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TECHNICAL REPORT

75-45-AMEL

DATA RETRIEVAL AND PROCESSING SYSTEM
A USER'S GUIDE

by

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Hamilton Standard
Division of United Aircraft

Contract No. DA-19-129-AMC-603 (N)

January 1975

UNITED STATES ARMY
NATICK LABORATORIES
Natick, Massachusetts 01760

Aero-Mechanical Engineering Lab

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SECURITY CLASSIFICATION OF THIS PAGE *(When Data Entered)*

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER 75-45-AMEL	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE *(and Subtitle)* Data Retrieval and Processing System - A User's Guide		5. TYPE OF REPORT & PERIOD COVERED Final 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) J. P. Ahladas		8. CONTRACT OR GRANT NUMBER(s) DA-19-129-AMC-603(N)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Hamilton Standard Division of United Aircraft Windsor Locks, Connecticut		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 1J662708D552
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Natick Laboratories Natick, Mass. 01760		12. REPORT DATE January 1975 13. NUMBER OF PAGES 42
14. MONITORING AGENCY NAME & ADDRESS*(if different from Controlling Office)*		15. SECURITY CLASS. *(of this report)* UNCLASSIFIED 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT *(of this Report)*

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT *(of the abstract entered in Block 20, if different from Report)*

18. SUPPLEMENTARY NOTES

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

Data Retrieval
Transportation Environment

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

This report defines the design of a specialized data retrieval system for logging analog data recorded on magnetic tape. It contains a description of the system, system interconnections, a list of equipment, and calibration and service procedures.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

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FOREWORD

The original work that resulted in the Data Retrieval and Processing System was conducted by the Hamilton Standard Division of United Aircraft under Contract No. DA-19-129-AMC-603(N), Project No. 1K643324D587. Project Officer and Alternate Project Officer for the U. S. Army Natick Laboratories were Mr. Matthew Venetos and Mr. Denis O'Sullivan, both formerly of the Engineering Sciences Division of the General Equipment and Packaging Laboratory.

Subsequent investigations and refinements, funded under Project No. 1J662708D552, were conducted by Mr. Clive Nickerson, Principal Investigator, formerly of the Engineering Sciences Division of the General Equipment and Packaging Laboratory.

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INTRODUCTION

This system is intended to reproduce data acquired by magnetic tape recorders installed in shipping containers. The parameters recorded are impact velocity, temperature, humidity, static force and dynamic load as a function of time.

Data is recorded in form of pulses whose amplitude and polarity is proportional to the parameter being measured.

Recordings are made with the tape in stationary position. The tape moves 1.6mm between data pulses.

Impact height is computed by the system from the three axis impact height components.

This data retrieval system accepts four parallel data channels which are recorded on magnetic tape. Three of these contain analog data and the fourth channel contains timing information. Each analog data point consists of either a positive leading and a negative lagging or a negative leading and a positive lagging pulse in which the peak magnitude is proportional to some physical quantity. The amplitude and polarity of the leading data pulse is recognized, measured and recorded by the system. A fourth analog data channel is generated in the system by combining the height vectors from the three height channels. At least one of the four input channels from the tape must contain information before the system will generate a read command. An uncertainty of pulse polarity and amplitude exists when first starting the system. Therefore, the first data point into the system from the tape after start-up is used to reset the system to its "ready" state and consequently is not recorded.

GENERAL DESCRIPTION

The system consists of a control panel, a tape playback unit, a programmer, an analog-to-digital converter, a high-speed electro-optical printer and power supply racks.

With the exception of the programmer and the control panel, all equipment was commercially available.

The programmer serves to interface and control the various equipment. Some special circuitry used in this unit for signal conditioning and control are built on plug-in boards similar to the purchased logic plug-in boards.

SPECIFICATIONS

1. Input voltage range to programmer $\pm$.0137 to $\pm$2V.

2. Tape playback speed 1-7/8 IPS (4.75cm/sec).

3. Logging Rate - 30 Lines/Sec./150 data channels/Sec. nominal - 100 Lines/Sec. maximum.

4. System accuracy $\pm$1% FS (excluding tape playback equipment).

5. Linearity $\pm$.1% FS best straight line.

6. Stability .05%/Day constant temp.
   .01%/^{o}C

7. Input power 105-135V, 10A at 60 HZ.

8. Number of input channels: 3 data channels plus time channel. A fourth data channel is generated internally by combining drop height vectors from the 3 input data channels.

In order that tape drop-out errors be reduced to a minimum, a high quality instrumentation tape should be used for recording the data.

THEORY OF OPERATION

For the discussion that follows refer to the system logical schematic 11-1-2505 and the timing diagram 11-1-2506 available in appendix.

A. POLARITY SENSE AND GATE GENERATION

Let it be assumed that the system is in the reset state, that a data point from channel 1 is entering into PB1A1 and that its leading pulse is positive. The pulse is amplified by the peak memory driver PB1A1 and applied simultaneously to the peak memories and the polarity sense zero crossing detectors. Operational trigger PB3A2 is biased to saturation by a negative bias potential, PB3A1 is biased to saturation by a positive bias. The positive incoming pulse will overcome the negative bias on PB3A2 and PB3A2 will switch states causing one shot PB24SS2 to generate a 5 microsecond pulse. This pulse is used for setting the positive peak memory store flip-flop, reset the system if this is the first data pulse entering the system after start-up, or initiate a print command through PB30SS2.

The positive pulse that triggered PB24SS2 is also applied to PB3A1, but since this operational trigger is already saturated by a positive forward bias it will have no effect on the output of this operational trigger.

The 5 microsecond pulse from PB24SS2 is applied simultaneously to PB27NAND2 and PB32ACOR1-4. Input 9 of PB27NAND2 is forward biased by PB23FF1. The incoming pulse to pin 8 of PB27NAND2 will pass through PB27NAND2; PB23FF2 will be set and the positive peak memory will be unclamped which allows the storage capacitors in the memory to charge the peak amplitude of the positive incoming pulse. A short time later the negative pulse of the data will trigger PB3A1 by overcoming its positive bias, PB3A1 will switch states and generate a 5 microsecond pulse via PB24SS1. This pulse, however, is ignored since PB27NAND1 in inhibited by PB23FF2 being in the set state. For a negative initial pulse PB23FF1 would be set first and would inhibit PB27NAND-2 and the positive peak memory.

B. INITIAL SYSTEM RESET

The system becomes operational when SW3 is actuated. SW3B opens to forward bias PB20NAND5 to permit control gates to initiate printing action, and SW3A closes to discharge C1. When C1 discharges, a pulse is generated that resets PB26FF3 and triggers PB51SS3 to generate a 15 microsecond reset pulse that is applied to all flip-flops and the printer. This pulse closes the peak memory clear gates and resets them to zero. It resets the sequencing flip-flops in the multiplexer so that switch Ch1 is closed and it resets the printer to column number 1. The first pulse from PB32ACOR1-4 will set PB26FF3 and trigger PB30SS2. In setting, PB26FF3 will trigger PB30SS1. A 10 millisecond pulse

is applied to pin 6 of PB20NAND5 from PB30SS1, via PB31IA1. The 10 millisecond pulse inhibits PB20NAND5; hence the first initial print command is inhibited. The lagging edge of the 10 millisecond pulse triggers PB51SS3 to generate a reset pulse for resetting the peak memories that may have been charged up by the first data pulse.

C. PRINT CYCLE

Subsequent pulses coming from PB32ACOR1-4 will not affect PB26FF3, but these pulses will trigger 2 millisecond time delay PB30SS2. The function of this time delay is twofold. First, it gives sufficient delay for the counter to register the timing pulse and second, it gives the peak memory sufficient time to charge to the peak value in the event of tape head misalignment.

At the end of the two-millisecond delay PB30SS3 is triggered and generates a 5 microsecond pulse which resets and sets PB26FF4. In setting, PB26FF4 triggers PB51SS2 via PB45DCOR5, PB31IA3 and PB51SS1. The output of PB51SS2 is the print command to the printer. Upon receipt of the initial print command, the printer prints column No. 1 which is the thousands digit for the time. It is obvious that more than one pulse can come from PB32ACOR1-4 in any given print cycle. But only the first pulse initiates the print cycle because once PB26FF4 sets, additional pulses to its set input have no effect on its state.

When the printer is reset, it moves to column No. 1, PB33AND1 is activated, and it in turn activates gates PB46AND5 through PB46AND8 to couple the binary bits of the thousand digits on the time counter to the printer via DCOR gates PB42DCOR2 through PB45DCOR2. After printing the thousand digits in column No. 1, the printer will move to column No. 2; in doing so PB33AND1 will be inhibited and PB33AND2 will be activated. Gates PB46AND5 through 8 will be inhibited and gates PB46AND1 through 4 will be activated and binary information of the 100 units of the time counter is coupled to the printer. On activation, PB33AND2 will also trigger 10 microsecond delay PB51SS1; after 10 microseconds PB51SS2 is triggered which in turn generates a print command, so that binary information on column No. 2 is printed. The 10 microsecond delay of the print command is necessary to allow binary information coupled to the printer to reach steady state. Upon printing of column No. 2, columns No. 3 and 4 (10's and units) will be printed in similar manner. After column No. 4 has been printed, PB33AND4 is inhibited, and PB34AND1 is activated. A digitize command is now applied to the ADC converter through PB45DCOR. Upon receipt of this command, the ADC will digitize the data of channel No. 1. After completion of the digitization cycle, the ADC delivers a "space" command to the printer. The printer leaves a blank on column 5 and moves to column 6. Gate PB34AND2 will now be activated which in turn will activate gates PB45AND1 through 4 to couple to the printer binary information representing polarity sign of the first channel. The 10 microsecond print command delay is also

triggered so that at the end of 10 microseconds the printer will print either a blank indicating a positive quantity or a minus sign for a negative quantity on channel No. 1. At the same instant the sign polarity gates PB40AND1 are activated, PB19FF1 is pulsed causing the sequencing flip-flops to open channel 1, the system will proceed to print the 100's, 10's and units on the ADC in a similar manner as for the time counter. On columns No. 10, 15 and 20, the ADC will receive a command to digitize and on columns 11 and 16 the sequencer will receive a command to step to channels 3 and 4 respectively.

If height data is not required, SW2 is set to the four channel mode. When the printer reaches column No. 20, the output of PB38AND4 is coupled to the reset line through PB42DCOR5, PB31IA2, and PB57DR2. The system now is reset; that is, the peak memories are discharged (set to zero); the multiplexer is set to channel 1; PB26FF4 sets to await the next initial print command, and the printer resets to a new line and column No. 1.

When height computation data is required, the system will print 5 channels of information, and system reset will occur when the printer reaches column 24.

The column decoder gates, PB33AND1 through PB39AND4, provide a digital feedback loop with positive control on the entire system. The entire system is reset for each line of recorded data and cannot remain out of synchronization for more than one line of printout.

DESCRIPTION OF EQUIPMENT

The Monroe MC400N optical printer is capable of printing up to 100 lines per second. It accepts four parallel bit characters serially with -12 volt true logic and 0V false logic. Printing is done on Kodak Linagraph Direct Print oscillograph paper, type 1855, Spec. 111.

The analog-to-digital convertor (ADC) is a Beckman Model 4040A which accepts 10 volts full scale input with a 1.33K per volt input impedance and has an 8-4-2-1 binary coded three-digit decimal output (13 binary digits including the sign). The output of this unit is also -12 volt true and 0 volt false. The maximum time per conversion is 51 microseconds.

Temperature and humidity plotter outputs are provided for graphically recording the history of a package over the time of shipment or storage. A Honeywell Electro Instruments Model 400 plotter is used with vertical differential amplifier (maximum sensitivity: 1 mv/inch) and time base (0.02 to 2 inches/sec.) plug-ins. Response of this unit is 3 db down at 5 Hz. Plots are made on 11 x 17 inch graph paper.

A description of the programmer and its function for system control and interfacing of equipment is given in the "Theory of Operation" section. For more detailed information on the other units, the manufacturers' manuals should be consulted.

DESCRIPTION OF PLUG-IN MODULES

A description and function of the analog modules and multiplex switch is given in this manual. Plug-in digital modules are described in the manufacturer's module manual which should be referenced whenever information is required on the digital modules. These modules are generally of the DTL type, using discrete components and -12 volt true and 0 volt false logic levels.

CONTROL PANEL - 11-1-2518

As the name implies, this unit provides the necessary controls for turning the power on and off, selecting the mode of operation, starting and stopping the system, and selecting the desired channel for monitoring on the scope.

On depressing the log/standby switch for the logging operation, the unit first starts the tape transport. After full speed is reached by the tape transport the unit resets the system and activates NAND gate PB20NAND5 in the programmer to allow logging operation. On setting the system on "standby", the print control gates are first deactivated, then the tape transport is turned off. This procedure avoids erroneous printouts of data.

Control of the system is accomplished as follows:

When SW1 is pressed to the "log" position, C1 charges through SW1A CR1 and R2 and K1 energizes. SW1C closes and the contacts of K1 open to turn on the tape transport. C2 also charges, but at much lower rate, through R1 and CR2. After about one second delay, the voltage across C2 overcomes the zener voltage of CR3, and K2 is energized. K2 energizes mercury relay K3. When K3 is energized, pin No. 5 swings to -12V to activate the print control gate PB20NAND5 in the programmer. Pin No. 3 is shorted to ground. C3 delivers a positive pulse to the programmer for resetting the system.

When SW1 is set to the standby position, K3 de-energizes. PB20NAND5 in the programmer is inhibited, thus preventing initial print commands from reaching the printer. The charge on C1 prevents K1 from de-energizing until a few milliseconds later. This guarantees that the tape transport is always at full speed while the system performs the logging operation. Mode control is accomplished through SW2A and SW2B by connecting the reset gate to the proper column on the column decoder gate. Deck SW2C switches the correct scaling factor the output amplifier, thus minimizing calibration time when switching tapes.

The lines of SW4 terminate to the output of the tape preamplifier. The arms of SW4 terminate to the oscilloscope, thus permitting channel monitoring.

SW3 is the time override switch. If it is necessary to stop the logger and restart it on the same tape, SW3 is set to "off" position. This will prevent the time counter from resetting to zero when restarting the logger.

PEAK MEMORY DRIVER - 11-1-2508

This unit amplifies the incoming signal and has enough drive capability to rapidly charge the peak memories without overloading. It also drives the zero crossing detectors.

It consists of an operational differential amplifier A1 whose gain is fixed by R1 and R2. The gain of this amplifier is equal to (R1 + R2)/R1. A 1.5-volt signal to the input will give a full scale reading on any scale. The three boards this unit drives must be D.C. isolated from each other. Capacitors C1 to C3 are used to provide this isolation.

PEAK MEMORIES - 11-1-2515

This circuit is used for storing the data pulse amplitude until logging is completed.

The peak memories consist of rectifier diodes for polarity sensing, integrated chopper for clamping and an operational voltage follower. The rectifiers CR5 and CR6 are forward biased with approximately 0.4VDC to

overcome the diodes forward barrier voltage. This bias is obtained from the 15 ± volt supplies and is developed across CR2 and CR4. The change in the voltage drop across CR2 and CR4 with temperature, temperature compensates the rectifiers.

Assuming a positive leading data pulse, the bases of Q1 and Q3 will be driven positive. This will cut off Q1 and Q3 and allow the peak memory capacitors C1 and C2 to charge to the peak value of the incoming pulse. One half of the amplitude is applied to the operational voltage follower. The output of this unit is the data signal applied to the ADC via the output amplifier.

For a negative leading data pulse, the negative switches Q2 and Q4 open to allow C3 and C4 to charge.

At the end of the logging cycle the bases of Q1 and Q3 are driven positive. Q1 and Q3 conduct to discharge the peak memory capacitors C1 and C2. The function of Q3 and Q4 is to prevent the operational followers A1 and A2 from drifting due to leakage currents that can flow into C1 and C3 from A1 and A2 respectively.

Resistors R6, R7, R11 and R15 serve to limit the discharge currents from the peak memory capacitors into the integrated choppers. R5 and R14 limit the charging current that can flow from the peak memory driver.

The peak memories are capacitively coupled to the peak memory driver. The coupling capacitors accumulate a small charge during the leading data pulse. R1 CR1 and R9 CR3 act to remove this charge during the lagging data pulse period.

The peak memory is adjusted for zero output with zero input as follows:

Apply power and let stand 1/2 hour. Remove the tape that may be on the tape deck and depress the "Log" switch. Adjust R8 and R16 for zero output at TP1 and TP2.

ZERO CROSSING DETECTORS - 11-1-2510

These units sense the polarity of the incoming pulse and perform a switching function when the incoming pulse exceeds 0.137 volts. The output pulse from these units is used for opening the peak memories and to initiate a readout cycle.

Each unit consists of two high-speed, high-gain differential amplifiers in a positive feedback loop. The output of these amplifiers switches rapidly from plus to minus or from minus to plus when the input exceeds a certain threshold.

The threshold voltages of 0.137 volts are obtained from the ±15 V supplies and voltage dividers R1, R2, R3 and R4.

A1 is biased with 0.137 V from the junction of R1 and R2. Positive feedback is applied to this unit from the junction of R10 and R11. With zero input to pin No. 8, the output of A1 is at the -11 to -14 volt level. When a negative input voltage to pin No. 8 exceeds the positive threshold voltage of 0.137 by about 10 MV, the output of A1 switches from minus to plus 11 to 14 volts.

A2 is biased with a negative bias of 0.137 V. Its output with zero input is +11 to +14 V. When the input to pin 8 is greater than 0.137 volts, A2 switches from plus to minus 11 to 14 V. An inverter consisting of Q1, CR5, R16, R17 and R15 follows A2. It is necessary to invert the pulse from A2 since the logical circuitry following these units responds to positive going pulses.

CR1 through CR4 prevent damage to the amplifier through excessive input voltages.

This unit is initially adjusted as follows:

With power applied, the plus and minus inputs of each amplifier are shorted to the common. R9 and R8 are then adjusted until the output of each amplifier is zero, as measured at TP1 and TP2.

OUTPUT AMPLIFIER - 11-1-2512

This unit combines the negative or positive data input from the peak memories and provides the necessary scaling of voltages for readout in engineering units by the ADC.

The input data voltage is divided by R1, R2 and R4 and is reamplified by A1 to the proper level. The correct scale factor is selected by energizing one of the three relays. This connects the feedback resistors around the amplifier for proper scaling.

The gain of the amplifier at either input while the other is shorted is given by

$$A = \left(\frac{R5 + Rf}{R5}\right)\left(\frac{R4}{R_{in} + R4}\right)$$

Where Rf is the feedback resistance, R6 + R7, for example. When K2 is energized, the amplifier is scaled to read temperature in degrees F.

With zero input the amplifier output is -.5 V representing -50°F. The transfer function of the amplifier under the "temperature" mode is given by

$$E_o = .25\ (Ei - 2.0)$$

The 2.0 V offset is provided by the R12 - R13 divider. Negative tem-

peratures from -50°F through -1°F will print out 950 through 999. Subtract print-out from 1,000 to determine the correct value in this range.

These units are initially adjusted as follows: Pins 8 and 10 are shorted to common. R3 is then adjusted for zero output on pin 16.

An adjustable zero offset is provided in the drop height playback mode to compensate for any apparent negative offset caused by the non-linearity on the lower part of the drop height-playback voltage.

Adjustment procedure is as follows:

1. Graphical determination of intercept of drop height-playback voltage curve by extension of linear portion of the curve through the zero drop height line.

2. Computation of equivalent print-out from the intercept value. Print-out = 320 x Intercept (volts).

3. Setting of the extra potentiometer (mounted on an operational amplifier) on PB9 so that with zero input into PB4, PB9 and PB14, the print-out in channels 1, 2 and 3 agrees with the determined print-out.

For calibration of these units refer to the calibration procedure.

MULTIPLEX SWITCH - 11-1-2517

This unit sequentially connects the four data channels to the ADC for digitalization.

The inputs from the sequence NAND gates are fed to the integrated chopper bases. The logical connection to the sequence NAND gates are such that only one integrated chopper is forward biased at any one time. When the system is in reset state, Q1 is forward biased with the remaining integrated choppers off.

The conducting chopper has an "on" resistance of about 10 ohms with a typical offset voltage between E1 and E2 of less than 5 MV. The "off" resistance of these units is greater than 500 megohms.

PEAK MEMORY SWITCH DRIVER - 11-1-2514

This circuit converts the memory set flip-flop voltage levels to those required for driving the integrated chopper clamp.

When Q1 and Q2 are off, their collector voltage swings to the +24 V supply, opening the integrated choppers in the peak memory.

The drivers are cut off when the input to the bases is between -9 to -12. They become saturated when the input to their bases is

at ground potential. When the drivers are driven to saturation, their collectors swing toward -9 V DC. This forward biases the integrated choppers in the peak memories and prevents the memory capacitors from charging.

Three similar units are built on a single plug-in board.

ARBITRARY FUNCTION CIRCUIT - 11-1-2511

This circuit has an adjustable transfer characteristic consisting of eleven straight-line segments whose slopes are set by potentiometric screwdriver adjustments on a Philbrick/Nexus SPFX-P arbitrary function transconductor module. The initial slope is fixed at 45° by a 20K resistor across pins 9 and 10 of the SPFX-P module. A differential subtractor amplifier (PBX01) is used to allow arbitrary conditioning of both positive and negative outputs of memory, and an additional inverting amplifier (PBX02) follows the module to allow both positive and negative changes in slope.

These features are incorporated into the read-out unit to allow compensation for non-linear playback behavior. Setting of the arbitrary function so that it is the inverse of the input function serves to linearize the overall characteristic.

The initial slope interval is between 0.0 and +0.5 volts input. Subsequent segments are in 1-volt input increments up to 9.5 volts. The final segment is from +9.5 volt to +10 volt input. The largest incremental slope change allowed is 0.4V/V.

The procedure for use of this circuit follows:

1. Draw the inverse of the function to be fitted.

2. Determine the incremental slope changes necessary to obtain the inverse.

3. Using the test card in place of the peak memory board in the channel to be adjusted, feed in a low frequency sine wave of 8 volts peak amplitude into the memory No. 1 terminal while grounding memory No. 2 terminal on test card.

4. Monitor input (sine wave) and output of arbitrary function circuit at test point on PB5, PB10 or PB15 using an X-Y oscilloscope display.

5. Adjust SPFX-P module by setting potentiometers 1 through 8 in order, so that the incremental slopes on the X-Y display agree with those determined for the function inverse.

SUMMING AMPLIFIER - 11-1-2509

This unit sums and scales height inputs. It performs the mathematical operation of

$$Vo = A\ (V11 + V22 + V33)$$

Where V11, V22 and V33 are the voltages from the arbitrary function circuits, the output of this amplifier is then analog to

$$h = \frac{V_1^2 + V_2^2 + V_3^2}{2g} = h_x + h_y + h_z$$

The gain of this stage is given by

$$A = \frac{R6 + R7 + R4}{R4}$$

This unit is initially adjusted as follows: Pins 8, 9 and 10 are shorted to the common, and R5 is adjusted for zero output at TP1. When shorting pins 8, 9 and 10 to common, be sure the arbitrary function circuits are removed or disconnected from these pins.

COLUMN GATE DRIVER - 11-1-2507

This circuit is used to increase the driving capability of the printer column decoder lines.

The driver is a Darlington, complementary push-pull emitter follower capable of driving 90 AND gates. CR1 and CR2 provide a slight forward bias to the drivers, Q2 and Q3, to increase the unit's speed of response. In the event the drop across the biasing diodes is high compared to the forward base drop of Q1 and Q2, R4 limits the collector current of Q1 and Q2 from becoming high while the driver is in its quiescent state. R1 limits the power dissipation and collector current of Q2. The voltage gain of this circuit is between 0.85 and 0.95 with 0 to -10 V at the base of Q1 and a 120 ohm load at the output.

CALIBRATION PROCEDURE

After a half-hour warmup period the read-out unit should be calibrated according to the following procedure:

1. Zero amplifiers in the following sequence with the inputs to channels 1, 2 and 3 all shorted to ground.

a. Input amplifiers (PB1, PB6, PB11)
b. Memories (PB2, PB7, PB12)
c. PBX01 outputs (use test card)
d. PBX02 outputs (use test card)
e. Arbitrary function output (PB5, PB10, PB15)
f. Output amplifiers (PB4, PB9, PB14) (Set to load mode and use test card.)
g. Summing amplifier (PB16) (Set to load mode.)

2. Check and adjust the arbitrary functions using a sine wave input into the test card for linear transfer characteristics or adjust to the desired non-linear characteristics.

3. Check and adjust the offset for zero in the drop height mode or adjust to desired offset.

4. Set the mode switch to drop height and feed in a 1.5 volt, 400 microsecond, 30pps pulse train into channel number 1 while other channels are shorted.

5. Adjust the output amplifier (PB4) drop hight potentiometer and the summing amplifier (PB16) potentiometer for pint-outs of 480.

6. Repeat 1. through 5. for channel 2 (PB9) and channel 3 (PB14).

7. Switch to the temperature/humidity mode.

8. Feed the above signal into channel 1 and adjust the output amplifier (PB4) temperature potentiometer for print-out of 150.

9. Feed into channel 2 and adjust for a print-out of 100.

10. Feed into channel 3 and adjust for a print-out of 600.

Before each use of the read-out unit to retrieve drop height or temperature/humidity static load information, the playback tape deck output amplifiers should be adjusted to yield 1.5 volts out for the following recorded information that is applicable:

Drop Height	48 inches (122cm)
Temperature	150°F (65.6°C)
Humidity	100%
Static Load	6,000 pounds (2,718 Kg)

OPERATING INSTRUCTIONS

1. Turn on power on all equipment and allow 1/2-hour warmup on standby mode.

2. Place data tape on tape deck.

3. Place all tape deck push button controls on their "off" position.

4. Select the mode of operation to correspond to the data tape with the mode selector switch on the control panel.

5. Depress the standby-log switch to the log position for commencing the logging operation.

6. The system will automatically cease logging when the tape reel is finished.

7. To stop the logging cycle, depress the standby-log switch to the standby position.

TROUBLE SHOOTING

Trouble shooting time can be shortened considerably if it is well understood how the system functions. Therefore, the system description and logical schematic should be carefully studied. Once the system is well understood, "effect-to-cause" reasoning and through waveform observation at various test points provided should quickly locate the defect.

The first steps in trouble shooting should be to check all power supply outputs. In many cases, a readjustment of power supply settings will correct the malfunction.

Because semiconductors are used exclusively, resistance measurements on a normal or defective circuit can exhibit a wide range of deviations, depending on the ohmmeter used, polarity connections, and the ambient temperature. Resistance measurements are not recommended. A good oscilloscope with 2 or more simultaneous traces is the most effective service tool for localizing the trouble.

The defective circuit or unit can be easily traced by referring to the timing waveform diagram drawing 11-1-2506 and 11-1-2516.

When trouble is located in one of the commercial units, the manufacturer's manual for that particular unit should be consulted.

It is recommended that the circuit used for calibrating the system be also used for trouble shooting. The normal waveforms at various test points specified on 11-1-2516 with the input data pulse on channel 1 are shown on this drawing.

If printing action stops after printing the time channel or at columns No. 5, 10, 15 and 20, the trouble is either with the column decoder or the ADC. If no readout occurs or the system stops at some other column, the trouble is either in the column decoder or the printer.

With a negative input data pulse, waveforms No. 1 and 2 on 11-1-2516 are reversed in polarity.

Waveform No. 2 appears on PB2TP2. Waveforms 3 through 6 appear on PB3TP1, PB24TP3, PB27TP6 and PB23TP4, respectively.

Waveforms 7 through 21 will appear at the same test points, regardless of the channel being tested or the polarity of the input data pulse.

The waveforms shown on timing diagram 11-1-2506 are essentially the waveforms that appear on the column decoder. Waveform No. 1, for example, should appear on PB33TP6. Waveform No. 5 appears on PB34TP1, PB37TP6, PB38TP4 and PB39TP4 with one pulse on each test point for every readout cycle.

The table which follows lists the programmer test points for waveforms 1 to 6 for checking out the three channels with negative and positive data pulses. All waveforms should have similar characteristics shown on 11-1-2516, except waveforms 1 and 2 should be reversed in polarity with negative input data pulses.

	Waveform No.					
Input Data Pulse	1	2	3	4	5	6
Ch. #1 Pos.	PB1TP1	PB2TP1	P33TP2	PB24TP2	PB27TP5	PB23TP3
Ch. #1 Neg.	PB1TP1	PB2TP2	PB3TP1	PB24TP3	PB27TP6	PB23TP4
Ch. #2 Pos.	PB6TP1	PB7TP1	PB8TP2	PB24TP1	PB27TP3	PB23TP1
Ch. #2 Neg.	PB6TP1	PB7TP2	PB8TP1	PB25TP3	PB27TP4	PB23TP2
Ch. #3 Pos.	PB11TP1	PB12TP1	PB13TP2	PB25TP1	PB27TP1	PB26TP3
Ch. #3 Neg.	PB11TP1	PB12TP2	PB13TP1	PB25TP2	PB27TP2	PB26TP4

DATA RECORDING AND PLAYBACK

It is recommended that the recording head gap be 0.001" (.025mm). A wider gap will cause cross talk between channels and partial erasure from data point to data point.

A smaller recording head gap will reduce the pulse width. This will require shorter peak memory responses, which could result in poorer noise rejection by the system and also increase tape dropout errors.

The reproduce heads should have a narrow gap for good high frequency response. The 4-channel standard playback heads as installed by Precision Instruments on their tape transport units are satisfactory in this respect.

LIST OF PLUG-IN MODULES REQUIRED FOR PROGRAMMER

Programmer cabinet is Raytheon MCR-75-500

Type	No. Required		Drawing or Manufacturer
GDG2-.2	10	Diode AND Gate	Raytheon
GDG3-.2	4	D.C. OR Gate	Raytheon
GFF1-.2	3	Flip-Flop	Raytheon
G1G1-.2*	2	A.C. OR Gate	Raytheon
GOS3-.2	4	One Shot	Raytheon
GNA1-.2	2	NAND Gate	Raytheon
GST2-.2	1	Schmitt Trigger	Raytheon
GDC1-.2	4	Decade Counter	Raytheon
GAI2-.2	1	Inverting Amplifier	Raytheon
GRG1-.2	1	Reset Gate	Raytheon
700125	3	Peak Memory Driver	Hamilton Standard
700131	1	Peak Memory Switch Driver	Hamilton Standard
700132	3	Peak Memory	Hamilton Standard
700127	3	Zero Crossing Detector	Hamilton Standard
700128	3	Arbitrary Circuit	Hamilton Standard
700126	3	Summing Amplifier	Hamilton Standard
700129	1	Output Amplifier	Hamilton Standard
700134	2	Multiplex Switch	Hamilton Standard
700124	4	Column Gate Driver	Hamilton Standard
700137	1	A.C. OR Gate	Hamilton Standard
700139	1	Low Pass Filter	Hamilton Standard

*One of these gates is modified per Drawing 11-1-2520.

LIST OF DRAWINGS AND MANUALS

Number	Title
11-1-2505	System Logical Schematic
11-1-2506	Timing Diagram
11-1-2507	Column Gate Driver PB48, PB49, PB50 and PB57
11-1-2508	Peak Memory Driver PB1, PB6 and PB11
11-1-2509	Summing Amplifier PB16
11-1-2510	Zero Crossing Detector & Gate Generator PB3, PB8 & PB13
11-1-2511	Arbitrary Function PB5, PB10 and PB15
11-1-2512	Output Amplifier PB4, PB9 and PB14
11-1-2513	Programmer Power Supply Connections
11-1-2514	Peak Memory Switch Driver PB28
11-1-2515	Peak Memory PB2, PB7 and PB12
11-1-2516	Trouble Shooting Timing Diagram
11-1-2517	Multiplex Switch PB17 and PB18
11-1-2518	Control Panel
11-1-2519	Programmer Wiring Diagram
11-1-2520	A.C. OR Negative Input PB32
11-1-2521	System Wiring Diagram
11-1-2522	Recorder Filter PB21
Model 404DA	ADC Manual, Beckman Instruments
Model 4000	Printer Manual, Monroe Data/Log.
Model PI6001	Tape Transport Manual, Precision Instruments
Model SPFX-P	Arbitrary Function Transconductor Philbrick/Nexus
LM	Power Supply-Series-Specifications, Lambda Electronics
CPM 3001	Modules Manual - Raytheon

APPENDIX

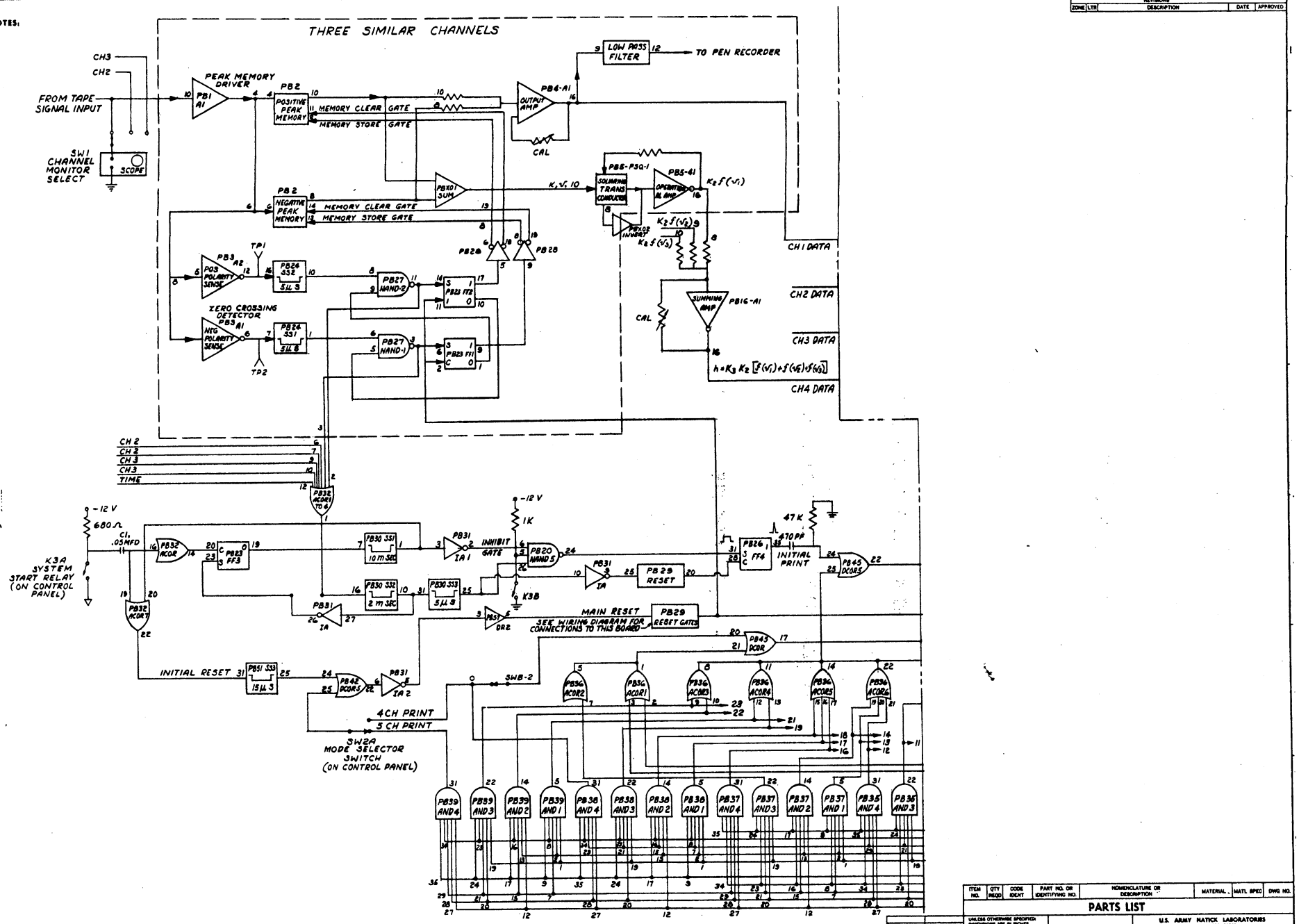
ELECTRICAL SCHEMATICS

US ARMY NATICK LABORATORIES DRAWINGS

11-1-2505 THROUGH 11-1-2522

NOTES:

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED



ITEM NO.	QTY REQD	CODE IDENT	PART NO. OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL	MATL SPEC	DWG NO.

PARTS LIST

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES WIRE AND METAL BASES EXCLUDED

TOLERANCES: FRACTIONS ± ANGLES ± 2 PLACE DIMS. ± 3 PLACE DIMS. ±

MATERIAL

NEXT ASSY | USED ON APPLICATION

DATE 20 OCT 74

PREPARED F. NILOS

CHECKED F.M.

ENGINEER J. Brunel

APPROVAL DESIGN ACTIVITY

APPROVAL OTHER

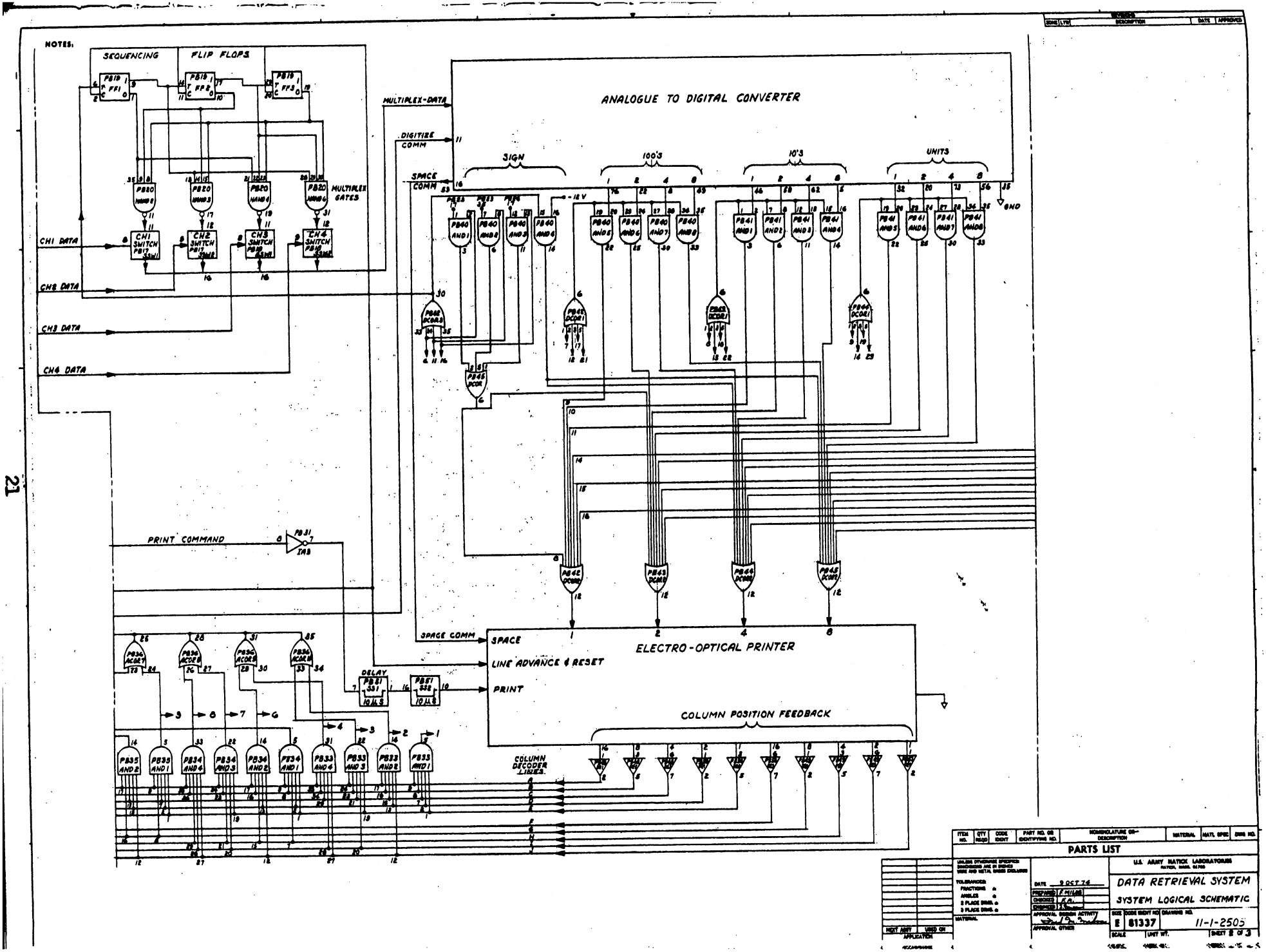
U.S. ARMY NATICK LABORATORIES
NATICK, MASS. 01760

DATA RETRIEVAL SYSTEM

SYSTEM LOGICAL SCHEMATIC

SIZE	CODE IDENT NO	DRAWING NO.
E	81337	11-1-2505

SCALE | UNIT WT. | SHEET 1 OF 3



ITEM NO.	QTY REQD	CODE IDENT	PART NO. OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL	MAT'L SPEC	DWG NO.

PARTS LIST

U.S. ARMY NATICK LABORATORIES
NATICK, MASS. 01760

DATA RETRIEVAL SYSTEM

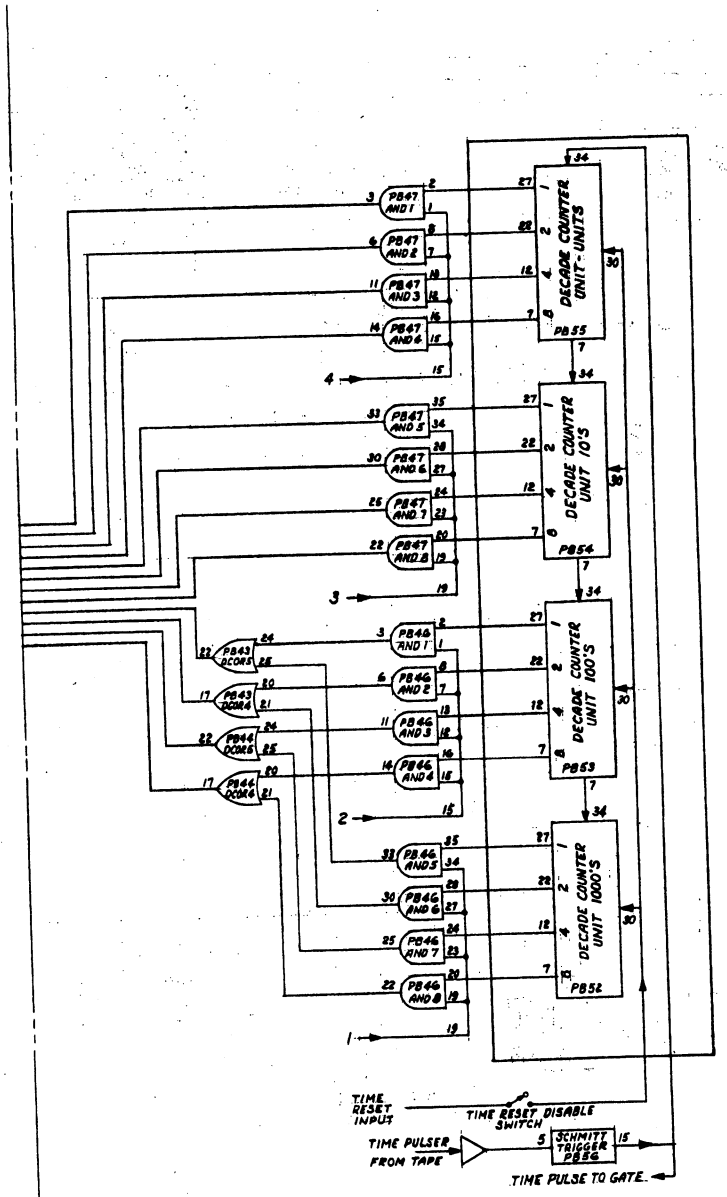
SYSTEM LOGICAL SCHEMATIC

DATE 9 OCT 74
PREPARED F MILLER
CHECKED R.A.
DISPROVED
APPROVAL SYSTEM ACTIVITY
APPROVAL OTHER

SIZE E | CODE IDENT NO. 81337 | DRAWING NO. 11-1-2505
SCALE | UNIT WT. | SHEET 8 OF 3

NEXT ASSY USED ON APPLICATION

NOTES:



ZONE	LTR	REVISIONS DESCRIPTION	DATE	APPROVED

ITEM NO.	QTY REQD	CODE IDENT	PART NO. OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL	MATL SPEC	DWG NO.

PARTS LIST

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. WIRE AND METAL GAGES EXCLUDED

TOLERANCES: FRACTIONS ± ANGLES ± 2 PLACE DIMS. ± 3 PLACE DIMS. ±

MATERIAL

DATE 9 OCT 74

PREPARED R.MILLER

CHECKED F.CAL

ENGINEER L.Bruno

APPROVAL, SENIOR ACTIVITY

APPROVAL, OTHERS

U.S. ARMY MATICK LABORATORIES NATICK, MASS. 01760

DATA RETRIEVAL SYSTEM

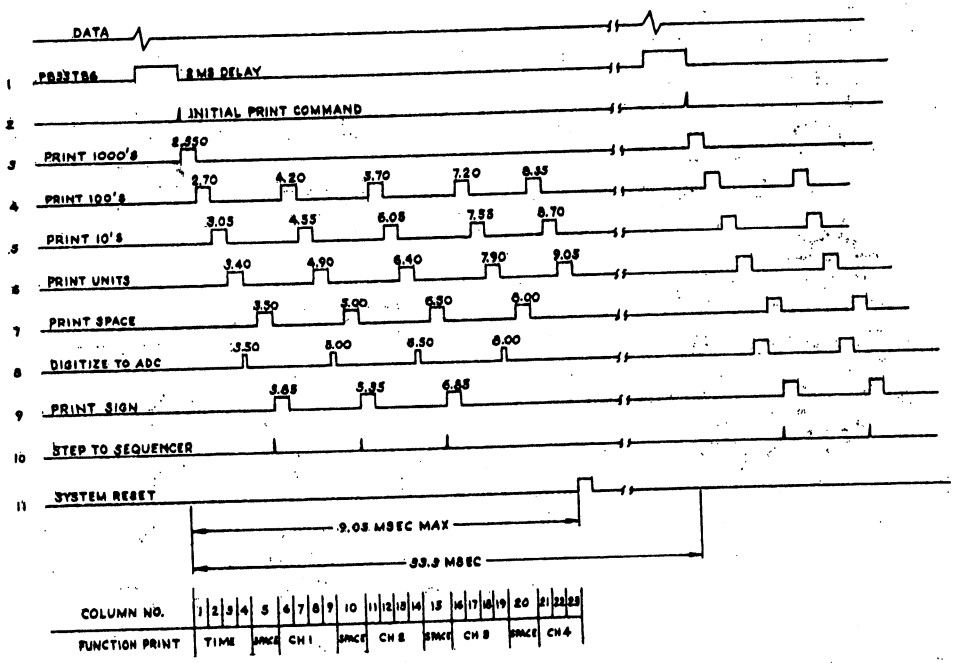
SYSTEM LOGICAL SCHEMATIC

SIZE B | CODE IDENT NO. 81337 | DRAWING NO. 11-1-2505

SCALE | SHEET NO. | REV

NOTES:

REVISIONS			
ZONE	LTR	DESCRIPTION	DATE	APPROVED



ITEM NO.	QTY REQD	CODE IDENT	PART NO. OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL	MATL SPEC	DWG NO.

PARTS LIST

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES WIRE AND METAL GAGES EXCLUDED

TOLERANCES: FRACTIONS ± ANGLES ± 2 PLACE DIMS. ± 3 PLACE DIMS. ±

MATERIAL

NEXT ASSY | USED ON APPLICATION

DATE 9 OCT 74

PREPARED [illegible]
CHECKED R.M.
ENGINEER [illegible]

APPROVAL DESIGN ACTIVITY [illegible]

APPROVAL OTHER

U.S. ARMY NATICK LABORATORIES
NATICK, MASS. 01760

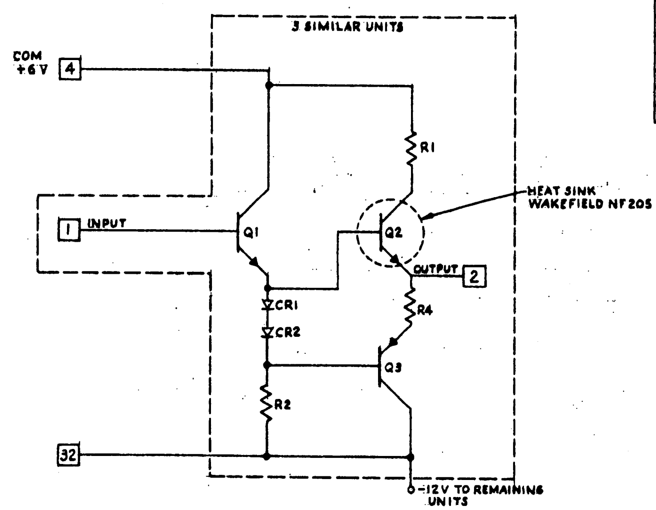
DATA RETRIEVAL SYSTEM

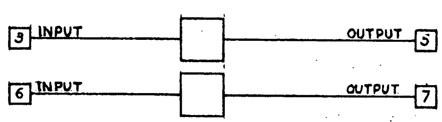
TIMING DIAGRAM

SIZE	CODE IDENT NO	DRAWING NO.
D	81337	11-1-2506

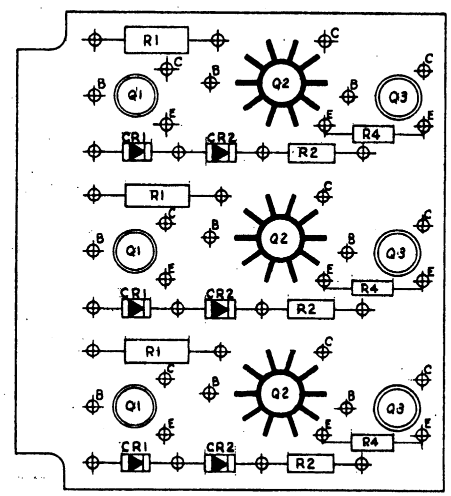
SCALE | UNIT WT. | SHEET OF

NOTES:





SYM	COMPONENT	VALUE	TOL
	HEAT SINK WAKEFIELD NF 204		
CR1	IN643A		
CR2	IN643A		
Q1	2N2219		
Q2	2N2219		
Q3	2N2905		
R1	RC32GF330J	33Ω	5%
R2	RC20GF821J	820Ω	5%
R4	RC20GF220J	22Ω	5%
PB1	RAYTHEON PLUG IN BOARD MB81		



REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED

ITEM NO.	QTY REQD	CODE IDENT	PART NO. OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL	MATL SPEC	DWG NO.

PARTS LIST

UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES WIRE AND METAL GAGES EXCLUDED

TOLERANCES:
FRACTIONS ±
ANGLES ±
2 PLACE DIMS. ±
3 PLACE DIMS. ±

MATERIAL

NEXT ASSY | USED ON
APPLICATION

DATE 9 OCT 74
PREPARED G.F.
CHECKED F.M.
ENGINEER
APPROVAL DESIGN ACTIVITY [signature]
APPROVAL OTHER

U.S. ARMY NATICK LABORATORIES
NATICK, MASS. 01760

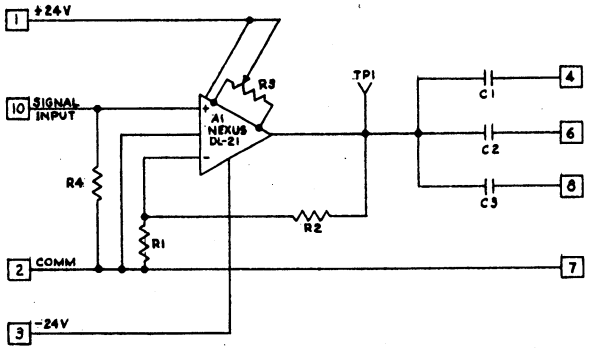
DATA RETRIEVAL SYSTEM
COLUMN GATE DRIVER
PB48, PB49, PB50, PB57

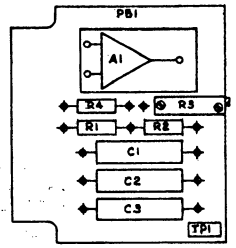
SIZE D | CODE IDENT NO 81337 | DRAWING NO. 11-1-2507

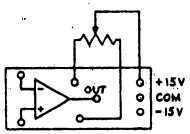
SCALE | UNIT WT. | SHEET OF

NOTES:

REVISIONS			
ZONE	LTR	DESCRIPTION	DATE	APPROVED







BOTTOM VIEW OF NEXUS AMPLIFIER

SYM	COMPONENT	VALUE	TOL
A1	NEXUS RESEARCH LABS DL-21		
C1	SPRAGUE 113D606C7030J1	60MFD	+75% -13%
C2	SPRAGUE 113D606C7030J1	60MFD	+75% -13%
C3	SPRAGUE 113D606C7030J1	60MFD	+75% -13%
R1	MEPCO RN65C1001F	1.0K	1%
R2	MEPCO RN65C9011F	9.01K	1%
R3	BOURNS 200L-2-104K	100K	10%
R4	RN65B5113F	511K	1%
TP1	UNICITE 119437 TEST JACK		
PB1	RAYTHEON PLUG IN BOARD M881		

ITEM NO.	QTY REQD	CODE IDENT	PART NO. OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL	MATL SPEC	DWG NO.

PARTS LIST

UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES. WIRE AND METAL GAGES EXCLUDED

TOLERANCES: FRACTIONS ± ANGLES ± 2 PLACE DMNS. ± 3 PLACE DMNS. ±

MATERIAL

NEXT ASSY | USED ON

APPLICATION

DATE 9 OCT 74

PREPARED GRN/mw

CHECKED F.M.

ENGINEER

APPROVAL DESIGN ACTIVITY

APPROVAL OTHER

U.S. ARMY NATICK LABORATORIES
NATICK, MASS. 01760

DATA RETRIEVAL SYSTEM
PEAK MEMORY DRIVER
PB1, PB6 & PB11

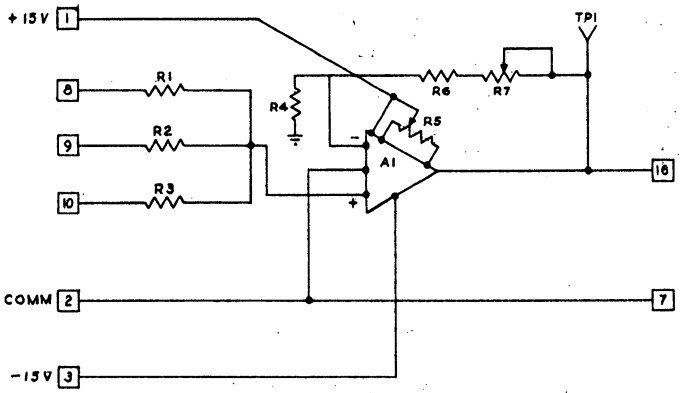
SIZE D | CODE IDENT NO 81337 | DRAWING NO. 11-1-2508

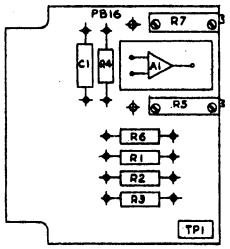
SCALE | UNIT WT. | SHEET OF

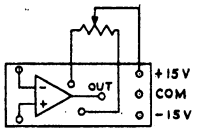
NOTES:

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED

SYM	COMPONENT	VALUE	TOL
A1	NEXUS RESEARCH LAB CDA-12A		
C1	SPRAGE 118P1039282	.01MF	10%
R1	MEPCO RN65C2002C	20K	.25%
R2	MEPCO RN65C2002C	20K	.25%
R3	MEPCO RN65C2002C	20K	.25%
R4	MEPCO RN65B6811F	6.81K	1%
R5	BOURNS 200L-2-104	100K	10%
R6	MEPCO RN65C1001F	10K	1%
R7	BOURNS 200L-2-103	10K	10%
PB1	RATHEON PLUG IN BOARD MBB1		
TP1	UCINITE TEST JACK 119437		







BOTTOM VIEW OF
NEXUS AMPLIFIER

ITEM NO.	QTY REQD	CODE IDENT	PART NO. OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL	MATL SPEC	DWG NO.

PARTS LIST

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
WIRE AND METAL GAGES EXCLUDED

TOLERANCES:
FRACTIONS ±
ANGLES ±
2 PLACE DIMS. ±
3 PLACE DIMS. ±

MATERIAL

NEXT ASSY | USED ON
APPLICATION

DATE 9 OCT 74
PREPARED G. Ritchie
CHECKED R.M.
ENGINEER

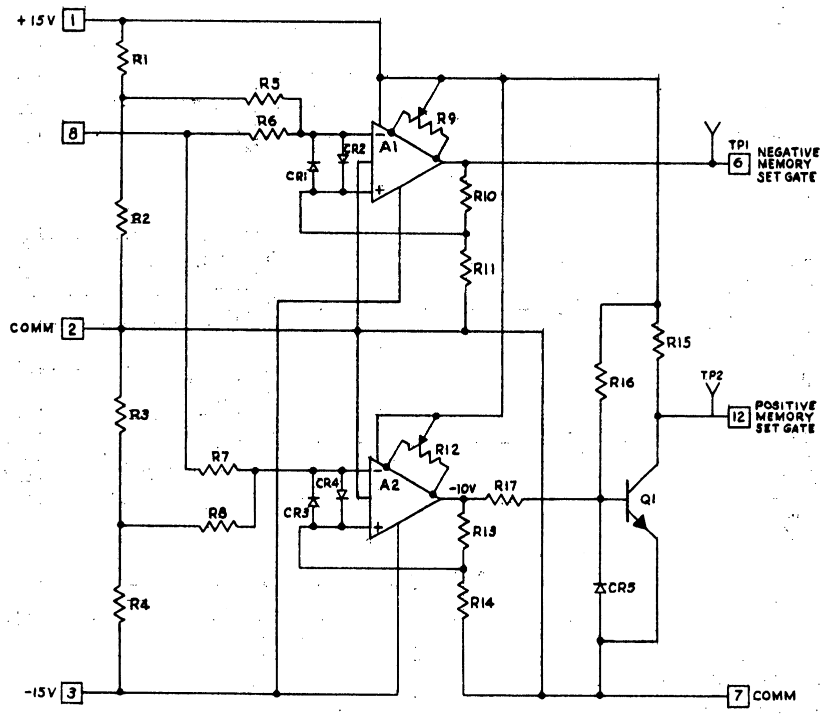
APPROVAL DESIGN ACTIVITY
APPROVAL OTHER

U.S. ARMY NATICK LABORATORIES
NATICK, MASS. 01760

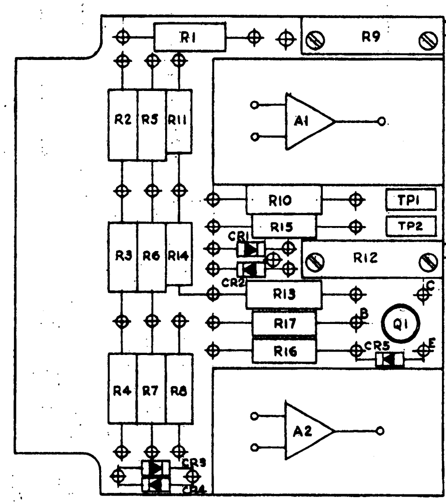
DATA RETRIEVAL SYSTEM
SUMMING AMPLIFIER
PB16

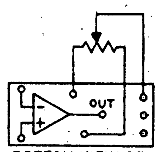
SIZE	CODE IDENT NO	DRAWING NO.
D	81337	11-1-2509

SCALE | UNIT WT. | SHEET OF



SYM	COMPONENT	VALUE	TOL
CR1	IN483B		
CR2	IN483B		
CR3	IN483B		
CR4	IN483B		
CR5	IN483B		1%
A1	NEXUS RESEARCH LABS FSL-12		
A2	NEXUS RESEARCH LABS FSL-12		
R1		4.99K	1%
R2		47Ω	1%
R3		47Ω	1%
R4		4.99K	1%
R5	RN65B1002F	10K	1%
R6	RN65B1002F	10K	1%
R7	RN65B1002F	10K	1%
R8	RN65B1002F	10K	1%
R9	BOURNS 200L-2-104 TRIMPOT	100K	10%
R10	RN65B2002F	20K	1%
R11	RC20GF100J	10Ω	5%
R12	BOURNS 2002-2-104 TRIMPOT	100K	10%
R13	RN65B200F	20K	5%
R14	RC20GF1003	10K	5%
R15	RC20GF222J	2.2K	5%
R16	RC20GF223J	22K	5%
R17	RC20GF472J	4.7K	5%
PB1	RAYTHEON PLUG IN BOARD MBB1		
Q1	2N2219		
TP1	UCINITE 119437 TEST JACK		
TP2	UCINITE 119437 TEST JACK		





BOTTOM VIEW OF NEXUS AMPLIFIER

REVISIONS

ITEM LIST

U. S. ARMY NATICK LABORATORIES
NATICK, MASS.

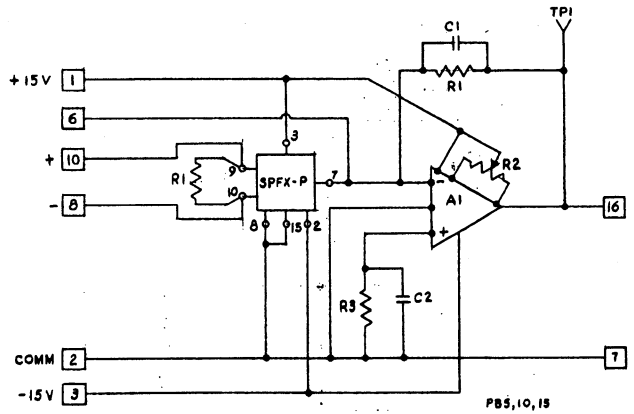
DATA RETRIEVAL SYSTEM
ZERO CROSSING DETECTOR
PB3, PB8 & PB13

DWG NO. 11-1-2510

DATE 9 OCT 74

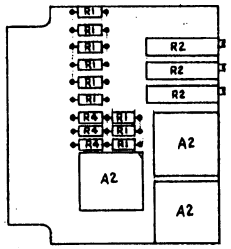
NOTES:

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED

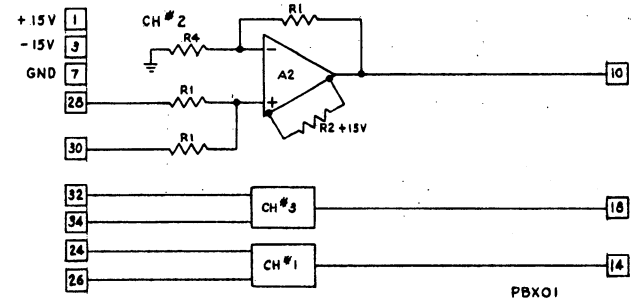


PB5,10,15

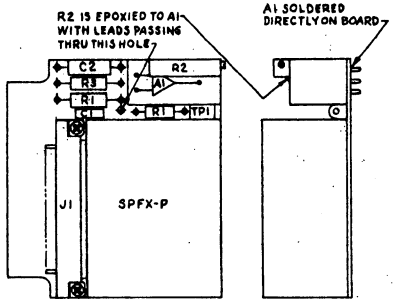
SYM	COMPONENT	VALUE	TOL	QTY
A1	NEXUS RESEARCH LAB COA-12			1
A2	TELEDYNE PHILBRICK 8Q-10A			6
SPFX-P	TRANSCONDUCTOR			1
C1	ELMENCO DM10-180J	18 PF	10%	1
C2	SPRAGUE 118P1039E82	.01MF	10%	1
R1	MEPCO RN65C2002C	20K	.25%	11
R2	BOURNS 200L-2-104	100K	10%	7
R3	RN60B1002F	10K	1%	7
R4	MEPCO	15K	1%	3
PB1	RAYTHEON PLUG IN BOARD MBB1			3
TP1	UCINITE TEST JACK 119457			1
J1	METHODE SDR-615B			1



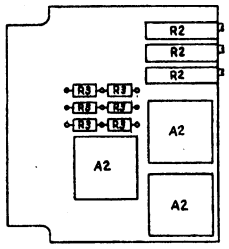
PBX01



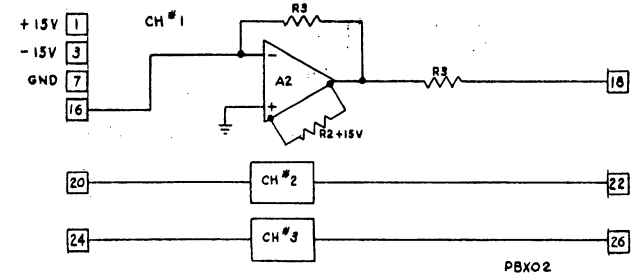
PBX01



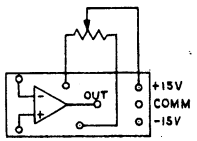
PB5, 10, 15



PBX02



PBX02



BOTTOM VIEW OF NEXUS AMPLIFIER

ITEM NO.	QTY. REQD	CODE IDENT	PART NO. OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL	MATL SPEC	DWG NO.

PARTS LIST

UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES WIRE AND METAL GAGES EXCLUDED

TOLERANCES:
FRACTIONS ±
ANGLES ±
2 PLACE DIMS. ±
3 PLACE DIMS. ±

MATERIAL

NEXT ASSY | USED ON
APPLICATION

DATE 9 OCT 74
PREPARED Gavin
CHECKED EM
ENGINEER

APPROVAL DESIGN ACTIVITY
APPROVAL OTHER

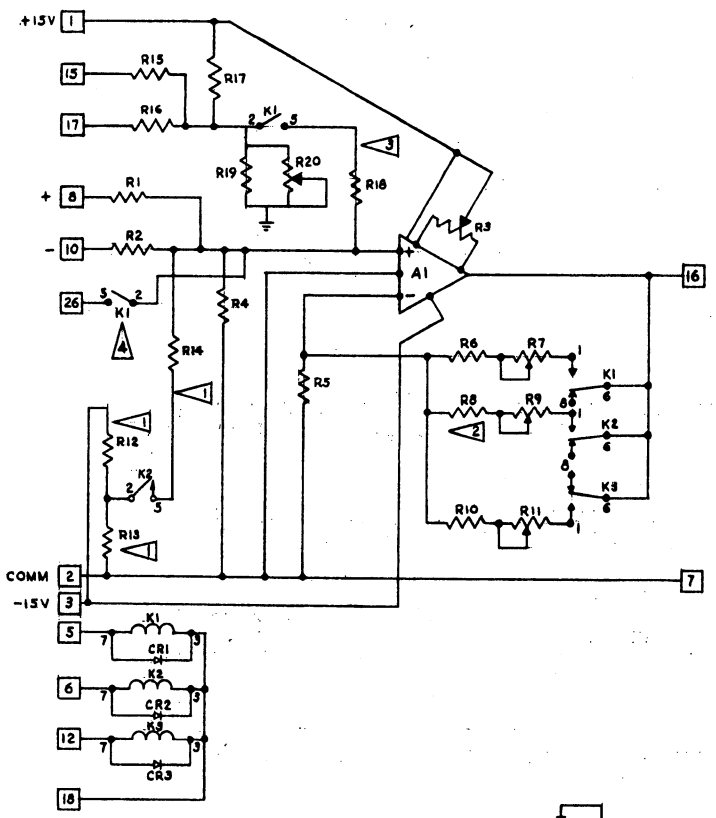
U.S. ARMY NATICK LABORATORIES
NATICK, MASS. 01760

DATA RETRIEVAL SYSTEM
ARBITRARY FUNCTION
PB5, PB10, PB15, PBX01, PBX02

SIZE	CODE IDENT NO	DRAWING NO.
D	81337	11-1-2511

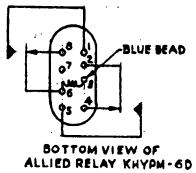
SCALE | UNIT WT. | SHEET OF

NOTES:

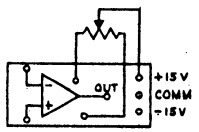


SYM	COMPONENT	VALUE	TOL
K1	ALLIED CONTROL KHYPM-6D-12D		
K2	ALLIED CONTROL KHYPM-6D-12D		
K3	ALLIED CONTROL KHYPM-6D-12D		
R1	MEPCO RN65C2002C	20K	.25%
R2	MEPCO RN65C2002C	20K	.25%
R3	BOURNS 200L-2-104	100K	10%
R4	MEPCO RN65C1001C	1K	.25%
R5	MEPCO RN65C2001C	2K	.25%
R6	MEPCO RN65C1692F	2.49K	1%
R7	BOURNS 200L-2-103	10K	10%
R8	MEPCO RN65C5111F	5.1K	1%
R9	BOURNS 200L-2-502	5K	1%
R10	MEPCO RN65C3832F	35.2K	10%
R11	BOURNS 200L-2-103	10K	10%
R12	MEPCO RN65C2491C	2.49K	.25%
R13	MEPCO RN65C499IC	499Ω	.25%
R14	MEPCO RN65C1962C	19.6K	.25%
R15	MEPCO RN65C1962C	19.6K	.25%
R16	MEPCO RN65C1962C	19.6K	.25%
R17	MEPCO RN65C2001C	2K	.25%
R18	MEPCO RN65C1962C	19.6K	.25%
R19	SPRAGUE RN65C	390Ω	.25%
R20	BOURNS 200L-2-502	5K	1%
CR1	IN4838		
CR2	IN4838		
CR3	IN4838		
A1	NEXUS RESEARCH LABS CDA-12 a		
PB1	RAYTHEON PLUG IN BOARD MBBI		

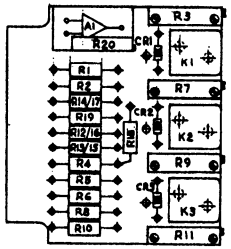
2



BOTTOM VIEW OF
ALLIED RELAY KHYPM-6D



BOTTOM VIEW OF
NEXUS AMPLIFIER



1 - R12, R13, AND R14 ARE USED ON THE PLUG IN BOARD IN THE TEMPERATURE CHANNEL (PB4)

2 - R8 IS RN65C2802F 28K 1% ON THE PLUG IN BOARD IN THE STATIC LOAD CHANNEL (PB9)

3 - ON PB9 ONLY

4 - ON PB4 AND PB14 ONLY

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED

ITEM NO.	QTY REQD	CODE IDENT	PART NO. OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL	MATL SPEC	DWG NO.

PARTS LIST

UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES. WIRE AND METAL GAGES EXCLUDED.

TOLERANCES: FRACTIONS ±, ANGLES ±, 2 PLACE DIMS. ±, 3 PLACE DIMS. ±

MATERIAL

NEXT ASSY | USED ON APPLICATION

DATE 9 OCT 74

PREPARED GRWm

CHECKED FM

ENGINEER

APPROVAL DESIGN ACTIVITY

APPROVAL OTHER

U.S. ARMY NATICK LABORATORIES
NATICK, MASS. 01760

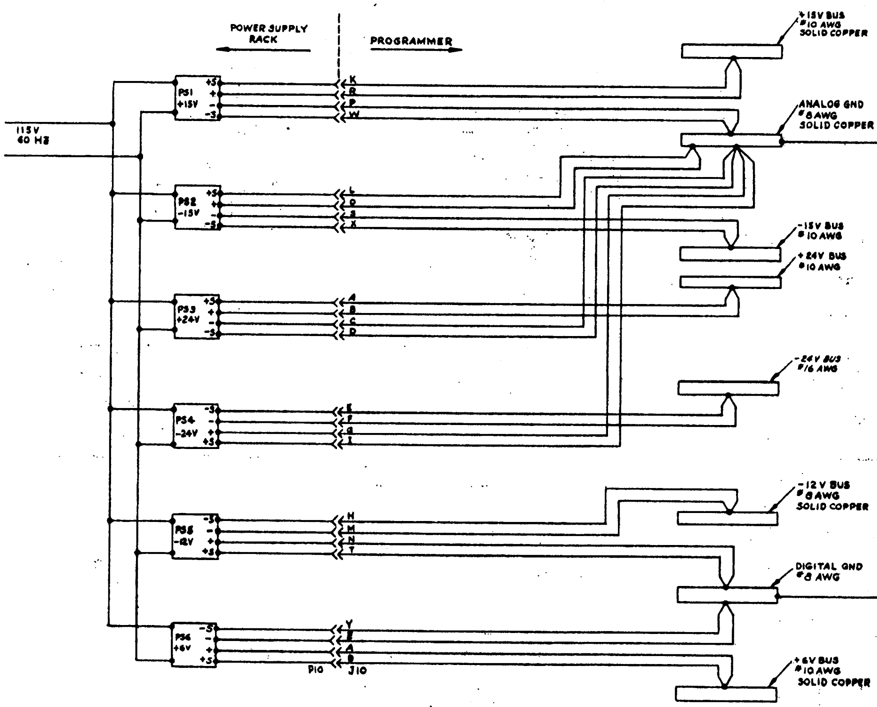
DATA RETRIEVAL SYSTEM
OUTPUT AMPLIFIER
PB4, PB9, PB14

SIZE D | CODE IDENT NO 81337 | DRAWING NO. 11-1-2512

SCALE | UNIT WT. | SHEET OF

NOTES:

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED



SYM	COMPONENT
PS1	LAMDA LM217
PS2	LAMDA LM217
PS3	LAMDA LM204
PS4	LAMDA LM204
PS5	LAMDA LM226
PS6	LAMDA LM202
P1	MS3106A-40-1S
J1	MS3102A-40-1P

BUS TO MODULE USE #22 AWG
SENSE WIRES USE #22 AWG
± 24V WIRES USE #20 AWG
± 15V WIRES USE #16 AWG
- 12V WIRES USE #12 AWG
+ 6V WIRES USE #16 AWG

ITEM NO.	QTY REQD	CODE IDENT	PART NO. OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL	MATL SPEC	DWG NO.

PARTS LIST

UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES WIRE AND METAL GAGES EXCLUDED
TOLERANCES: FRACTIONS ± ANGLES ± 2 PLACE DIMS. ± 3 PLACE DIMS. ±
MATERIAL

DATE 9 OCT 74
PREPARED
CHECKED
ENGINEER
APPROVAL DESIGN ACTIVITY
APPROVAL OTHER

U.S. ARMY NATICK LABORATORIES
NATICK, MASS. 01760

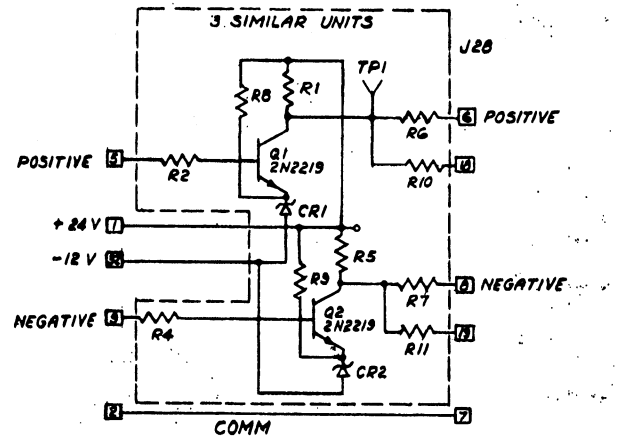
DATA RETRIEVAL SYSTEM
PROGRAMMER DC
POWER SUPPLY CONNECTIONS

SIZE E | CODE IDENT NO. 81337 | DRAWING NO. 11-1-2513

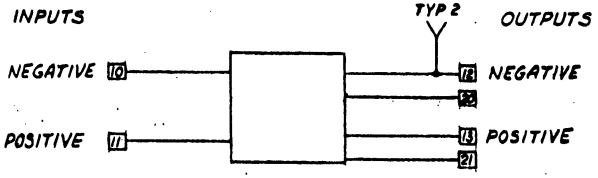
NEXT ASSY | USED ON
APPLICATION

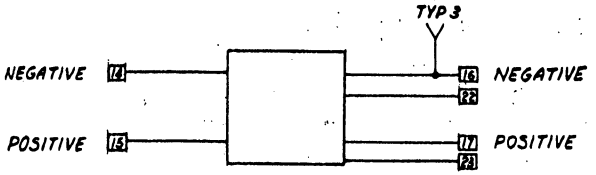
NOTES:

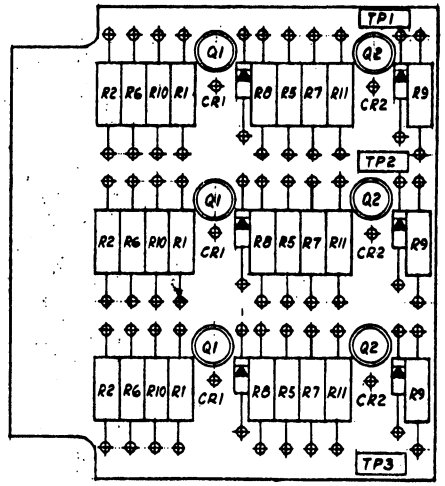
REVISIONS			
ZONE	LTR	DESCRIPTION	DATE	APPROVED



SYM	COMPONENT	VALUE	TOL
CR1	IN703A		
CR2	IN703A		
Q1	2N2219		
Q2	2N2219		
R1	RC20GF103J	10 K	5%
R2	RC20GF222J	2.2 K	5%
R4	RC20GF222J	2.2 K	5%
R5	RC20GF103J	10 K	5%
R6	RC20GF472J	4.7 K	5%
R7	RC20GF472J	4.7 K	5%
R8	RC20GF682J	6.8 K	5%
R9	RC20GF682J	6.8 K	5%
PB1	RAYTHEON PLUG IN BOARD MEM		
R10	RC20GF472J	4.7 K	5%
R11	RC20GF472J	4.7 K	5%
TP1	UCINITE 119437 TEST JACK		
TP2	UCINITE 119437 TEST JACK		
TP3	UCINITE 119437 TEST JACK		







ITEM NO.	QTY REQD	CODE IDENT	PART NO. OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL	MATL SPEC	DWG NO.

PARTS LIST

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. WIRE AND METAL GAGES EXCLUDED

TOLERANCES: FRACTIONS ± ANGLES ± 2 PLACE DIMS. ± 3 PLACE DIMS. ±

MATERIAL

NEXT ASSY | USED ON

APPLICATION

DATE 9 OCT 74

PREPARED F. MILOS

CHECKED

ENGINEER

APPROVAL DESIGN ACTIVITY

APPROVAL OTHER

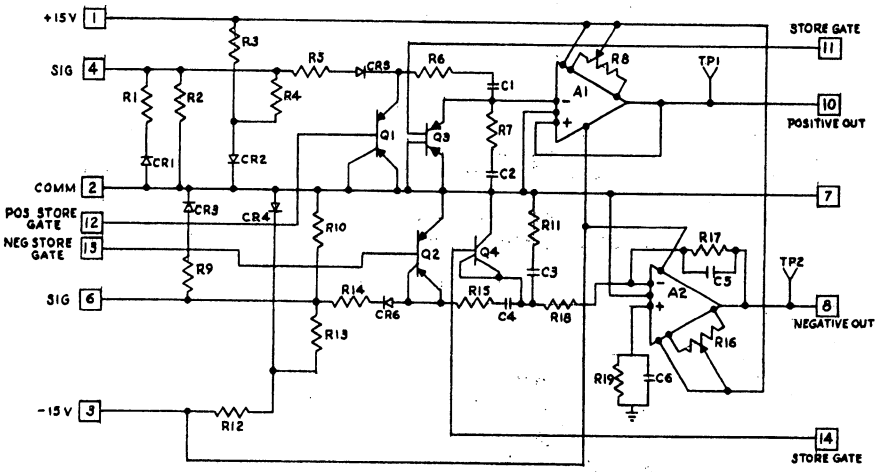
U.S. ARMY NATICK LABORATORIES
NATICK, MASS. 01760

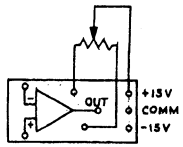
DATA RETRIEVAL SYSTEM
PEAK MEMORY SWITCH DRIVER
PB28

SIZE D | CODE IDENT NO 81337 | DRAWING NO. 11-1-2514

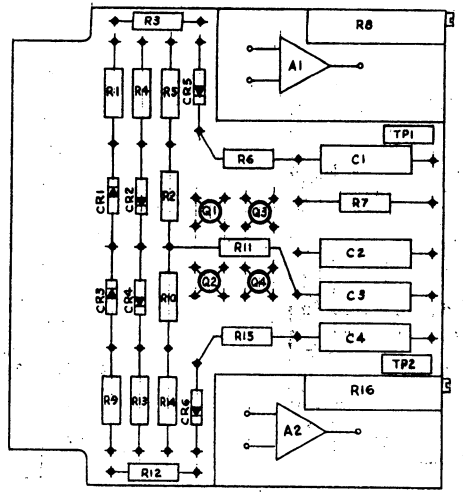
SCALE | UNIT WT. | SHEET OF

NOTES:





BOTTOM VIEW OF NEXUS AMPLIFIER



SYM	COMPONENT	VALUE	TOL
A1	NEXUS CLA-3 DC AMPLIFIER		
A2	NEXUS CLA-3 DC AMPLIFIER		
C1	SPRAGUE 260P104553	.1 MFD	5%
C2	SPRAGUE 260P104553	.1 MFD	5%
C3	SPRAGUE 260P104553	.1 MFD	5%
C4	SPRAGUE 260P104563	.1 MFD	5%
CR1	IN4638		
CR2	IN4638		
CR3	IN4638		
CR4	IN4638		
CR5	IN4638		
CR6	IN4638		
R1	RC20GF102J	1K	5%
R2	RN60B1503F	150K	1%
R3	RN60B1003F	100K	1%
R4	RN60B1008F	100K	1%
R5	RC20GF471J	470Ω	5%
R6	RC20GF271J	270Ω	5%
R7	RC20GF271J	270Ω	5%
R8	BOURNS 200L-2-104	100K	10%
R9	RC20GF102J	1K	5%
R10	RN60B1503F	150K	1%
R11	RC20GF271J	270Ω	5%
R12	RN60B1003F	100K	1%
R18	RN60B1003F	100K	1%
R14	RC20GF471J	470Ω	5%
R15	RC20GF271J	270Ω	5%
R16	BOURNS 200L-2-104	100K	10%
R17		20M	
R18		20M	
R19		470K	
Q1	CRYSTALONICS 3N109		
Q2	CRYSTALONICS 3N109		
Q3	CRYSTALONICS 3N109		
Q4	CRYSTALONICS 3N109		
PB2	RAYTHEON PLUG IN BOARD MBB1		
TP1	UCINITE 119437 TEST POINT		
TP2	UCINITE 119437 TEST POINT		
C5		5pf	
C6		0.01μf	

NOTE:
PB HAS NOT BEEN MODIFIED TO INCLUDE R17, R18, R19, C5, & C6.

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED

ITEM NO.	QTY REQD	CODE IDENT	PART NO. OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL	MATL SPEC	DWG NO.

PARTS LIST

UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES. WIRE AND METAL GAGES EXCLUDED.
TOLERANCES: FRACTIONS ±, ANGLES ±, 2 PLACE DIMS. ±, 3 PLACE DIMS. ±
MATERIAL
NEXT ASSY | USED ON APPLICATION

DATE 9 OCT 74
PREPARED GAHm
CHECKED F.M.
ENGINEER H.G.
APPROVAL DESIGN ACTIVITY
APPROVAL OTHER

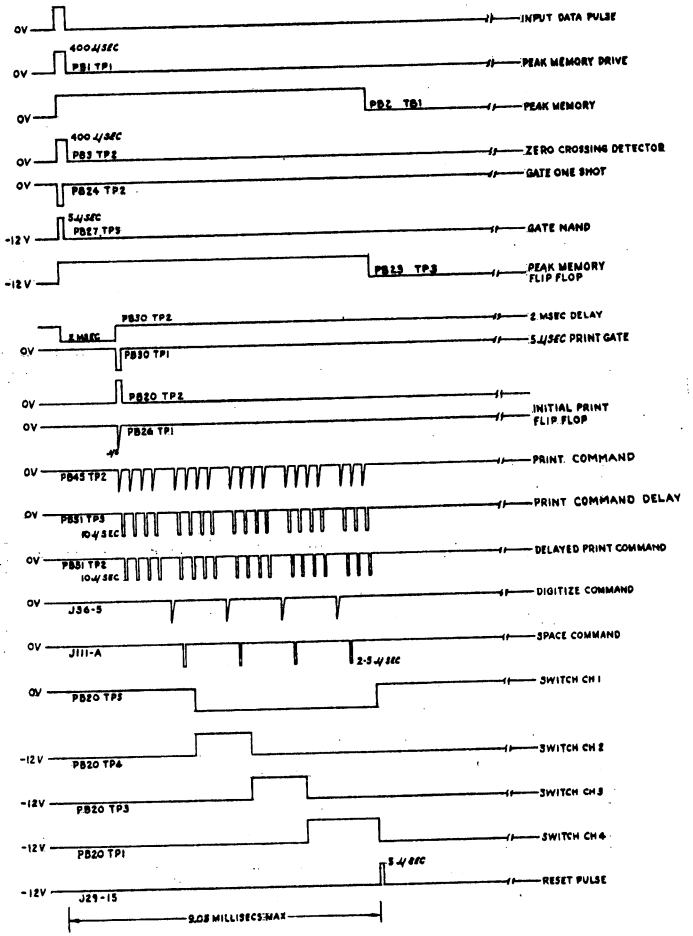
U.S. ARMY NATICK LABORATORIES
NATICK, MASS. 01760

DATA RETRIEVAL SYSTEM
PEAK MEMORY
PB2, PB7 & PB12

SIZE D | CODE IDENT NO 81337 | DRAWING NO. 11-1-2515
SCALE | UNIT WT. | SHEET OF

NOTES:

TROUBLE SHOOTING PROGRAMMER TIMING DIAGRAM
WITH POSITIVE DATA PULSE



4- WAVEFORMS 2 THRU 6 APPEAR ON TEST POINTS PB2, TP2, PB3 TP2, PB24 TP3, PB27 TP6 AND PB23 TP4, FOR A NEGATIVE DATA PULSE IN CH1.

3- POLARITIES OF WAVEFORMS 1 & 2 ARE REVERSED FOR A NEGATIVE DATA REFERENCE PULSE.

2- WAVEFORM LEVELS 4 THRU 21 ARE -9 TO -12 V AND 0 TO -.5 V NOMINAL.

1- INPUT DATA TO J112, PINS A & B; PIN A HIGH SIDE.

PARTS LIST

ITEM NO.	QTY REQD	CODE IDENT	PART NO. OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL	MATL SPEC	SMS NO.

U.S. ARMY NATICK LABORATORIES
NATICK, MASS. 01760

DATA RETRIEVAL SYSTEM
TROUBLE SHOOTING
TIMING DIAGRAM

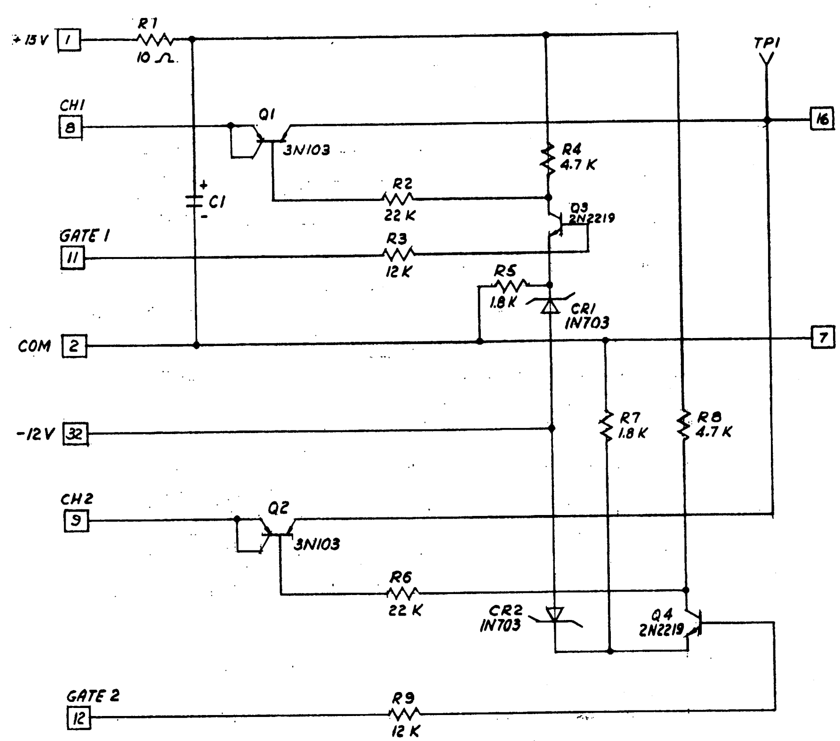
DATE 9 OCT 74
PREPARED
CHECKED R.H.
ENGINEER
APPROVAL DESIGN ACTIVITY
APPROVAL OTHER

SIZE E | CODE IDENT NO 81337 | DRAWING NO. 11-1-2516

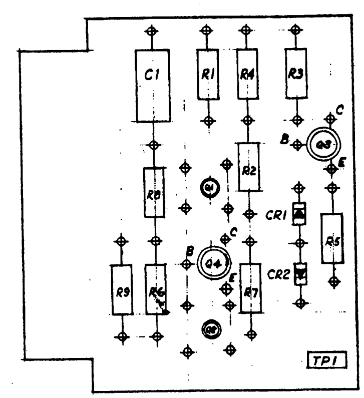
SCALE | WEIGHT | SHEET

33

NOTES:



SYM	COMPONENT	VALUE	TOL.
CR1	DIODE IN703		
CR2	DIODE IN703		
C1	SPRAGUE 150D107X020S2	100MF	
R1	RC20GF100J	10 Ω	5%
R2	RC20GF223J	22 K	5%
R3	RC20GF123J	12 K	5%
R4	RC20GF472J	4.7 K	5%
R5	RC20GF182J	1.8 K	5%
R6	RC20GF223J	22 K	5%
R7	RC20GF182J	1.8 K	5%
R8	RC20GF472J	4.7 K	5%
R9	RC20GF123J	12 K	5%
Q1	3N103		
Q2	3N103		
Q3	2N2219		
Q4	2N2219		



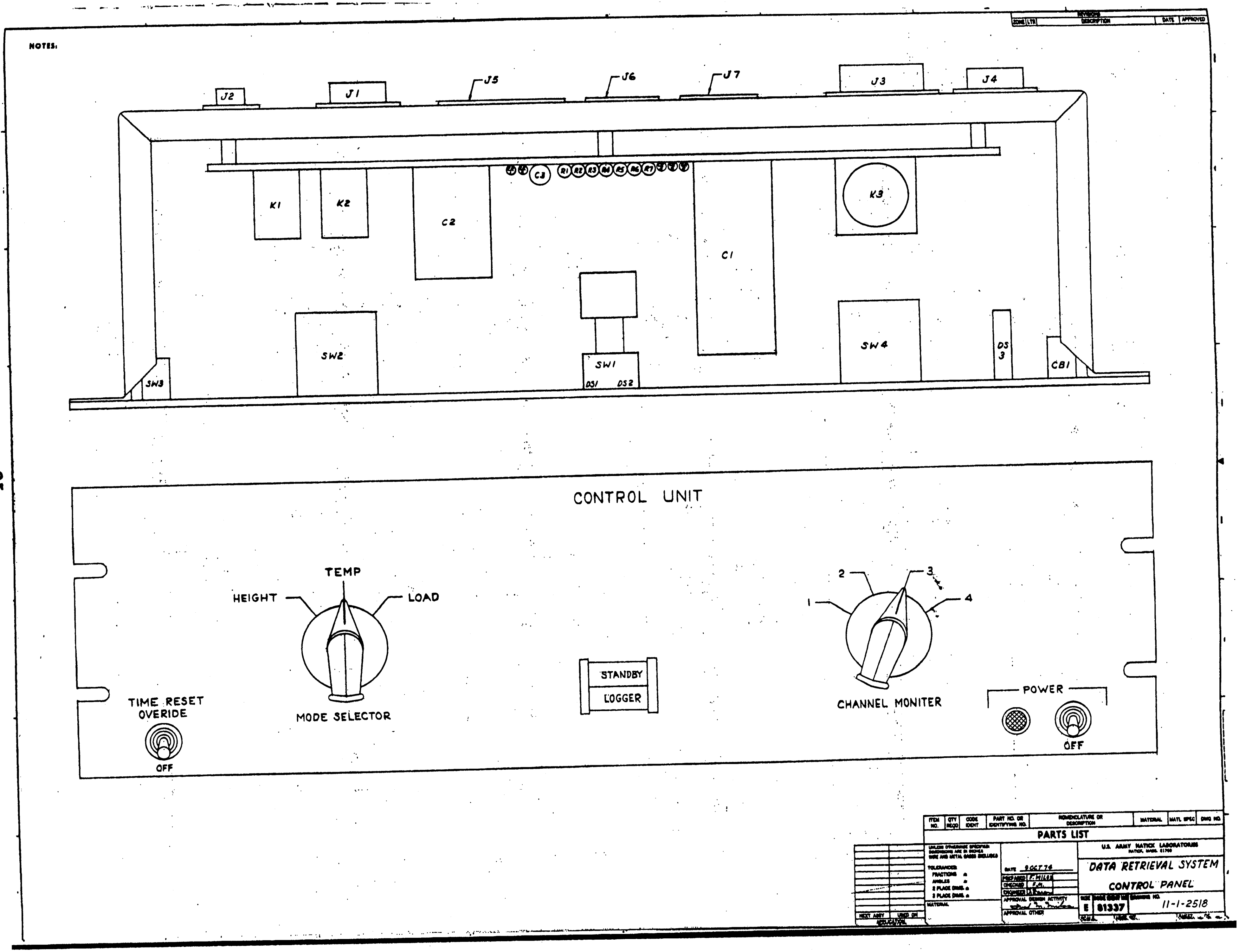
PARTS LIST

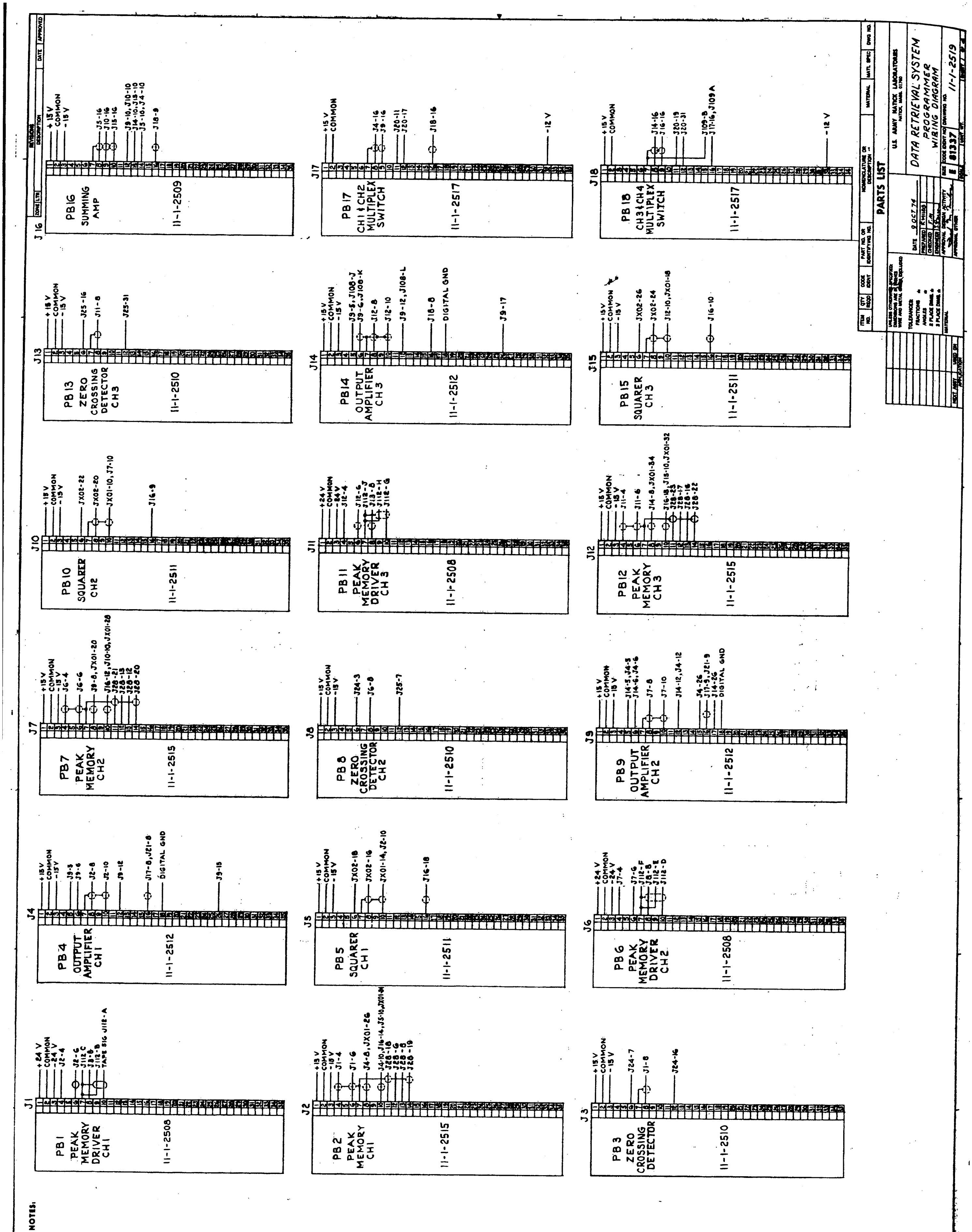
U.S. ARMY NATICK LABORATORIES

DATA RETRIEVAL SYSTEM
MULTIPLEX SWITCH
PB17, PB18

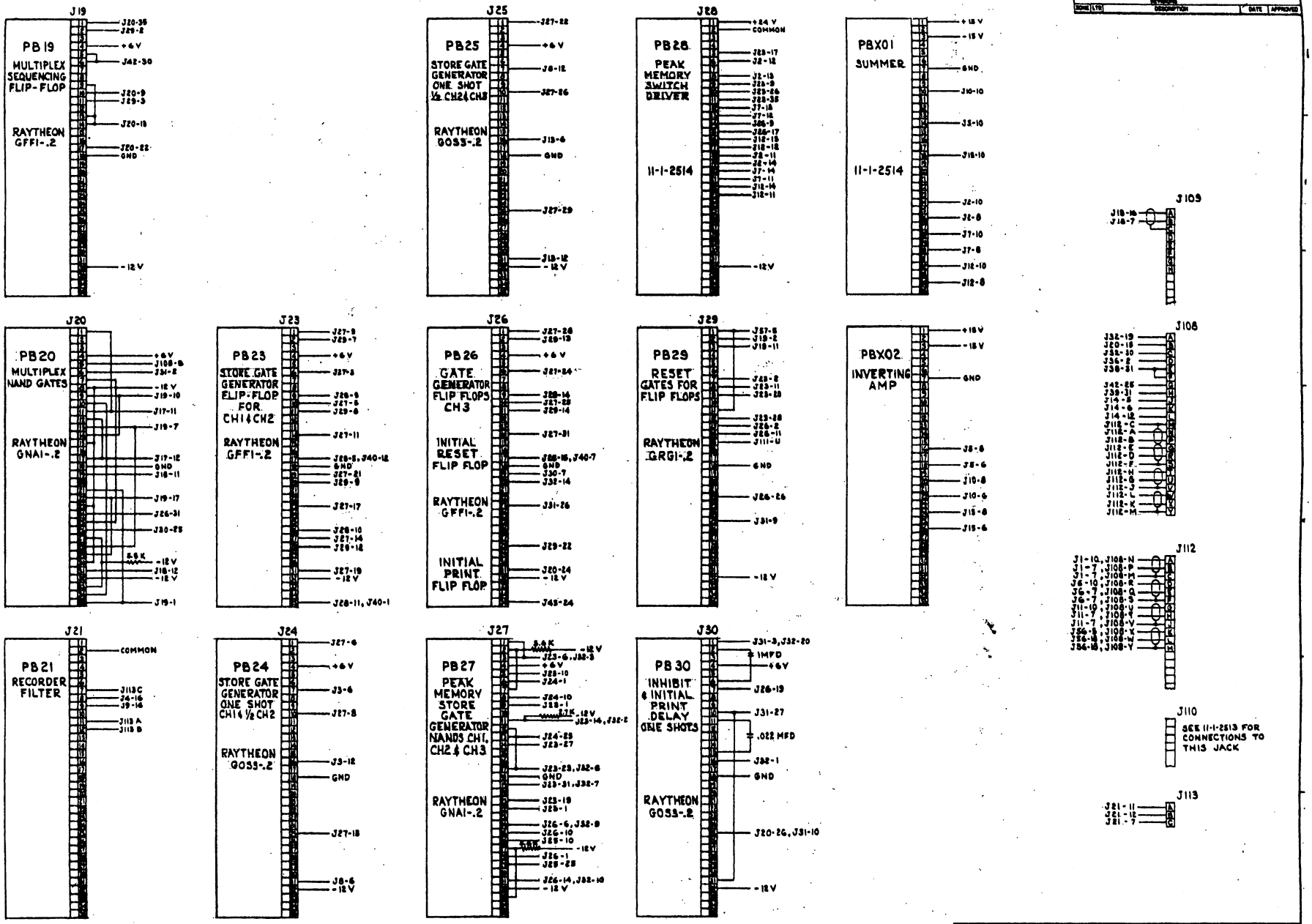
DATE 9 OCT 74

E 81337 11-1-2517


NOTES:
J2
J1
J5
J6
J7
J3
J4
K1
K2
C2
C3
R1 R2 R3 R4 R5 R6 R7
C1
K3
SW2
SW1
DS1 DS2
SW4
DS 3
CB1
SW3
CONTROL UNIT
HEIGHT
TEMP
LOAD
MODE SELECTOR
STANDBY
LOGGER
1
2
3
4
CHANNEL MONITER
POWER
OFF
TIME RESET OVERIDE
OFF
PARTS LIST
U.S. ARMY NATICK LABORATORIES
DATA RETRIEVAL SYSTEM
CONTROL PANEL
E 81337
11-1-2518


NOTES:
PB1 PEAK MEMORY DRIVER CH1 11-1-2508
PB2 PEAK MEMORY CH1 11-1-2515
PB3 ZERO CROSSING DETECTOR 11-1-2510
PB4 OUTPUT AMPLIFIER CH1 11-1-2512
PB5 SQUARER CH1 11-1-2511
PB6 PEAK MEMORY DRIVER CH2 11-1-2508
PB7 PEAK MEMORY CH2 11-1-2515
PB8 ZERO CROSSING DETECTOR CH2 11-1-2510
PB9 OUTPUT AMPLIFIER CH2 11-1-2512
PB10 SQUARER CH2 11-1-2511
PB11 PEAK MEMORY DRIVER CH3 11-1-2508
PB12 PEAK MEMORY CH3 11-1-2515
PB13 ZERO CROSSING DETECTOR CH3 11-1-2510
PB14 OUTPUT AMPLIFIER CH3 11-1-2512
PB15 SQUARER CH3 11-1-2511
PB16 SUMMING AMP 11-1-2509
PB17 CH1 & CH2 MULTIPLEX SWITCH 11-1-2517
PB18 CH3 & CH4 MULTIPLEX SWITCH 11-1-2517
PARTS LIST
U.S. ARMY NATICK LABORATORIES
DATA RETRIEVAL SYSTEM PROGRAMMER WIRING DIAGRAM
11-1-2519

NOTES:



REVISIONS			
SYMBOL	LTR	DESCRIPTION	DATE	APPROVED

ITEM NO.	QTY REQD	CODE IDENT	PART NO. OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL	MAT'L SPEC	SPEC NO.

PARTS LIST

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. WIRE AND METAL GAGES SWG.AWG

TOLERANCES
FRACTIONS ±
ANGLES ±
2 PLACE DECIMAL ±
3 PLACE DECIMAL ±

MATERIAL

NEXT ASSY | USED ON

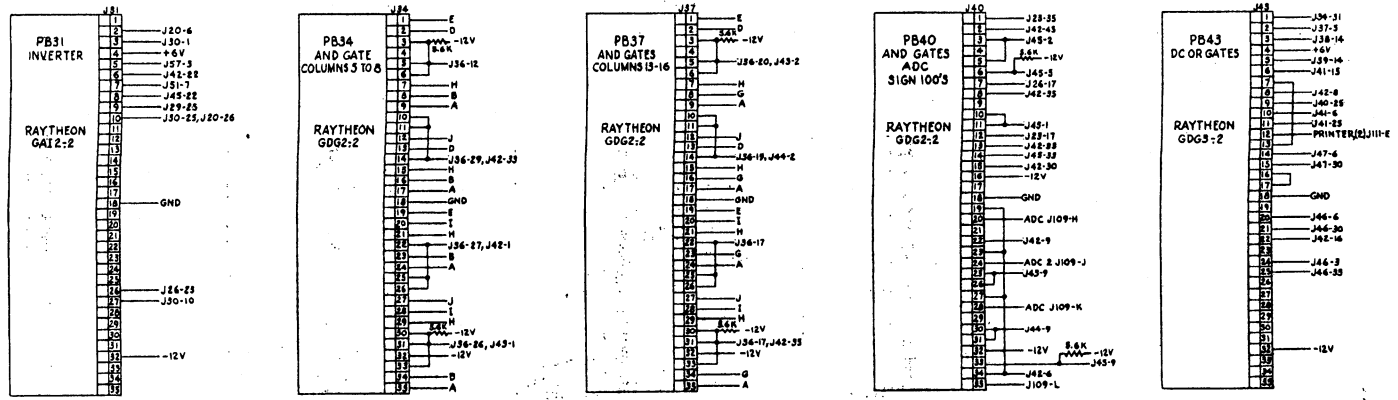
DATE 9 OCT 76
PREPARED P. MILLER
CHECKED
ENGINEER
APPROVAL DESIGN ACTIVITY
APPROVAL OTHER

U.S. ARMY NATICK LABORATORIES
NATICK, MASS. 01760

DATA RETRIEVAL SYSTEM
PROGRAMMER WIRING DIAGRAM

SIZE E | CODE IDENT NO 81337 | DRAWING NO. 11-1-25.1

NOTES:



ZONE	LTR	REVISIONS DESCRIPTION	DATE	APPROVED

ITEM NO.	QTY REQD	CODE IDENT	PART NO. OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL	MATL SPEC	DRG NO.

PARTS LIST

NEXT ASSY	USED ON APPLICATION

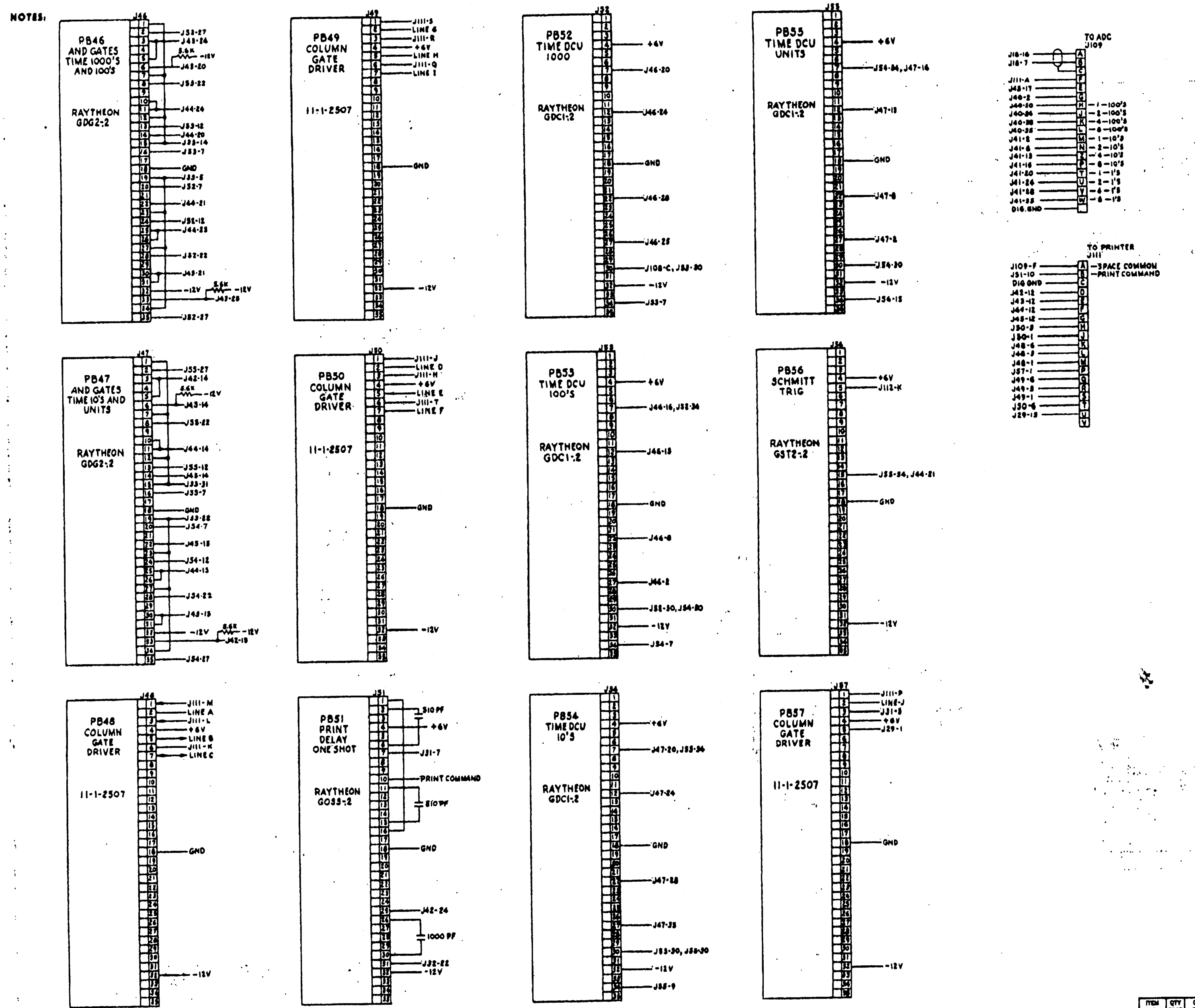
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. WIRE AND METAL BASES EXCLUDED.
TOLERANCES: FRACTIONS ±, ANGLES ±, 2 PLACE DIMS. ±, 3 PLACE DIMS. ±
MATERIAL

DATE 3 OCT 74
PREPARED Gomez
CHECKED
ENGINEER
APPROVAL DESIGN ACTIVITY
APPROVAL OTHER

U.S. ARMY NATICK LABORATORIES
NATICK, MASS. 01760

DATA RETRIEVAL SYSTEM
PROGRAMMER, WIRING DIAGRAM

SIZE E | CODE IDENT NO. 81337 | DRAWING NO. 11-1-2519
SCALE | UNIT WT. | SHEET 38 OF 43



ITEM NO.	QTY REQD	CODE IDENT	PART NO. OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL	MATL SPEC	DWG NO.

PARTS LIST

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES

DATE 9 OCT 74

U.S. ARMY NATICK LABORATORIES NATICK, MASS.

DATA RETRIEVAL SYSTEM PROGRAMMER, WIRING DIAGRAM

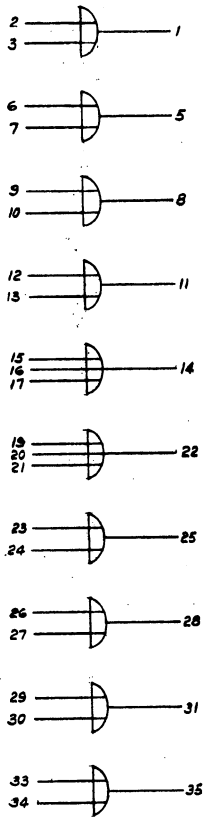
SIZE E CODE IDENT NO. 81337 DRAWING NO. 11-1-25

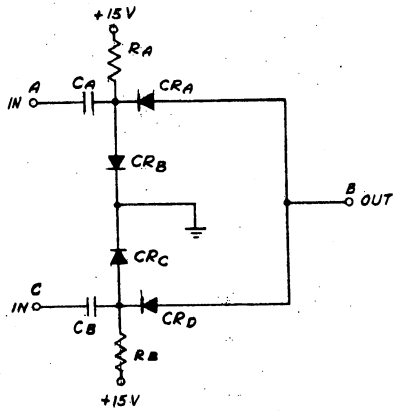
SHEET 4 OF 4

REVISIONS			
ZONE LTR	DESCRIPTION	DATE	APPROVED

NOTES:

1. THIS BOARD IS A RAYTHEON GIGI-.2 WITH THE DIODES REVERSED AND R_A & R_B REPLACED WITH 47K RESISTORS.





SYM	COMPONENT	VALUE	TOL
C_A	CAPACITOR	390pf	±10%
C_B	CAPACITOR	390pf	±10%
CR_A	RAYTHEON PBC503050		
CR_B	RAYTHEON PBC503050		
CR_C	RAYTHEON PBC503050		
CR_D	RAYTHEON PBC503050		
R_A	RC20GF473J	47K	5%
R_B	RC20GF473J	47K	5%

ITEM NO.	QTY REQD	CODE IDENT	PART NO. OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL	MATL SPEC	DWG NO.

PARTS LIST

NEXT ASSY	USED ON
APPLICATION	

UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES. WIRE AND METAL GAGES EXCLUDED.

TOLERANCES: FRACTIONS ±, ANGLES ±, 2 PLACE DIMS. ±, 3 PLACE DIMS. ±

MATERIAL

DATE 9 OCT 74

PREPARED F. MILES

CHECKED R.M.

ENGINEER J. B.

APPROVAL DESIGN ACTIVITY

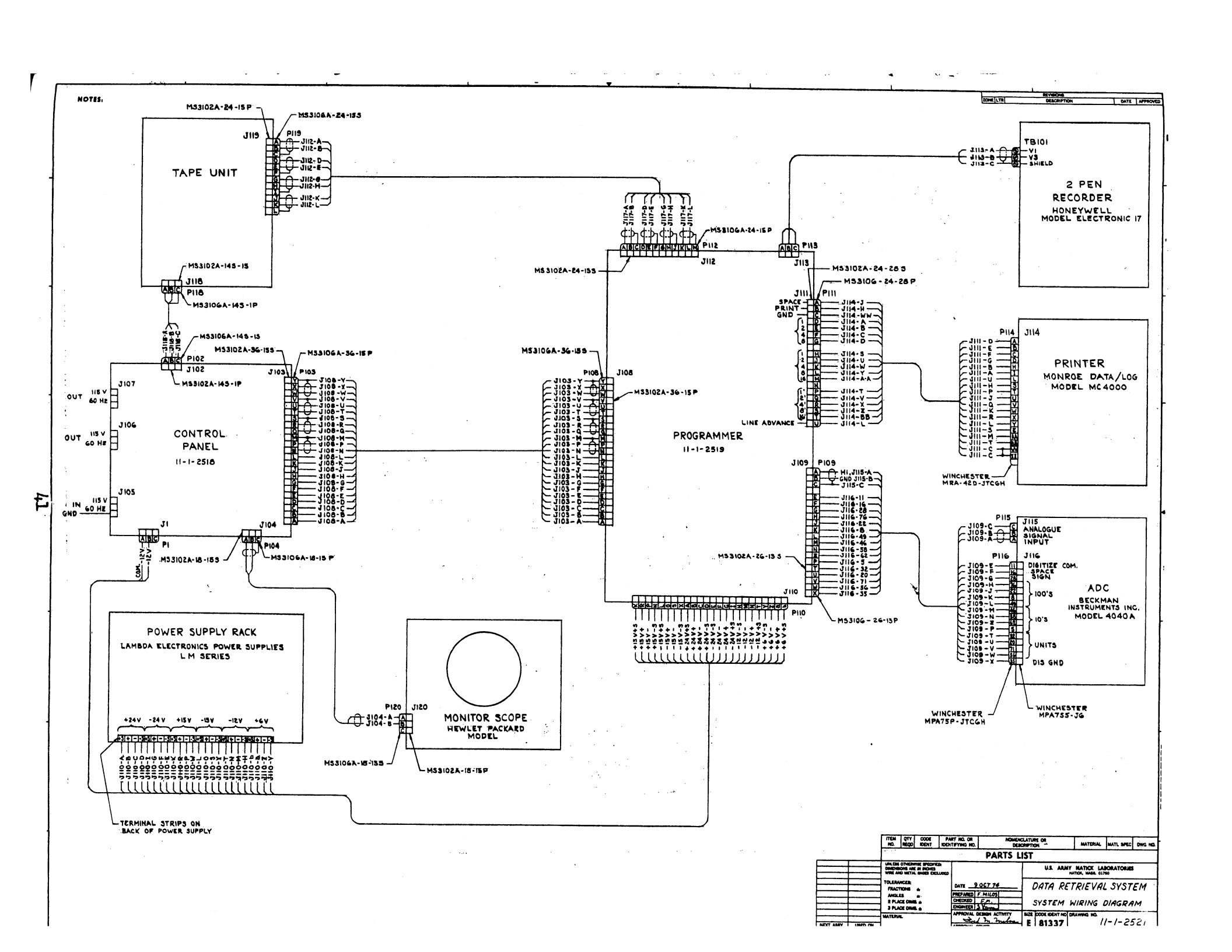
APPROVAL OTHER

U.S. ARMY NATICK LABORATORIES
NATICK, MASS. 01760

DATA RETRIEVAL SYSTEM
AC O R GATE NEGATIVE INPUT
PB3G

SIZE	CODE IDENT NO	DRAWING NO.
D	81337	11-1-2520

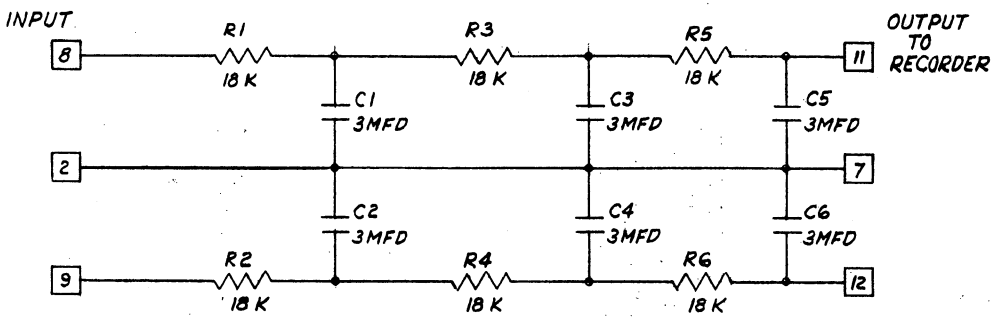
SCALE | UNIT WT. | SHEET OF


NOTES:
TAPE UNIT
J119
P119
MS3102A-24-15P
MS3106A-24-15S
J112-A
J112-B
J112-D
J112-E
J112-G
J112-H
J112-K
J112-L
MS3102A-14S-15
J118
P118
MS3106A-14S-1P
MS3106A-14S-15
MS3102A-36-15S
MS3106A-36-15P
P102
J102
MS3102A-14S-1P
J103
P103
J107
J106
J105
OUT 115 V 60 HZ
OUT 115 V 60 HZ
IN 115 V 60 HZ
GND
CONTROL PANEL
11-1-2518
J1
P1
J104
P104
MS3102A-18-15S
MS3106A-18-15P
COM
-12V
+12V
POWER SUPPLY RACK
LAMBDA ELECTRONICS POWER SUPPLIES
L M SERIES
+24V -24V +15V -15V -12V +6V
TERMINAL STRIPS ON BACK OF POWER SUPPLY
P120
J120
J104-A
J104-B
MONITOR SCOPE
HEWLET PACKARD
MODEL
MS3106A-18-15S
MS3102A-18-15P
J117-A
J117-B
J117-D
J117-E
J117-G
J117-H
J117-K
J117-L
MS3106A-24-15P
P112
J112
MS3102A-24-15S
MS3106A-36-15S
P108
J108
MS3102A-36-15P
PROGRAMMER
11-1-2519
J110
P110
MS3106-24-13P
MS3102A-24-28S
MS3106-24-28P
J111
P111
SPACE
PRINT
GND
LINE ADVANCE
J114-J
J114-H
J114-WW
J114-A
J114-B
J114-C
J114-D
J114-S
J114-U
J114-W
J114-Y
J114-AA
J114-T
J114-V
J114-X
J114-Z
J114-BB
J114-L
MS3102A-26-13S
J109
P109
HI, J115-A
GND J115-B
J115-C
J116-11
J116-16
J116-28
J116-76
J116-22
J116-8
J116-49
J116-46
J116-58
J116-62
J116-5
J116-32
J116-20
J116-71
J116-56
J116-35
J113-A
J113-B
J113-C
TB101
V1
V3
SHIELD
2 PEN RECORDER
HONEYWELL
MODEL ELECTRONIC 17
P114
J114
PRINTER
MONROE DATA/LOG
MODEL MC4000
WINCHESTER MRA-42D-JTCGH
P115
J115
ANALOGUE SIGNAL INPUT
P116
J116
DIGITIZE COM.
SPACE
SIGN
100'S
10'S
UNITS
DIS GND
ADC
BECKMAN INSTRUMENTS INC.
MODEL 4040A
WINCHESTER MPA75P-JTCGH
WINCHESTER MPA75S-JG
ZONE LTR
REVISIONS
DESCRIPTION
DATE
APPROVED
ITEM NO.
QTY REQD
CODE IDENT
PART NO. OR IDENTIFYING NO.
NOMENCLATURE OR DESCRIPTION
MATERIAL
MATL SPEC
DWG NO.
PARTS LIST
U.S. ARMY MATICK LABORATORIES
NATICK, MASS. 01760
DATA RETRIEVAL SYSTEM
SYSTEM WIRING DIAGRAM
DATE 9 OCT 74
PREPARED F. MILOS
CHECKED E.A.
ENGINEER
APPROVAL DESIGN ACTIVITY
SIZE E
CODE IDENT NO 81337
DRAWING NO. 11-1-2521

NOTES:

ZONE	LTR	REVISIONS DESCRIPTION	DATE	APPROVED

SYM	COMPONENT	VALUE	TOL
C1	SPRAGUE 118P30592S2	3 MFD	10 %
C2	SPRAGUE 118P30592S2	3 MFD	10 %
C3	SPRAGUE 118P30592S2	3 MFD	10 %
C4	SPRAGUE 118P30592S2	3 MFD	10 %
C5	SPRAGUE 118P30592S2	3 MFD	10 %
C6	SPRAGUE 118P30592S2	3 MFD	10 %
R1	RC20GF183J	18 K	5 %
R2	RC20GF183J	18 K	5 %
R3	RC20GF183J	18 K	5 %
R4	RC20GF183J	18 K	5 %
R5	RC20GF183J	18 K	5 %
R6	RC20GF183J	18 K	5 %



ITEM NO.	QTY REQD	CODE IDENT	PART NO. OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL	MATL SPEC	DWG NO.

PARTS LIST

UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES. WIRE AND METAL GAGES EXCLUDED.

TOLERANCES: FRACTIONS ±, ANGLES ±, 2 PLACE DIMS. ±, 3 PLACE DIMS. ±

MATERIAL

NEXT ASSY | USED ON

APPLICATION

DATE 20CT 74

PREPARED F. MILOS

CHECKED F.M.

ENGINEER J.T. Dow

APPROVAL DESIGN ACTIVITY Fred M. Imbo

APPROVAL OTHER

U.S. ARMY NATICK LABORATORIES
NATICK, MASS. 01760

DATA RETRIEVAL SYSTEM
RECORDER FILTER
PB21

SIZE	CODE IDENT NO	DRAWING NO.
D	81337	11-1-2522

SCALE | UNIT WT. | SHEET OF