
32    MULT(M)  = DVOLT(MULT(M))
C
      CALL DALOAD (SPECT, KEY)
      IF (.NOT. LIST) GOTO 49
C
      WRITE (DUMP,72) KEY, (SPECT(N), N = 1,DTSIZ)
      WRITE (DUMP,73)      (RADIO(N), N = 1,DTSIZ)
      WRITE (DUMP,74) MULT
C
```

```
49      KEY = KEY + 1
        COUNT = COUNT + 1
        GOTO 20
C
C       IDENTIFICATION RECORD FOUND
40      IF (COUNT .NE. 0) GOTO 47
C
C       IDENTIFICATION RECORD CONTAINS NO DATA
        WRITE (PRINT,62) SAVEID
        NINV = NINV + 1
        GOTO 45
C
C       WRITE IDENTICATION RECORD
47      NIDS = NIDS + 1
        WRITE (INDEX,66) SAVEID, SAVKEY, COUNT
        WRITE (PRINT,64) NIDS, SAVEID, SAVKEY, COUNT
        SAVKEY = KEY
        COUNT = 0
C
45      DO 46 I = 1,6
46      SAVEID(I) = IDENT(I)
        GOTO 20
C
C       END OF FILE EXIT
50      IF (COUNT .NE. 0) GOTO 48
C
C       IDENTIFICATION RECORD CONTAINS NO DATA
        WRITE (PRINT,62) SAVEID
        NINV = NINV + 1
        GOTO 60
C
C       WRITE FINAL IDENTIFICATION RECORD
48      NIDS = NIDS + 1
        WRITE (INDEX,66) SAVEID, SAVKEY, COUNT
        WRITE (PRINT,64) NIDS, SAVEID, SAVKEY, COUNT
C
60      NREADS = NREADS - 1
        KEY = KEY - 1
        WRITE (PRINT,63) NREADS, NIDS, KEY, NINV, NERR
        IF (LIST) WRITE (DUMP,63) NREADS, NIDS, KEY, NINV, NERR
        STOP
C
C       READ ERROR ROUTINE
80      WRITE (PRINT,69) NREADS, (INPA(J), J = 1,160)
        NERR = NERR + 1
        IF (NERR .LE. ERRCNT) GOTO JUMP, (11, 20)
C
C       TOO MANY ERRORS
        WRITE (PRINT,71) NREADS
        STOP
C
C
C       FORMATS
```

```
C
61     FORMAT (///' RSL042I  RECORD',I5,' INVALID',I4,' BYTES'//
      *              (' RSL042I',16Z6))
C
62     FORMAT (///' RSL040I  IDENTIFICATION RECORD CONTAINS NO DATA'//
      *              ' RSL040I  DAY IS    ',I9/
      *              ' RSL040I  TIME IS   ',3I3/
      *              ' RSL040I  SAMPLE IS',I9/
      *              ' RSL040I  SITE IS   ',I9///)
C
63     FORMAT ('1RSL000I',I6,' RECORDS READ'/
      *        ' RSL000I',I6,' IDENTIFICATION RECORDS SAVED'/
      *        ' RSL000I',I6,' DATA RECORDS SAVED'/
      *        ' RSL000I',I6,' INVALID RECORDS FOUND'/
      *        ' RSL000I',I6,' PERMANENT READ ERRORS'//
      *        ' RSL001I        NORMAL END OF RUN')
C
64     FORMAT (T15,I4,')  DAY  =',I4,';  TIME  =',3I3,';  SAMPLE  =',
      *             I4,';  SITE  =',I4,';  START  =',I5,';  COUNT  =',I3)
C
65     FORMAT ('1',T35,'IDENTIFICATION RECORDS SAVED ON ',5A4//)
66     FORMAT (8I5)
67     FORMAT (////)
C
69     FORMAT (///' RSL044I  RECORD NO',I5,' PERMANENT READ ERROR'//
      *        10(' RSL044I',16Z6/)///)
C
71     FORMAT (///' RSL046I  I/O ERROR COUNT EXCEEDED  ',I5,
      *              ' RECORDS READ')
72     FORMAT ('1',T32,'RECORD NO.',I5///' SPECTROMETER DATA'//(8I10))
73     FORMAT (////' RADIOMETER DATA'//(8I10))
74     FORMAT (////' MULTIPLEXED DATA'//6I10)
       END
//LKED EXEC PGM=IEWL,PARM=(LET,LIST,XREF),COND=(5,LT)
//SYSUT1 DD DSN=SYS1.UT1,DCB=KEYLEN=0,DISP=OLD
//SYSLIN DD DSN=&PUNCH,DISP=(OLD,DELETE)
//SYSLMOD DD DSN=J032.PROGLIB(TRKLOAD),VOL=SER=SYS12,UNIT=2314,DISP=OLD
//SYSLIB DD DSN=SYS1.FORTLIB,DISP=SHR
//         DD DSN=J032.SUBLIB,VOL=SER=SYS12,UNIT=2314,DISP=SHR
//SYSPRINT DD SYSOUT=A
//GO EXEC PGM=*.LKED.SYSLMOD,COND=(5,LT)
//FT06F001 DD SYSOUT=A
//FT04F001 DD SYSOUT=A,DCB=(RECFM=FA,BLKSIZE=133)
//FT10F001 DD DSN=J032.TRUCK.INDEX5,VOL=SER=SYS15,UNIT=2314,
//             DISP=(NEW,KEEP,DELETE),SPACE=(TRK,10,RLSE),
//             DCB=(RECFM=FB,LRECL=40,BLKSIZE=3520)
//SPECTAPE DD DSN=J032.TRUCK.TEST.DATA5,VOL=SER=SYS14,UNIT=2314,
//             DISP=SHR
//DIRECT DD DSN=J032.TRUCK.DATA5,VOL=SER=SYS15,UNIT=2314,
//             DISP=(NEW,KEEP,DELETE),SPACE=(TRK,10,RLSE),
//             DCB=(BLKSIZE=204,DSORG=DA)
//FT05F001 DD *
 &PARMS LIST=T, &END
```

```
//RSL JOB (J032,332),TM.RDTRK.SOURCE
//ASM EXEC PGM=ASMGASM,PARM=(FULLXREF,ESD)
//SYSUT1 DD DSN=SYS1.UT1,DCB=(KEYLEN=0,BLKSIZE=10175),DISP=OLD
//SYSUT2 DD DSN=SYS1.UT2,DCB=BLKSIZE=7294,DISP=OLD
//SYSUT3 DD DSN=SYS1.UT3,DCB=BLKSIZE=7294,DISP=OLD
//SYSLIN DD DSN=&PUNCH,UNIT=SYSDA,DISP=(MOD,PASS),
//          SPACE=(CYL,(3,3)),DCB=(RECFM=FM,LRECL=80,BLKSIZE=3200)
//SYSLIB DD DSN=SYS1.MACLIB,DISP=SHR
//          DD DSN=J032.MACLIB,VOL=SER=SYS10,UNIT=2314,DISP=SHR
//SYSPRINT DD SYSOUT=A
//SYSIN DD *
         TITLE    'ASSEMBLY PARAMETERS'
SGNSIZ   EQU      0
SGDSIZ   EQU      48
         TITLE    'SG-4 SPECTROMETER TAPE READ PROGRAM'
         PRINT    NOGEN
RDTRK    LINKS
         SPACE    2
***********************************************************************
*                                                                     *
*                       SUBROUTINE RDTRK (LRECL)                      *
*                 TONY MARSHALL -- STANFORD REMOTE SENSING LAB        *
*                                                                     *
*                                                                     *
*        LRECL    -- SIZE IN BYTES OF CURRENT RECORD, SET TO ZERO     *
*                       ON EOF READS.                                 *
*        SPECTAPE -- DDNAME FOR INPUT DATA SET                        *
*        TDATA    -- FORTRAN COMMON, HALFWORD INTEGERS                *
*                                                                     *
*  COMMON /TDATA/ INPA(200), IDENT(6), SPECT(48), RADIO(48), MULT(6)  *
*                                                                     *
*                                                                     *
*        THIS FORTRAN CALLABLE SUBROUTINE READS AND CONVERTS DATA     *
*        READ FROM 7-TRACK MAG TAPE GENERATED BY STANFORDS SG-4       *
*        SPECTROMETER SYSTEM.                                         *
*        THE RAW DATA IS CONTAINED IN TWO DIFFERENT RECORD FORMATS    *
*        EACH OF A DIFFERENT PHYSICAL LENGTH AND DATA RECORDING MODE. *
*        THE IDENTIFICATION RECORD CONTAINS DATA IN A PACKED BCD      *
*        FORMAT WHERE EACH PAIR OF SIX BIT BYTES CONTAIN THREE        *
*        FOUR BIT BCD CHARACTERS.                                     *
*                                                                     *
*        TAPE DATA FORMAT:      001FGHIJ 000ABCDE                     *
*        CONVERTED FORMAT:      000000AB CDEFGHIJ                     *
*                                                                     *
*        TAPE BCD FORMAT:       00EF IJKL   00ABCD GH                 *
*        CONVERTED FORMAT:      ABCD + 10*EFGH + 100*IJKL             *
*                                                                     *
*        THE DATA IS RETURNED IN COMMON TO FORTRAN, ALL NUMBERS       *
*        ARE CONVERTED TO 16 BIT TWOS COMPLIMENT INTEGERS.            *
*                                                                     *
***********************************************************************
         SPACE    2
         L        LRECL,0(0,PARM)          GET ARG ADDRESS
         SR       COUNT,COUNT              SET COUNT TO ZERO
         TITLE    'OPEN, READ, CLOSE SECTION'
```

```
         TOPEN    SPECTAPE,READ
         OPEN     (SPECTAPE)
         TOPEN    SPECTAPE,READ
         WTO      'RSL1001  SPECTAPE DD CARD MISSING'
         ABEND    20,DUMP
         SPACE
READ     READ     DECB,SF,SPECTAPE,INPA,'S'
         CHECK    DECB
         LTR      COUNT,COUNT              DID WE GET AN ERROR?
         BM       EXIT                     IF SO EXIT
         L        CBASE,=V(TDATA)          ESTABLISH COMMON BASE REG
         USING    INPA,CBASE
         BAL      LINKR,BLKSIZE            GET BYTE COUNT FOR THIS BLOCK.
         SPACE
         C        COUNT,=A(SGIDSIZ)        CHECK FOR IDENT RECORD
         BE       IDCONV
         C        COUNT,=A(SGDTSIZ)        CHECK FOR DATA RECORD
         BE       DATACONV
         B        EXIT                     RECORD LENGTH ERROR
         SPACE
EODAD    CLOSE    (SPECTAPE,LEAVE)         LEAVE IN CASE OF MULTIPLE FILES
EXIT     ST       COUNT,0(0,LRECL)         RETURN LRECL TO FORTRAN
         L        SAVER,4(0,SAVER)
         RETURN   (14,12)
         TITLE    'IDENTIFICATION CONVERSION ROUTINE'
IDCONV   DS       0H
         BCD      DAY,SGDAY
         BCD      TIMEH,SGTIME
         BCD      TIMEM,SGTIME+2
         BCD      SAMPLE,SGSAMPLE
         BCD      SITE,SGSITE
         SPACE
         SR       TEMP,TEMP                FIX TIME
         LH       TEM2,TIMEM               LOAD LOWEST THREE DIGITS
         D        TEMP,=F'100'             EXTRACT LOW ORDER TWO DIGITS
         STH      TEMP,TIMES               STORE SECONDS
         ST       TEM2,CSAVE               SAVE LOW ORDER MINUTES DIGIT
         LH       TEM2,TIMEH               LOAD HIGH ORDER THREE DIGITS
         SR       TEMP,TEMP                CLEAR EVEN REGISTER
         D        TEMP,=F'10'              EXTRACT HIGH ORDER TWO DIGITS
         STH      TEM2,TIMEH               SAVE HOUR DIGITS
         MH       TEMP,=H'10'              SCALE HIGH ORDER MINUTE DIGIT
         A        TEMP,CSAVE               ADD LOW ORDER MINUTE DIGIT
         STH      TEMP,TIMEM               SAVE MINUTES
         B        EXIT
CSAVE    DS       F
         TITLE    'DATA CONVERSION ROUTINE'
DATACONV DS       0H
         LA       POINT,SGCHANLA           CONVERT SPECT/RADIO DATA
         LA       STEP,4
         LA       LIMIT,SGMULT-4
         SR       INDEX,INDEX
```

```
         SPACE
DLOOP    DS      0H
         TENBIT  SPECT(INDEX),0(0,POINT)
         TENBIT  RADIO(INDEX),2(0,POINT)
         LA      INDEX,2(0,INDEX)
         BXLE    POINT,STEP,DLOOP
         SPACE
         LA      LIMIT,6                CONVERT MULTIPLEX DATA
         SR      INDEX,INDEX
MLOOP    DS      0H
         TENBIT  MULT(INDEX),SGMULT(INDEX)
         LA      INDEX,2(0,INDEX)
         BCT     LIMIT,MLOOP
         B       EXIT
         TITLE   'ROUTINE TO TURN OFF ERROR RETRY BITS'
         ENTRY   NOERR
         SPACE
         USING   *,15
NOERR    OI      SPECTAPE+49,X'0C'
         BR      14                     SHOULD BE CALLED BEFORE OPEN
         DROP    15
         TITLE   'INPUT BLKSIZE ROUTINE'
BLKSIZE  DS      0H
         L       POINT,DECB+16          GET POINTER TO STATUS INFO
         L       TEMP,12(0,POINT)       GET RESIDUAL COUNT
         N       TEMP,MASK              ONLY USE LOW ORDER HALFWORD
         L       COUNT,SPECTAPE+60      GET BLKSIZE FROM DCB
         N       COUNT,MASK             ONLY USE LOW ORDER HALFWORD
         SR      COUNT,TEMP             SUBTRACT REMAINDER
         BR      LINKR                  RETURN
         DS      0F
MASK     DC      X'0000FFFF'
         TITLE   'READ ERROR ROUTINE'
SYNAD    DS      0H
         SYNADAF ACSMETH=BSAM
         STM     14,1,ERRSAV            SAVE OS REGISTERS
         MVC     STATUS(27),=CL27'RSL1101  I/O ERROR INFO --'
         MVC     STATUS+27(78),50(PARM)
         WTOP    STATUS,LIMIT=20,MF=E
         L       COUNT,=F'-1'           SET ERROR FLAG
         SYNADRLS
         LM      14,1,ERRSAV            RESTORE THE REGISTERS
         BR      14                     RETURN TO CHECK MODULE
```

```
TDATA    COM
         COPY    RDTRK
         TITLE   'REGISTER DEFINITIONS'
PARM     EQU     1
TEMP     EQU     2
TEM2     EQU     TEMP+1
STEP     EQU     4
LIMIT    EQU     5
LRECL    EQU     6
BCD      EQU     7
COUNT    EQU     8
POINT    EQU     9
INDEX    EQU     10
CBASE    EQU     11
BASE     EQU     12
SAVER    EQU     13
LINKR    EQU     14
         END
/*
//LKED EXEC PGM=IEWL,PARM=(LET,LIST,XREF,NCAL),COND=(5,LT)
//SYSUT1 DD DSN=SYS1.UT1,DCB=KEYLEN=0,DISP=OLD
//SYSLIN DD DSN=&PUNCH,DISP=(OLD,DELETE)
//SYSLMOD DD DSN=J032.SUBLIB(RDTRK),VOL=SER=SYS12,UNIT=2314,DISP=OLD
//SYSPRINT DD SYSOUT=A
```

VI. ACKNOWLEDGEMENT

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VII. REFERENCES

I. Instruction manual, μ-PAC I/C Modules 5 MHz and 2 MHz, Volume I and Volume II, (1968). Honeywell Computer Control Division.

II. Preliminary service manual, Model 70 Magnetic Tape Recorder, (1968). Cipher Data Products, Inc.

III. Instruction manual, X-Mod-113-105, power supplies, Preston Scientific Incorporated.

IV. Logical design of digital computers, (1968). Montgomery Phister, Jr.

V. Exotech Model 10-34, CVF infrared spectro-radiometer instruction manual, (1970). Exotech Incorporated Instrumentation and Control Division.

VIII. APPENDICIES

A. The operational procedures:

(1) Mount the 7-track tape on the CIPHER.

(2) Turn on the power of the CIPHER.

(3) Turn on the power supplies of the system: (a) $\pm$ 6 V, (b) +18 V, (c) $\pm$ 24 V.

(4) Push load button (the ready light should be on when the silver marker of the tape passes the sensor to the right).

(5) Set the ID (i. e., the day, the time, the sample number, and the site number).

(6) Set scan number at 000.

(7) Turn on power of Exotech-10

(8) Load liquid N_2 into the Hg Cd Te detector.

(9) Set the ramp speed and turn on the switch of the electronic package of Exotech.

(10) Adjust the temperature null of Exotech.

(11) Push the START button (the complete light should be on).

(12) Set the number of scans.

(13) Plug in the inputs (i. e., channel-1, channel-2, and six weather channels--be sure that the inputs are less than +10 V and larger than -10V, any voltage beyond this range would damage the A/D converter!!!

(14) Push the FILE GAP button after the scan is over.

(15) Repeat (5) to (14) if any more operations have to be made.

(16) Turn off the switch of the electronic package of Exotech and press the FILE GAP button three times at the end of recording.

(17) Turn off the power supplies, rewind the tape, and turn off the power of CIPHER.

CIRCUIT DIAGRAMS

B. The data control circuit.

C. The weather control circuit.

D. The ID control circuit and the gating for 1st and 2nd five bits.

E. The multiplexer and A/D hookup.

F. The 7- and 25-bit counters.

G. The scan counter.

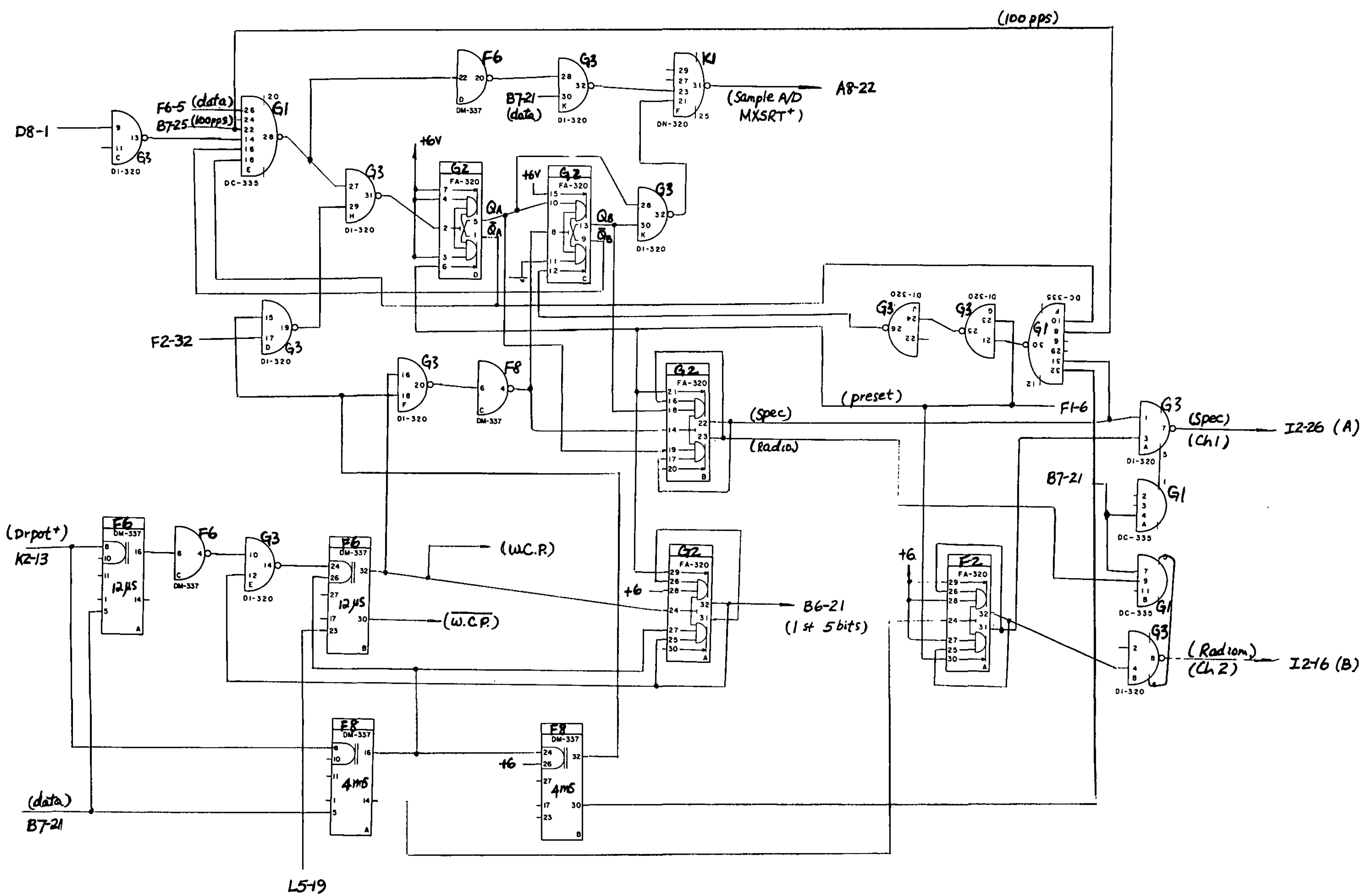
H. The 10-bit holding register.

I. The main control circuit (start/stop).

J. The 64 ppr and the reset pulses generator.

K. The data matrix.

L. The multiplexer and the status indicators.

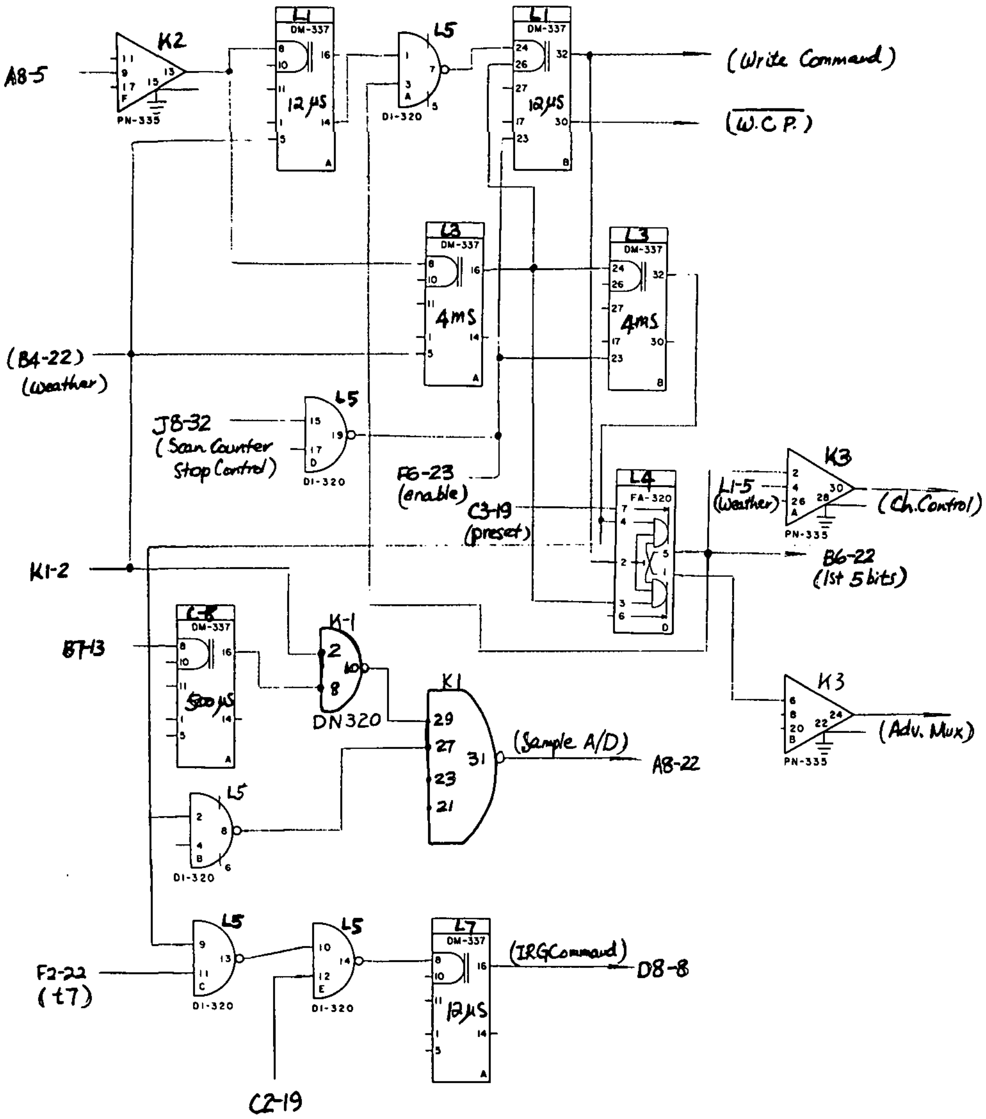


(2) Data Control Block

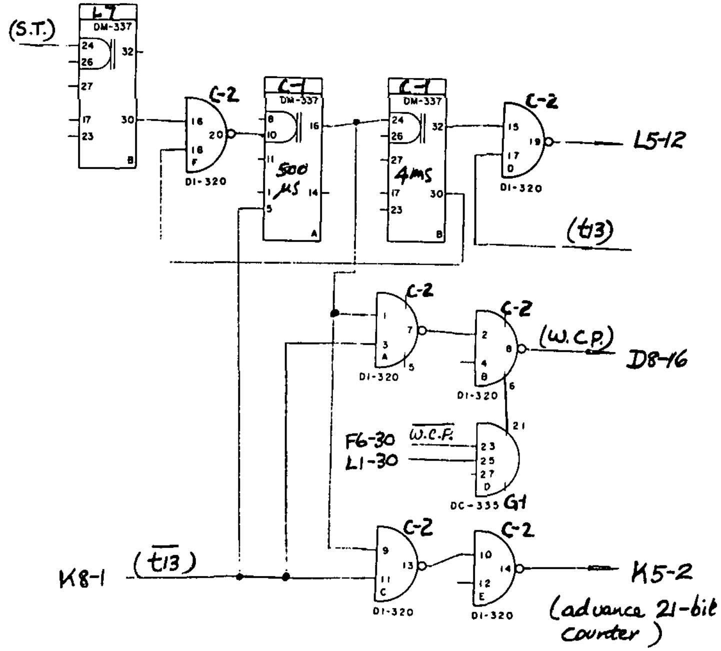
Lu: Phase IV(B) Final

RSL* 71-3

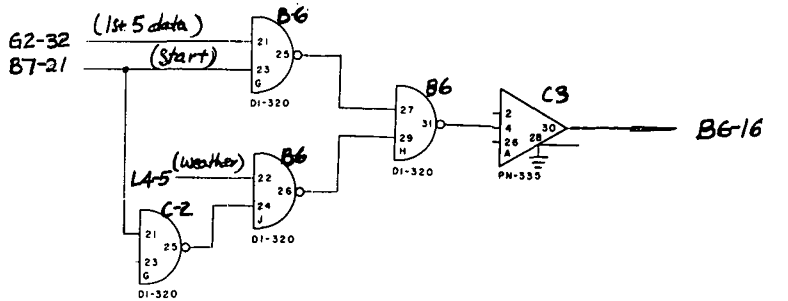
(3) Weather Control

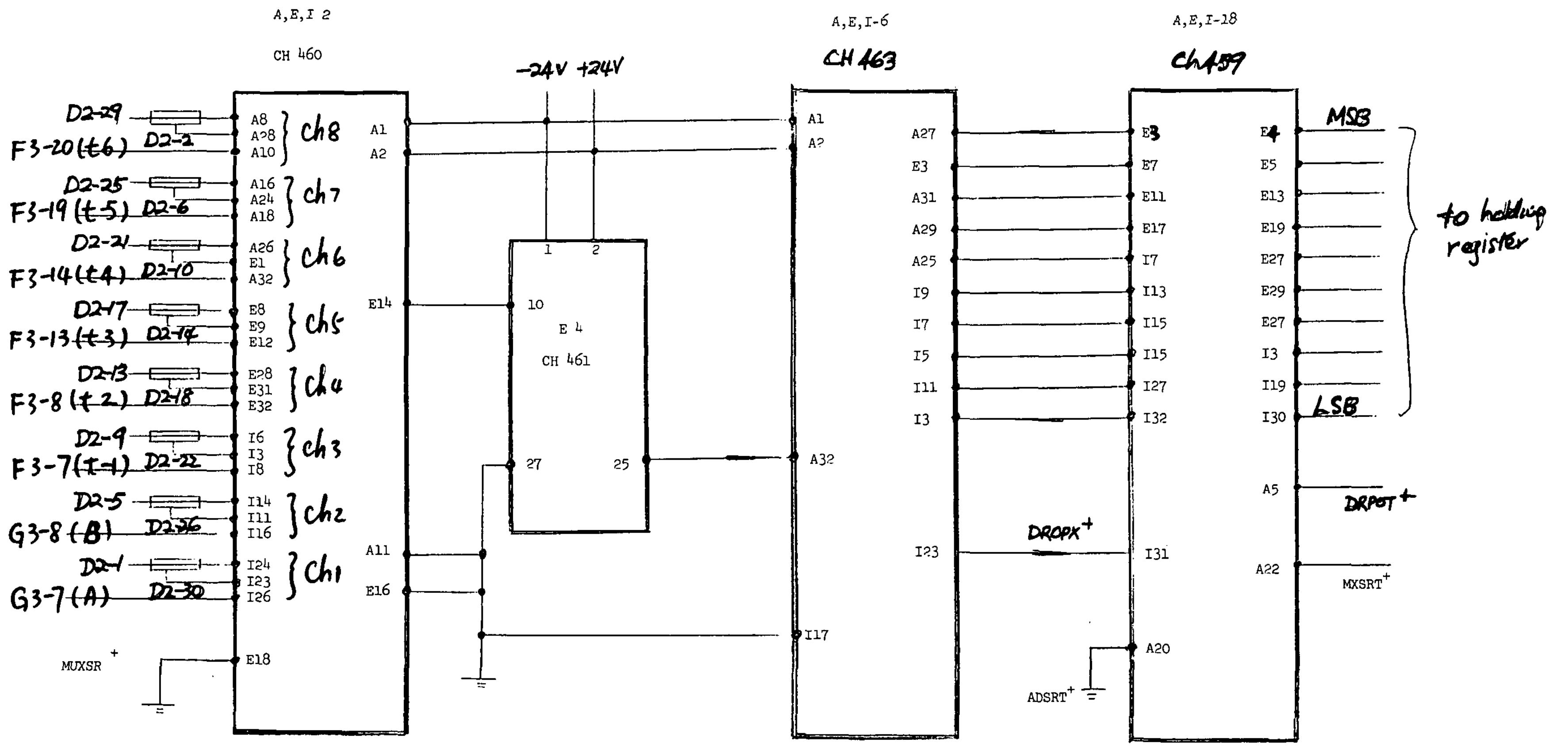


(4a.) I.D. Control



(4b). Gating for 1st & 2nd 5 bits

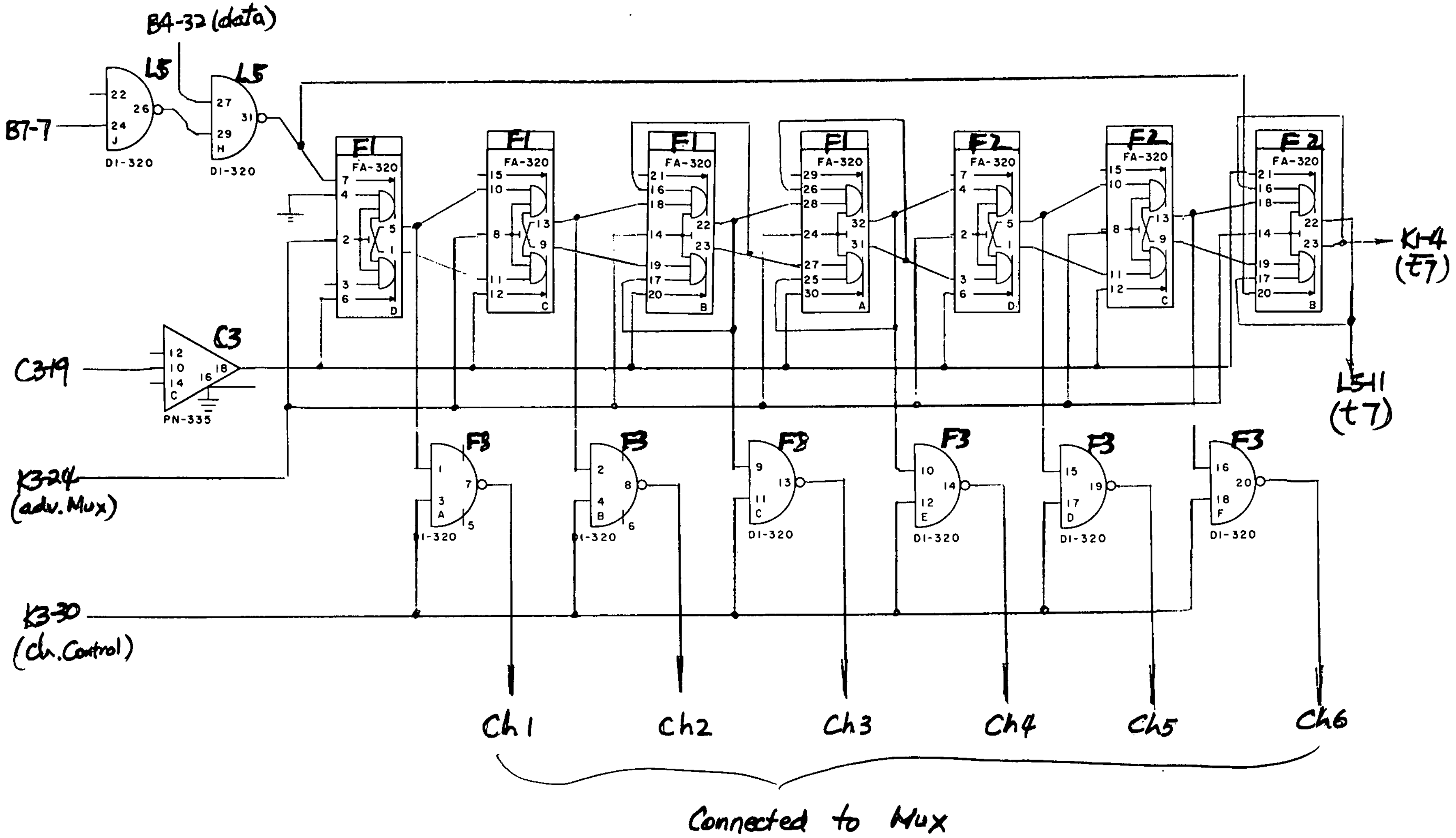




(5) Mux and A/D Hookup

Lu: Phase (IV) B Final

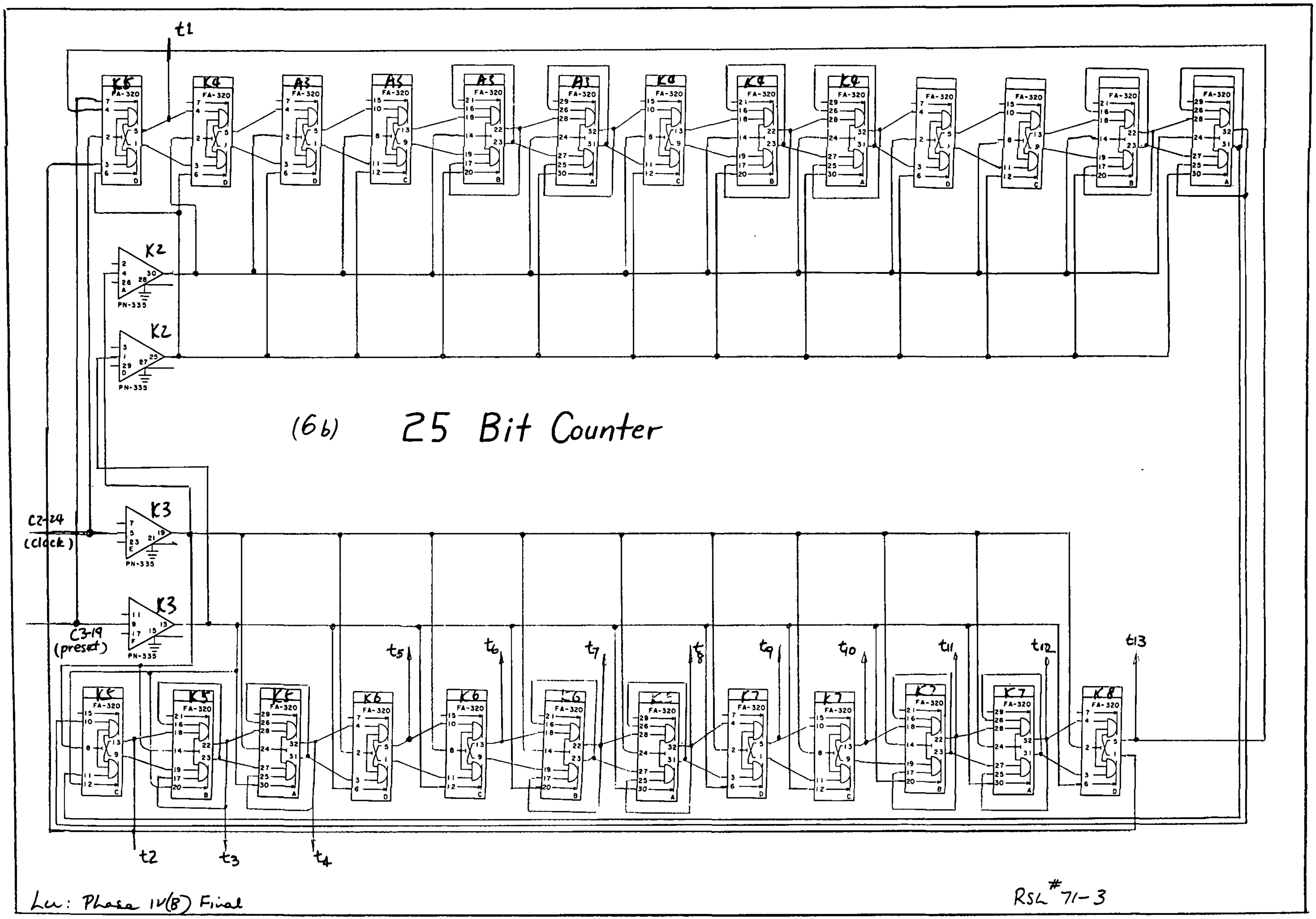
RSL # 71-3



(6a) 7 Bit Counter

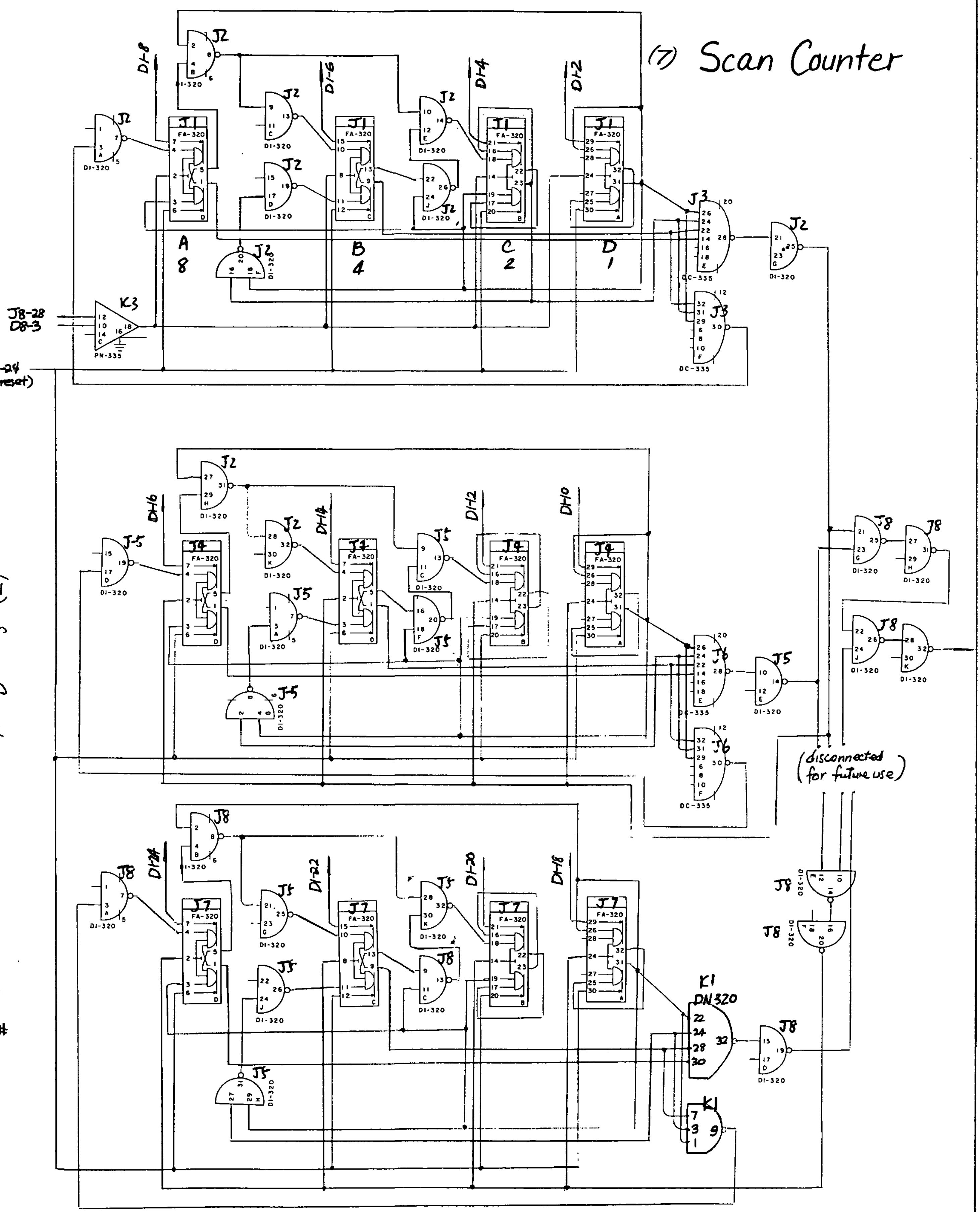
Lw: Phase IV(B) Final

RSL #71-3


(6b) 25 Bit Counter
t1
t2
t3
t4
t5
t6
t7
t8
t9
t10
t11
t12
t13
C2-24 (clock)
C3-19 (preset)
K2
K3
PN-335
FA-320
Lu: Phase IV(B) Final
RSL # 71-3

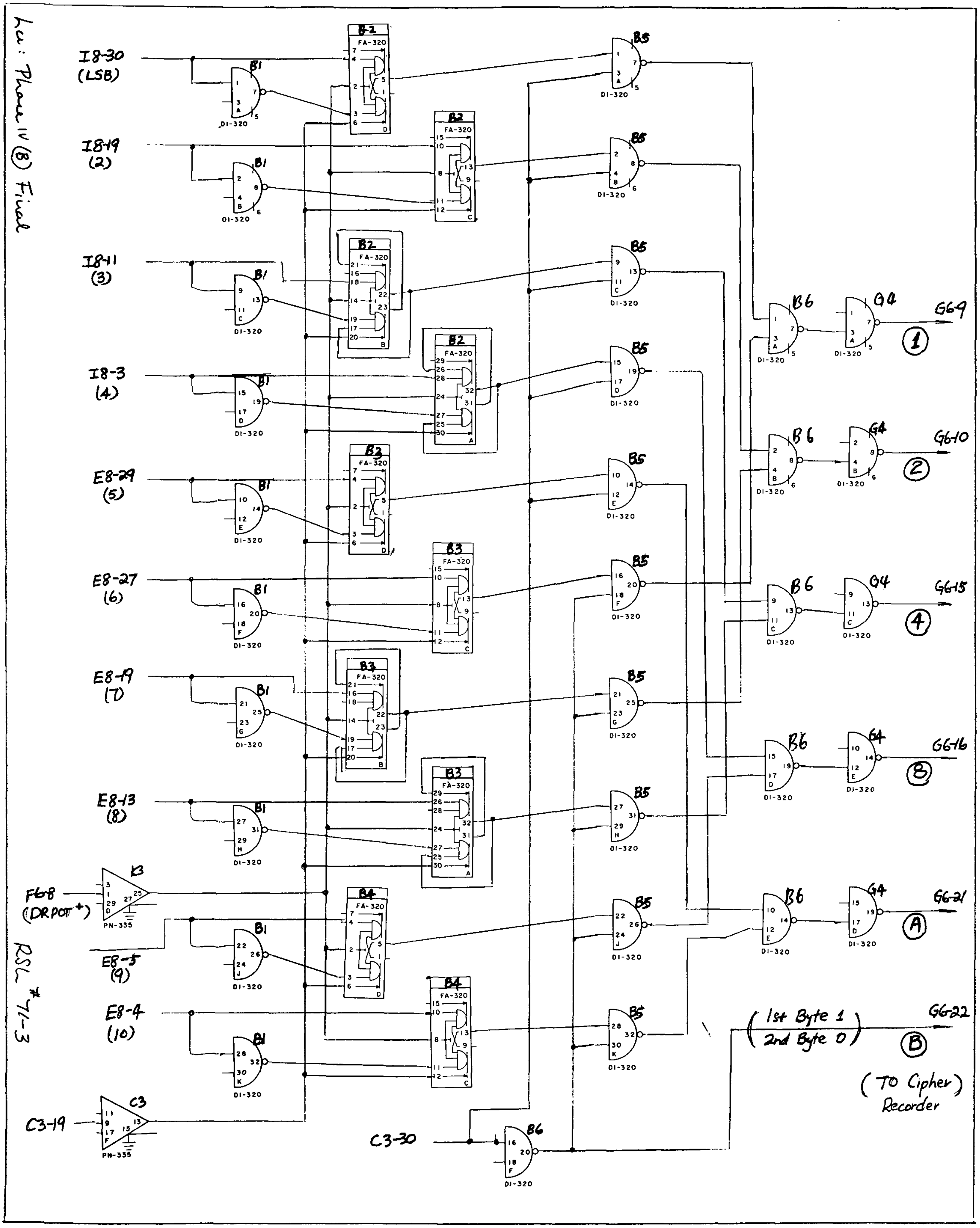
Lu: Phase IV (8) Final

(7) Scan Counter

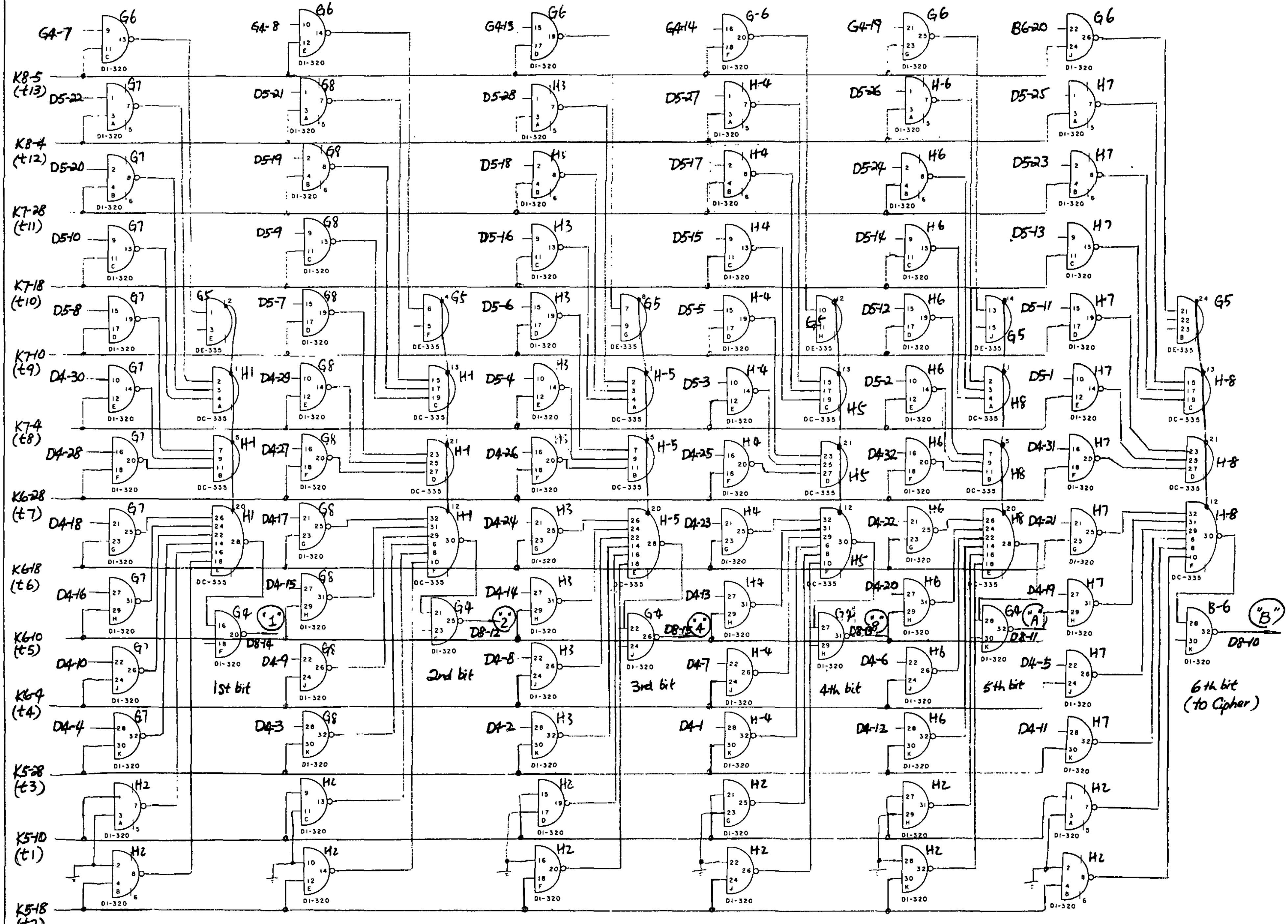


(7) Scan Counter

RSL #71-3



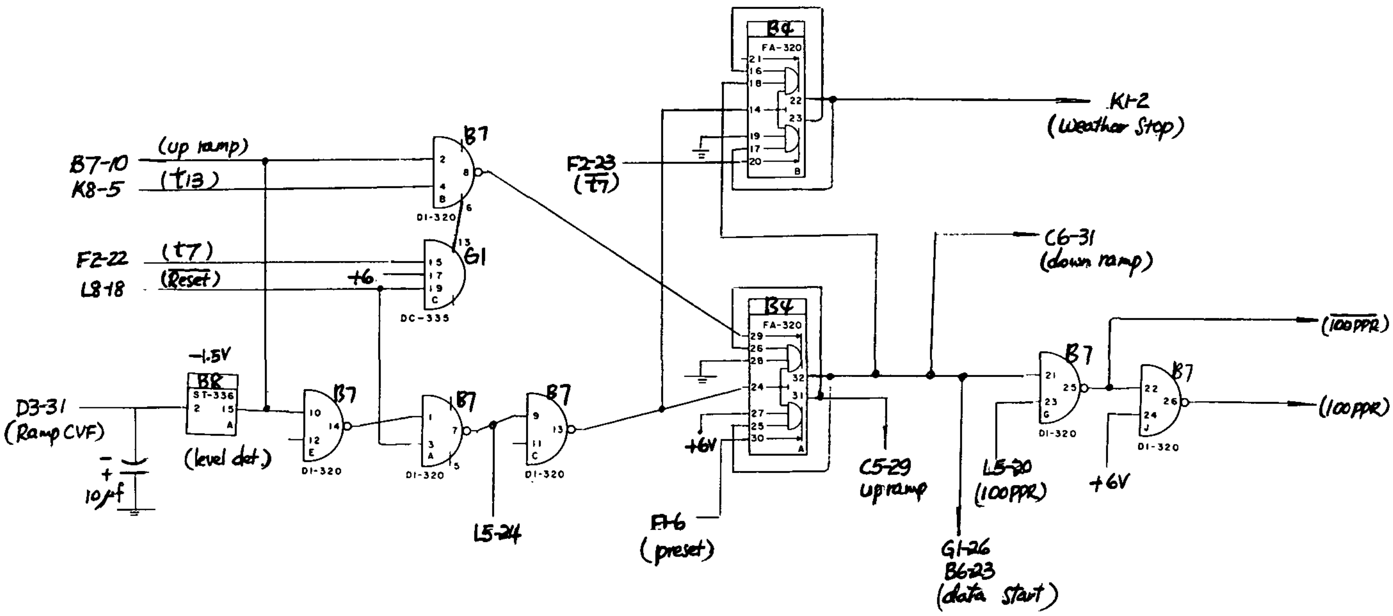
(8) 10 Bit Holding Register



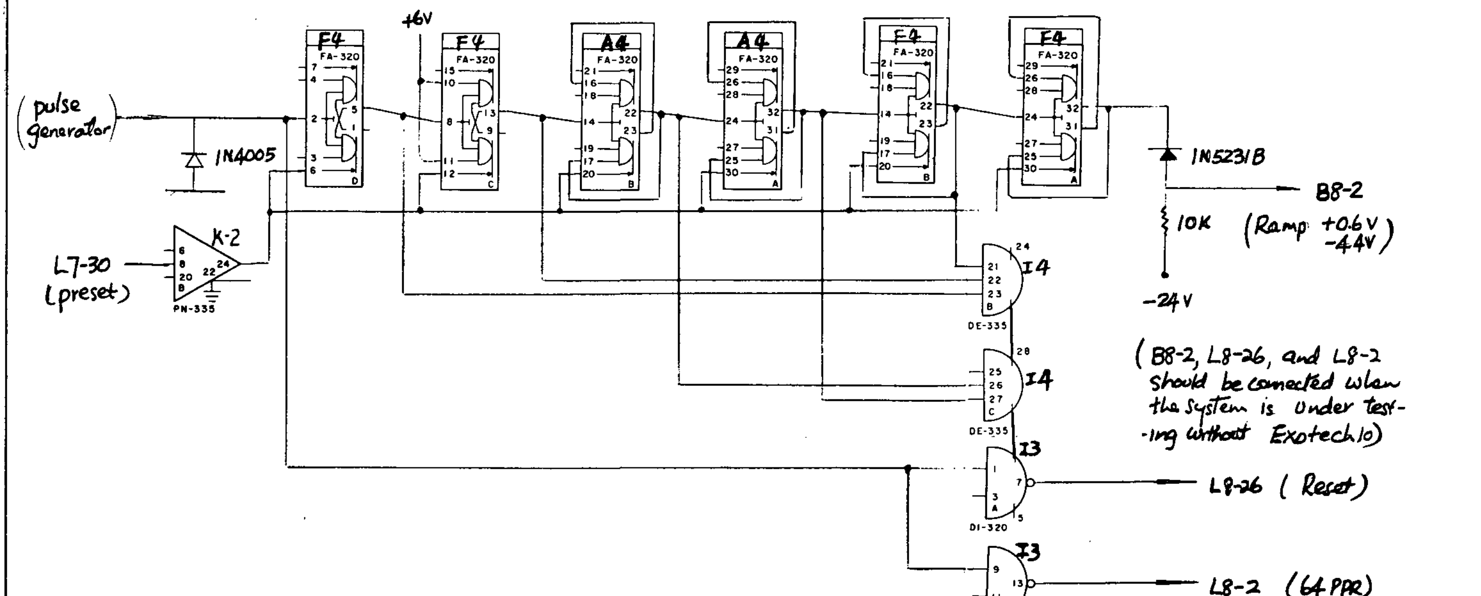
(11) DATA Matrix

Lu: Phase IV(B) Final

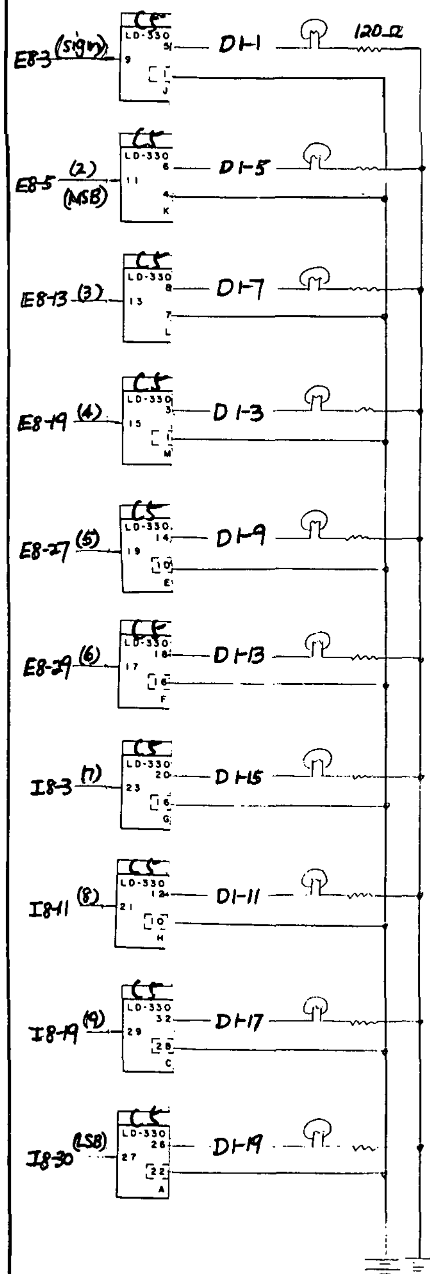
RSL # 71-3



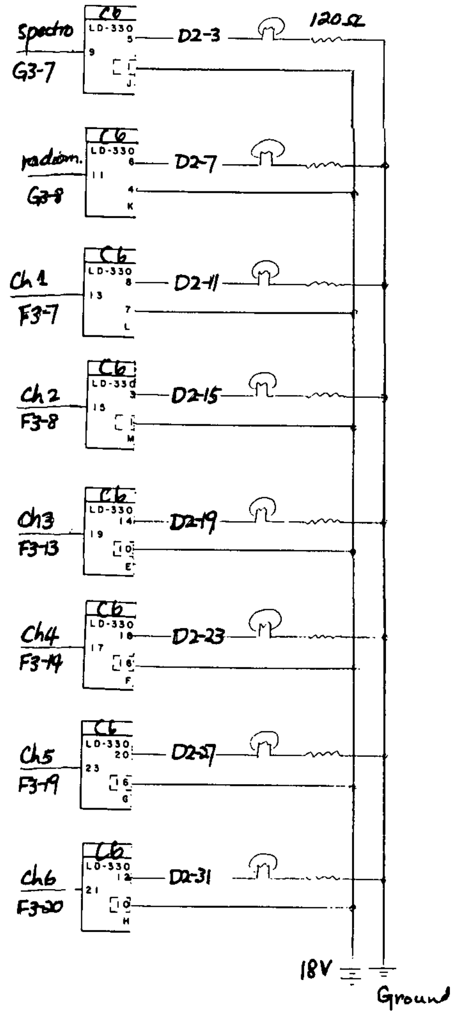
(9) Main Control (start / stop)



(10) 64 PPR and Reset Pulses Generator

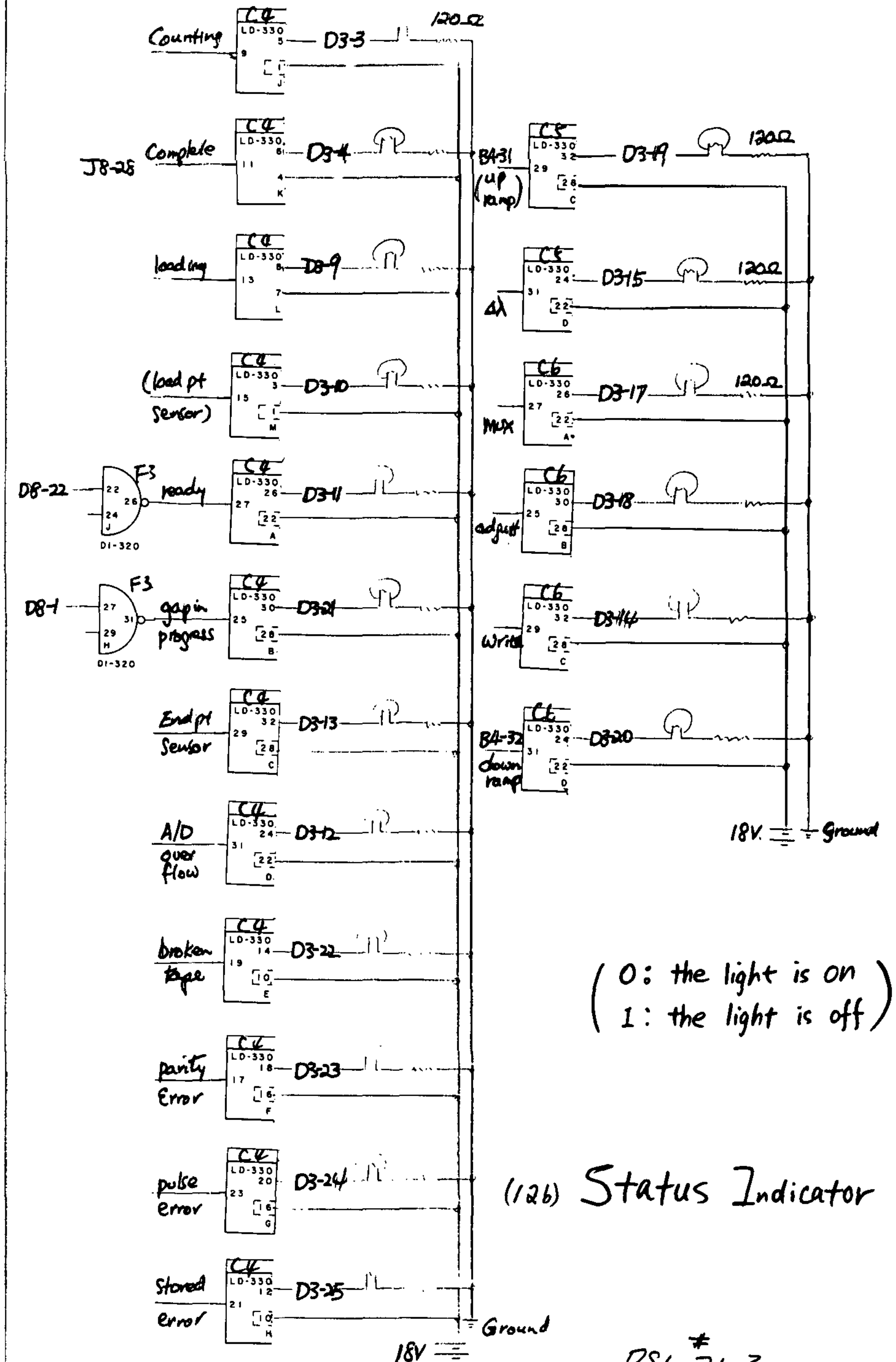


10 Bits Indicator



(12a) Mux. Indicator

(0 : the light is on
1 : the light is off)



(0: the light is on
1: the light is off)

(12b) Status Indicator

Lu: Phase IV(B) Final

RSL # 71-3