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Report on Completion of Task 1.1.1

THE LANL P14 TEMPERATURE CONTROL ELECTRONICS  
FOR THE WAVESHAPING FILTER

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## 1. Operating Instructions.

Los Alamos National Laboratory, P-14  
Waveform Standard Temperature Controller, based on the 1980  
NBS/Boulder CO design. NSN, 10/20/92.

### 1.1. ENVIRONMENT.

- 1.1.1. The Pulse Waveform Standard is designed to be operated in a laboratory environment in which the temperature is controlled and maintained nominally at 22 deg. C (72 deg.F).
- 1.1.2. The unit should be set up in a location free from drafts, sunlight, or other sources which cause temperature variations.
- 1.1.3 The unit should be connected to the operating measurement system, and the two systems should be allowed to operate together continuously for twenty four (24) hours prior to making a calibration measurement using the waveform of the pulse waveform standard.
- 1.1.4. The temperature controller of the Pulse Waveform Standard must be set to operate at 30 deg.C, thus the unit will be held at a temperature higher than that of the environment, 30 deg.C (84 deg.F).

### 1.2. OPERATION.

- 1.2.1. Before proceeding with placing the unit in operation set the AC line voltage switch on the rear panel of the temperature controller to the mains AC voltage at your installation.
- 1.2.2. Attach the cable which connects the temperature controller to the pulse wave shaping head.
- 1.2.3. Set the temperature controller temperature selector switch to 30 degrees Celsius.
- 1.2.4. Connect recorder channels to the insulated BNC connectors located on the rear panel of the temperature controller. The temperature channel output is 10 mV/degree Celsius, while that of the error channel is 1.0 V/degree Celsius.
- 1.2.5. Turn the unit on.

## 1. Operating Instructions.

### 1.2. OPERATION (CONT.).

- 1.2.6. When the temperature is not within a nominal temperature range of plus or minus 0.25 degree Celsius of the selected temperature, the red READY LED will be lit.
- 1.2.7. When the temperature is within a nominal temperature of range plus or minus 0.25 degree Celsius of the selected temperature, the green READY LED will be lit.
- 1.2.8. When the green ready light is on and after the operating temperature has stabilized, the temperature regulator will hold the temperature to a nominal plus and minus 0.1 degree Celsius.
- 1.2.9. IMPORTANT: However, even though the green READY light is on follow the environmental instructions given in 1.0 above before making a calibration measurement.

## 2. Calibration Sequence.

The calibration procedure consists of two tasks which must be accomplished in the proper order. The first task to be performed is the calibration of the controller circuitry located on the circuit board in the temperature controller unit. The second task is the calibration of the temperature sensing circuits located on the circuit board in the pulse shaping head. This circuit board is found behind the front panel of the pulse shaping head.

### 2.1. CALIBRATION OF THE CONTROLLER CIRCUITS.

- 2.1.1. The two (controller and pulse shaping head) units should be at ambient temperature; if they are not, turn the system off and wait at least two hours for the system to stabilize at the ambient temperature.
  - 2.1.2. Remove the cable connecting the controller to the pulse shaping head.
  - 2.1.3. Disable the heater circuits by removing the heater disabling jumper, P6 from J6.
  - 2.1.4. Turn on and allow a 30 minute warm-up.
- ## 2. Calibration Sequence.

### 2.1. CALIBRATION OF THE CONTROLLER CIRCUITS (CONT.).

- 2.1.5. Turn off; Remove IC U8.
- 2.1.6. Using short clip leads ground test points TP1, TP4, and TP6 to the circuit board ground.
- 2.1.7. Turn on.
- 2.1.8. Null IC U7 by adjusting R67 and observing the DC voltage at TP5; the green ready light should turn on.
- 2.1.9. Turn off.
- 2.1.10. Remove IC U4.
- 2.1.11. Turn on.
- 2.1.12. Null IC U3 by adjusting R65 and observing the DC voltage at TP2.
- 2.1.13. Turn off.
- 2.1.14. Reinstall IC U4.
- 2.1.15. Remove ground from TP1 and ground TP2.
- 2.1.16. Ground base of Q1.
- 2.1.17. Turn on.
- 2.1.18. Null IC U4 by adjusting R66 and observing the DC voltage at TP3. This is a high gain comparator; the zero crossing may be approximated by watching the DC meter reading.
- 2.1.19. Turn off.
- 2.1.20. Remove all of the grounding leads.
- 2.1.21. Reinstall IC U8.
- 2.1.22. Remove P5 from J5.
- 2.1.23. Ground TP7.

## 2.1. Calibration Sequence.

### 2.1. CALIBRATION OF THE CONTROLLER CIRCUITS (CONT.).

- 2.1.24. Turn on.
- 2.1.25. Null IC U8 by adjusting R64 and observing the DC voltage at TP6.
- 2.1.26. Turn off.
- 2.1.27. Replace P5 onto J5.
- 2.1.28. Remove ground from TP7.
- 2.1.29. Turn on.
- 2.1.30. Check reference voltage at TP6. This value should be minus (-) 3 volts when the controller temperature control is set to 30 Degrees Celsius.

The 20K trim pot R25 provides a small degree of adjustment of the reference voltage. This adjustment should be made using only a 4 and 1/2 digit DVM. When  $TP6 = 10 \times TP1$ , TP5 voltage should be zero. R67 should be adjusted slightly to make TP5 zero.

- 2.1.31. Replace heater disable jumper P6 onto J6; the red LED on the circuit board positioned next to P6/J6 should light when the jumper is reconnected.
- 2.1.32. Turn off.

### 2.2. CALIBRATION OF THE TEMPERATURE SENSING CIRCUITS.

- 2.2.1. On the temperature controller circuit board disable the heater circuits by removing the heater disabling jumper, P6 from J6.
- 2.2.2. Connect the cable connecting the controller to the pulse shaping head.
- 2.2.3. Remove the eight (8) screws holding the pulse shaping head front panel and rotate the panel downward to a horizontal position.
- 2.2.4. Note the black dot on the brass support block which marks the position for placing the temperature probe for calibration purposes.
- 2.2.5. Note the circuit board position in the circuit board slots as the circuit board must be returned to the same slot position.
- 2.2.6. Place some static free insulation below the circuit board slots and wedge it between the rotated panel plate and the pulse shaping housing, and on top of the coaxial line.

## 2. Calibration Sequence.

### 2.2. CALIBRATION OF THE TEMPERATURE SENSING CIRCUITS (CONT.).

- 2.2.7. Carefully withdraw the circuit board from its slot and place it on the insulator surface ensuring that the board's components, etc. are not in contact with the metal structure of the pulse shaping head.
- 2.2.8. Remove IC's U2 and U6.
- 2.2.9. Turn on.
- 2.2.10. Measure and monitor the brass block temperature at the black dot.
- 2.2.11. Refer to the Sensor Circuit Board Layout Drawing Top View. Attach a high impedance DVM to the Test Point "A" which connects to pin 3 of the IC U2 socket.
- 2.2.12. Adjust trim pot R84 to the voltage corresponding to the temperature observed in step 2.10 which should be 10 mVolts/degree Celsius. For example, 231 mVolts would correspond to 23.1 degrees Celsius.
- 2.2.13. Refer to the Sensor Circuit Board Layout Drawing Top View. Attach a high impedance DVM to the Test Point "B" which connects to pin 3 of the IC U6 socket.
- 2.2.14. Adjust trim pot R90 to the voltage corresponding to the temperature observed in step 2.10 which should be 10 mVolts/degree Celsius. For example, 231 mVolts would correspond to 23.1 degrees Celsius.
- 2.2.15. Turn off.
- 2.2.16. Reinstall IC's U2 and U6.
- 2.2.17. On the temperature controller circuit board remove IC U8.
- 2.2.18. On the temperature controller circuit board ground TP6.
- 2.2.19. Remove the plug PS from the temperature sensors U1 and U5 mounted on the brass block in the pulse shaping head.
- 2.2.20. On the plug PS insert jumper wires into pins 5,6,7,8,9, and 10 and connect them together; this shorts the inputs of the op-amps U2 and U6 which will allow their offsets to be set to zero.
- 2.2.21. Refer to the Sensor Circuit Board Layout Drawing Top View. Set the IC U2 offset to zero by adjusting R62 and observing the DC voltage at the "U2 Control Output Test Point" (the right hand wire of R86) which connects to pin 6 of IC U2. This point is electrically the same as test point TP1 on the controller board.

## 2. Calibration Sequence.

### 2.2. CALIBRATION OF THE TEMPERATURE SENSING CIRCUITS (cont.).

- 2.2.22. Refer to the Sensor Circuit Board Layout Drawing Top View. Set the IC U6 offset to zero by adjusting R63 and observing the DC voltage at the "U6 Control Output Test Point" (the right hand wire of R92) which connects to pin 6 of IC U6. This point is electrically the same as test point TP4 on the controller board.
- 2.2.23. Turn off.
- 2.2.24. Remove the jumper wires from PS and reconnect PS to the temperature sensors.
- 2.2.25. Carefully replace the temperature sensing circuit board in its original circuit board slot.
- 2.2.26. Ensure that the temperature sensor connection JS/PS has not become disconnected during the reinstallation of the circuit board.
- 2.2.27. Reinstall the pulse shaping head front panel.
- 2.2.28. On the temperature controller circuit board replace IC U8.
- 2.2.29. On the temperature controller circuit board remove the ground from TP6.
- 2.2.30. On the temperature controller circuit board replace the heater disable jumper P6 onto J6.

The calibration is now complete. Operate the system with the temperature controller set to 30 degrees Celsius. The performance of the temperature controller can be monitored by connecting DVM's or recorder channels to the BNC connectors on the rear panel of the temperature controller. The BNC connectors are insulated from the chassis. The Temperature Output Connector provides the same voltage that appears at test point TP4 while the Error Output Connector provides the same voltage appearing at Test Point TP5.

Note 1. After the system has been run for 24 hours, the Error Voltage offset may be adjusted so that the error fluctuates about zero volts by adjusting the trim pot. R67, the offset control for IC U7. In normal operation the green LED ready light will only remain lit when the error voltage is between plus and minus 250 mVolts which corresponds to plus and minus 0.25 degree C.

### 3. Maintenance Instructions for the Electronic Circuits.

The following instructions are for the maintenance of the electronic circuits found in the temperature controller and in the pulse waveform shaping head. The liquid filled coaxial line in the pulse waveform shaping head is a sealed unit and no instructions are given here to repair the coaxial structure if it is mechanically damaged.

#### 3.1. GENERAL.

- 3.1.1. The LANL P14 pulse waveform standard is a copy of the National Bureau of Standards (NBS) Pulse Transition Duration Standard, Model 100-2, which includes the NBS 724-04 temperature controller. However, some of the circuitry in the LANL P14 unit may be slightly different from that in the NBS unit.
- 3.1.2. P14 maintenance personnel should refer to the internal NBS report entitled " N.B.S. Transition Duration Standard Electronics", by E. E. Baldwin for the principles of operation of the electronic circuits in temperature controller and pulse shaping head. ( A copy of the NBS report is in the P14 file for the LANL set of NBS Reference Waveform Standards.)
- 3.1.3. For trouble shooting, repairs and calibration procedures only use the LANL P14 circuit diagrams, parts list, circuit board layouts, and calibration sequence.

#### 3.2. CIRCUIT AND ASSEMBLY NOTES.

- 3.2.1. The temperature controller circuit board has insulating nylon washers between the bottom of the circuit board (i.e., the copper trace side) and the metal stand-off posts supporting the circuit board. If the circuit board is removed, when replacing the circuit board, be sure to include the nylon washers.
- 3.2.2. Unpolarized plugs connecting to circuit board mounted jacks are position coded by a silver dot painted on the plug and a corresponding silver dot painted on the circuit board.

### 3. Maintenance Instructions for the Electronic Circuits.

#### 3.2. CIRCUIT AND ASSEMBLY NOTES (cont.).

- 3.2.3. If the circuit board in the pulse waveform shaping head must be removed for calibration or repair, for its removal follow the instructions given in the Calibration Sequence, Steps 2.1- 2.7 and its replacement, Step 2.23.
- 3.2.4. If the red or green (wait or ready) LED mounted on the front panel of the temperature controller needs to be replaced, the entire LED circuit board must be removed from the front panel.

To do so, grasp the top and bottom of the LED circuit board with a thumb and forefinger and then carefully rock the circuit board up and down while pulling away from the rear of the front panel. The LED's with their rubber inserts on the LED leads will come free from the panel mounted LED holders. Remove the faulty LED by desoldering it from the LED circuit board. Be sure to install the rubber insert on the new LED before soldering it to the circuit board.

#### 4. Parts List.

##### 4.1. RESISTORS.

| P/N | VALUE  | DESCRIPTION              |
|-----|--------|--------------------------|
| R1  | 34 K   | RESISTOR:                |
| R2  | 1.00 K | RESISTOR: 0.1%, 1W       |
| R3  | 1.00 K | RESISTOR: 0.1%, 1W       |
| R4  | 1.00 K | RESISTOR: 0.1%, 1W       |
| R5  | 1.00 K | RESISTOR: 0.1%, 1W       |
| R6  | 1.00 K | RESISTOR: 0.1%, 1W       |
| R7  | 1.00 K | RESISTOR: 0.1%, 1W       |
| R8  | 1.00 K | RESISTOR: 0.1%, 1W       |
| R9  | 1.00 K | RESISTOR: 0.1%, 1W       |
| R10 | 1.00 K | RESISTOR: 0.1%, 1W       |
| R11 | 1.00 K | RESISTOR: 0.1%, 1W       |
| R12 | 25 K   | RESISTOR:                |
| R13 | 24     | RESISTOR: 5%, 1/4W, C.F. |
| R14 | 0.0    | RESISTOR: 5%, 1/4W, C.F. |
| R15 | 4.7    | RESISTOR: 5%, 1/4W, C.F. |
| R16 | 39     | RESISTOR: 5%, 1/4W, C.F. |
| R17 | 100    | RESISTOR: 5%, 1/4W, C.F. |
| R18 | 191    | RESISTOR: 5%, 1/4W, C.F. |
| R19 | 300    | RESISTOR: 5%, 1/4W, C.F. |
| R20 | 470    | RESISTOR: 5%, 1/4W, C.F. |
| R21 | 630    | RESISTOR: 5%, 1/4W, C.F. |
| R22 | 820    | RESISTOR: 5%, 1/4W, C.F. |
| R23 | 1082   | RESISTOR: 5%, 1/4W, C.F. |
| R24 | 4.7 K  | RESISTOR: 5%, 1/4W, C.F. |
| R25 | 20 K   | MULTITURN TRIM POT       |
| R26 | 17.5 K | RESISTOR: 1%, 1/4W, C.F. |
| R27 | 10.0 K | RESISTOR: 1%, 1/4W, C.F. |
| R28 | 10.0 K | RESISTOR: 1%, 1/4W, C.F. |
| R29 | 91     | RESISTOR: 5%, 1/4W, C.F. |
| R30 | 909    | RESISTOR: 1%, 1/4W, C.F. |
| R31 | 100 K  | RESISTOR: 1%, 1/4W, C.F. |
| R32 | 910    | RESISTOR: 5%, 1/4W, C.F. |
| R33 | 1.0 K  | RESISTOR: 5%, 1/4W, C.F. |
| R34 | 1.0 K  | RESISTOR: 5%, 1/4W, C.F. |
| R35 | 47 K   | RESISTOR: 5%, 1/4W, C.F. |
| R36 | 1.5 K  | RESISTOR: 5%, 1/2W, C.F. |
| R37 | 2.0 K  | RESISTOR: 5%, 1/4W, C.F. |
| R38 | 10 K   | RESISTOR: 5%, 1/4W, C.F. |
| R39 | 1.5 K  | RESISTOR: 5%, 1/4W, C.F. |

#### 4. Parts List.

##### 4.1. RESISTORS (cont.).

| P/N | VALUE | DESCRIPTION                  |
|-----|-------|------------------------------|
| R40 | 10 K  | RESISTOR: 5%, 1/4W, C.F.     |
| R41 | 10 K  | RESISTOR: 5%, 1/4W, C.F.     |
| R42 | 1.0 K | RESISTOR: 5%, 1/4W, C.F.     |
| R43 | 10 K  | RESISTOR: 5%, 1/4W, C.F.     |
| R44 | 100   | RESISTOR: 5%, 1/4W, C.F.     |
| R45 | 1.0 K | RESISTOR: 5%, 1/4W, C.F.     |
| R46 | 91    | RESISTOR: 1%, 1/4W, C.F.     |
| R47 | 909   | RESISTOR: 1%, 1/4W, C.F.     |
| R48 | 100 K | RESISTOR: 1%, 1/4W, C.F.     |
| R49 | 910   | RESISTOR: 5%, 1/4W, C.F.     |
| R50 | 1.0 K | RESISTOR: 5%, 1/4W, C.F.     |
| R51 | 2.0 K | RESISTOR: 1%, 1/4W, C.F.     |
| R52 | 2.0 K | RESISTOR: 1%, 1/4W, C.F.     |
| R53 | 104 K | RESISTOR: 1%, 1/4W, C.F.     |
| R54 | 104 K | RESISTOR: 1%, 1/4W, C.F.     |
| R55 | 1.0 K | RESISTOR: 1%, 1/4W, C.F.     |
| R56 | 1.0 K | RESISTOR: 1%, 1/4W, C.F.     |
| R57 | 15 K  | RESISTOR: 1%, 1/4W, C.F.     |
| R58 | 10 K  | RESISTOR: 1%, 1/4W, C.F.     |
| R59 | 10 K  | RESISTOR: 1%, 1/4W, C.F.     |
| R60 | 470   | RESISTOR: 1%, 1/4W, C.F.     |
| R61 | 470   | RESISTOR: 1%, 1/4W, C.F.     |
| R62 | 20 K  | MULTITURN TRIM POT           |
| R63 | 20 K  | MULTITURN TRIM POT           |
| R64 | 20 K  | MULTITURN TRIM POT           |
| R65 | 20 K  | MULTITURN TRIM POT           |
| R66 | 20 K  | MULTITURN TRIM POT           |
| R67 | 20 K  | MULTITURN TRIM POT           |
| R68 | 0.0   | RESISTOR: jumper 1/4W size   |
| R69 | 0.0   | RESISTOR: jumper 1/4W size   |
| R70 | 0.0   | RESISTOR: jumper 1/4W size   |
| R71 | 0.0   | RESISTOR: jumper 1/4W size   |
| R72 | 0.0   | RESISTOR: jumper 1/4W size   |
| R73 | 0.0   | RESISTOR: jumper 1/4W size   |
| R74 | 0.0   | RESISTOR: jumper 1/4W size   |
| R75 | 470   | RESISTOR: 5%, 1/4W, C.F.     |
| R76 | 15    | RESISTOR: 15W, W.W. (heater) |
| R77 | 15    | RESISTOR: 15W, W.W. (heater) |
| R78 | 1.0   | RESISTOR: 5%, 1/2W, C.C.     |
| R79 | 1.0   | RESISTOR: 5%, 1/2W, C.C.     |

#### 4. Parts List.

##### 4.1. RESISTORS (cont.).

| P/N | VALUE  | DESCRIPTION                              |
|-----|--------|------------------------------------------|
| R80 | 1.0    | RESISTOR: 5%, 1/2W, C.C. (sensor heater) |
| R81 | 12 K   | RESISTOR: 1%, 1/4W, C.F.                 |
| R82 | 27.4 K | RESISTOR: 1%, 1/4W, C.F.                 |
| R83 | 39 K   | RESISTOR: 1%, 1/4W, C.F.                 |
| R84 | 5 K    | MULTITURN TRIM POT                       |
| R85 | 5.6 K  | RESISTOR: 1%, 1/4W, C.F.                 |
| R86 | 16 K   | RESISTOR: 1%, 1/4W, C.F.                 |
| R87 | 12 K   | RESISTOR: 1%, 1/4W, C.F.                 |
| R88 | 27.4 K | RESISTOR: 1%, 1/4W, C.F.                 |
| R89 | 39 K   | RESISTOR: 1%, 1/4W, C.F.                 |
| R90 | 5 K    | MULTITURN TRIM POT                       |
| R91 | 5.6 K  | RESISTOR: 1%, 1/4W, C.F.                 |
| R92 | 16 K   | RESISTOR: 1%, 1/4W, C.F.                 |
| R93 | 470    | RESISTOR: 5%, 1/4W, C.F.                 |
| R94 | 1.0 K  | RESISTOR: 5%, 1/4W, C.F.                 |

##### 4.2. INTEGRATED CIRCUITS.

| P/N | VALUE   | DESCRIPTION                |
|-----|---------|----------------------------|
| U1  | LM3911  | IC: TEMP. SENSOR           |
| U2  | OP-07   | IC: OP. AMP                |
| U3  | OP-07   | IC: OP. AMP                |
| U4  | OP-07   | IC: OP. AMP                |
| U5  | LM-3911 | IC: OP. AMP                |
| U6  | OP-07   | IC: OP. AMP                |
| U7  | OP-07   | IC: OP. AMP                |
| U8  | OP-07   | IC: OP. AMP                |
| U9  | IL-5    | IC: OPTO-ISOLATOR          |
| U10 | LM301   | IC: OP. AMP                |
| U11 | LM301   | IC: OP. AMP                |
| U12 | LM399H  | IC: 6.9V VOLTAGE REFERENCE |
| U13 | 7812    | IC: 12V VOLTAGE REGULATOR  |
| U14 | 7912    | IC: -12V VOLTAGE REGULATOR |

##### 4.3. DIODES.

| P/N | VALUE  | DESCRIPTION                                                              |
|-----|--------|--------------------------------------------------------------------------|
| D1  | 1N5230 | DIODE: 4.7V ZENER                                                        |
| D2  |        | DIODE: GREEN LED (front panel)                                           |
| D3  |        | DIODE: RED LED (front panel)                                             |
| D4  |        | DIODE: RED LED                                                           |
| D5  |        | DIODE: RED LED (front panel, diode and front panel socket not installed) |

#### 4. Parts List.

##### 4.3. DIODES (cont.).

|     |        |                                               |
|-----|--------|-----------------------------------------------|
| D6  | 1N4004 | RECTIFIER: +12V SUPPLY                        |
| D7  | 1N4004 | RECTIFIER: +12V SUPPLY                        |
| D8  | 1N4004 | RECTIFIER: -12V SUPPLY                        |
| D9  | 1N4004 | RECTIFIER: -12V SUPPLY                        |
| D10 | 1N4004 | RECTIFIER: +30V FULL WAVE SUPPLY              |
| D11 | 1N4004 | RECTIFIER: +30V FULL WAVE SUPPLY              |
| D12 | 1N4004 | RECTIFIER: +30V BRIDGE SUPPLY (not connected) |
| D13 | 1N4004 | RECTIFIER: +30V BRIDGE SUPPLY (not connected) |

##### 4.4. Transistors.

| P/N | VALUE  | DESCRIPTION                                  |
|-----|--------|----------------------------------------------|
| Q1  | 2N3904 | TRANSISTOR: OPTO-ISOLATOR DRIVER             |
| Q2  | 2N3906 | TRANSISTOR: HEATER SWITCH CIRCUIT            |
| Q3  | 2N3906 | TRANSISTOR: HEATER SWITCH CIRCUIT            |
| Q4  | 2N4922 | TRANSISTOR: HEATER DRIVER                    |
| Q5  | 2N3055 | TRANSISTOR: HEATER DRIVER                    |
| Q6  | 2N3904 | TRANSISTOR: LED INDICATORS DRIVER            |
| Q7  | 2N3904 | TRANSISTOR: LED INDICATORS DRIVER            |
| Q8  | 2N3906 | TRANSISTOR: RED LED WAIT INDICATOR DRIVER    |
| Q9  | 2N3906 | TRANSISTOR: GREEN LED READY INDICATOR DRIVER |

##### 4.5. CAPACITORS.

| P/N | VALUE   | DESCRIPTION                  |
|-----|---------|------------------------------|
| C1  | 0.1 UF  | CAPACITOR: 12V, DISC CERAMIC |
| C2  | 0.1 UF  | CAPACITOR: 12V, DISC CERAMIC |
| C3  | 1000 PF | CAPACITOR: 50V, MYLAR        |
| C4  | 0.01 UF | CAPACITOR: 50V, DISC CERAMIC |
| C5  | 0.1 UF  | CAPACITOR: 12V, DISC CERAMIC |

#### 4. Parts List.

##### 4.5. CAPACITORS (cont.).

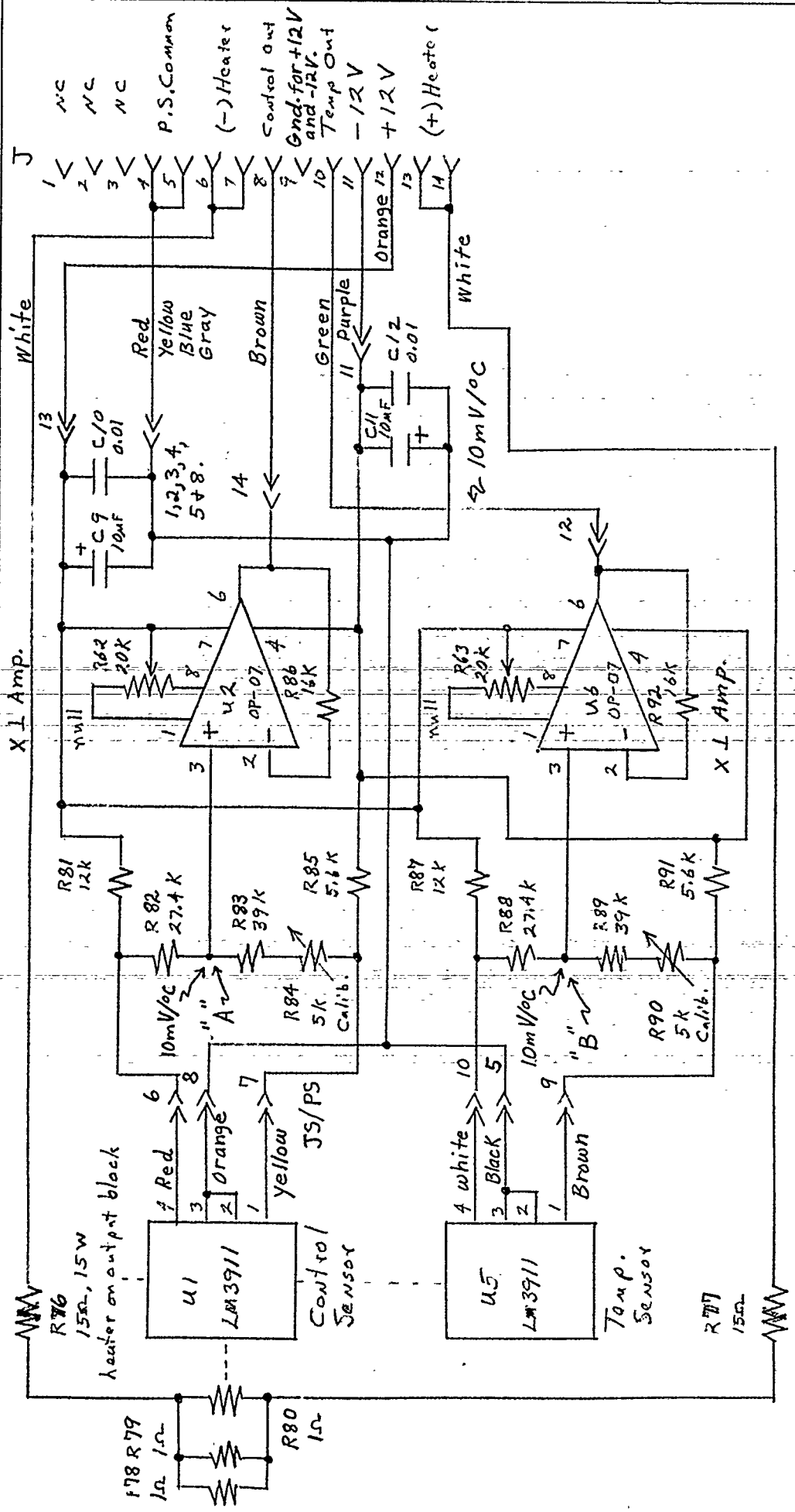
| P/N | VALUE   | DESCRIPTION                  |
|-----|---------|------------------------------|
| C6  | 1.0 UF  | CAPACITOR: 12V, DISC CERAMIC |
| C7  | 0.01 UF | CAPACITOR: 50V, DISC CERAMIC |
| C8  | 22 UF   | CAPACITOR: 16V, ELECTROLYTIC |
| C9  | 10 UF   | CAPACITOR: 16V, ELECTROLYTIC |
| C10 | 0.01 UF | CAPACITOR: 50V, DISC CERAMIC |
| C11 | 10 UF   | CAPACITOR: 16V, ELECTROLYTIC |
| C12 | 0.01 UF | CAPACITOR: 50V, DISC CERAMIC |
| C13 | 1000 UF | CAPACITOR: 35V, ELECTROLYTIC |
| C14 | 10 UF   | CAPACITOR: 35V, ELECTROLYTIC |
| C15 | 10 UF   | CAPACITOR: 16V, ELECTROLYTIC |
| C16 | 1000 UF | CAPACITOR: 35V, ELECTROLYTIC |
| C17 | 10 UF   | CAPACITOR: 35V, ELECTROLYTIC |
| C18 | 10 UF   | CAPACITOR: 16V, ELECTROLYTIC |
| C19 | 2200 UF | CAPACITOR: 35V, ELECTROLYTIC |

##### 4.6. SWITCHES.

| P/N | VALUE | DESCRIPTION                              |
|-----|-------|------------------------------------------|
| S1  | 2P1T  | FRONT PANEL AC POWER TOGGLE SW.          |
| S2  | 2P2T  | REAR PANEL AC VOLTAGE SLIDE SELECTOR SW. |
| S3  | 1P11T | FRONT PANEL TEMP. SELECTOR ROTARY SW.    |

##### 4.7. OTHER COMPONENTS.

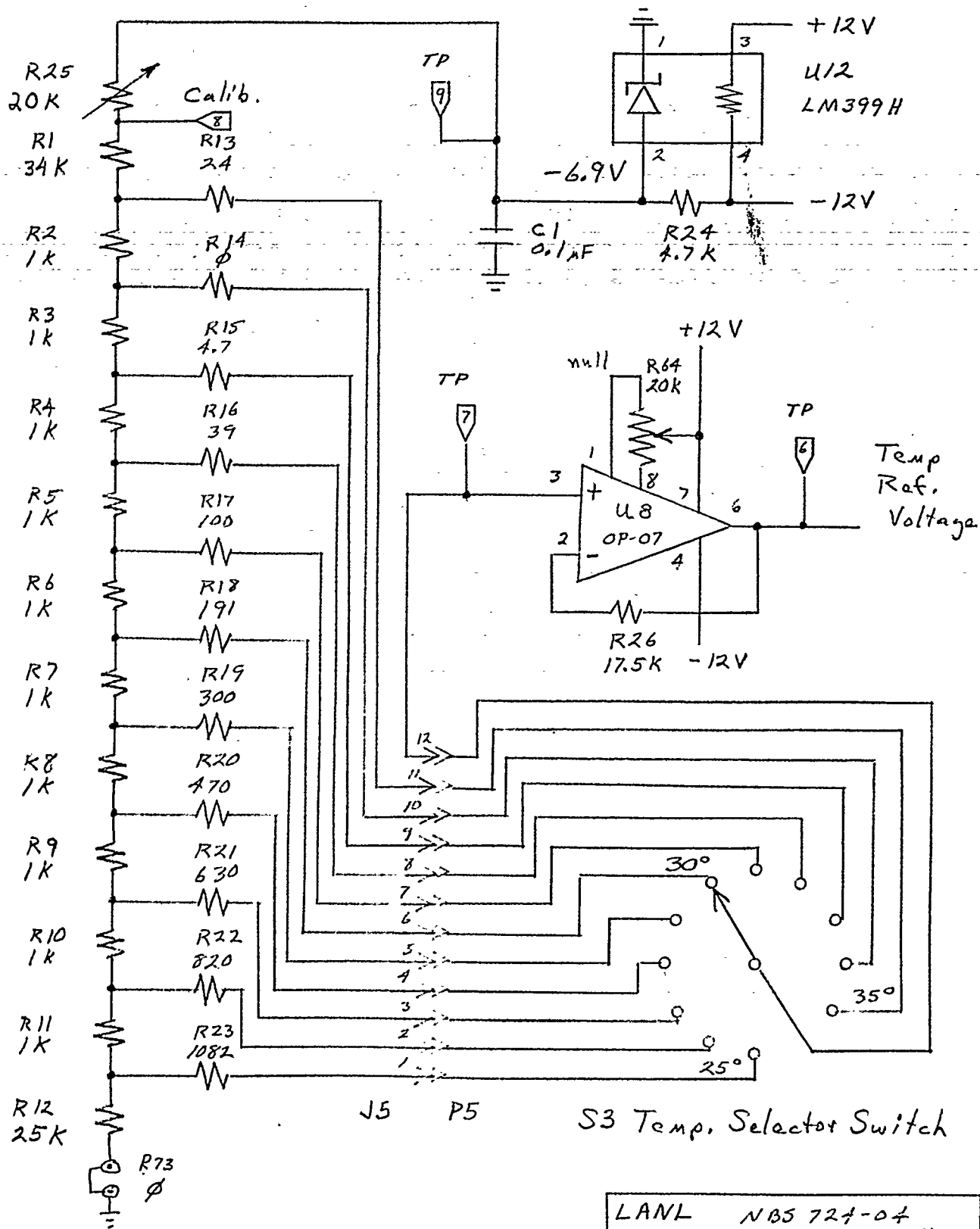
| P/N | VALUE    | DESCRIPTION                             |
|-----|----------|-----------------------------------------|
| J1  | 3 WIRE   | IEE MAINS RECEPTICLE/EMI FILTER         |
| F1  | 3AG/1AMP | FUSE                                    |
| FH1 | 3AG      | REAR PANEL FINGER GRIP FUSE HOLDER      |
| T1  |          | PRI:115/230 VAC,50/60 HZ. SEC:14/28 VAC |



LANL NBS 72A-04  
P-14 Temp. Controller  
Temperature Sensor  
Head Circuits.  
10/20/92 NSN

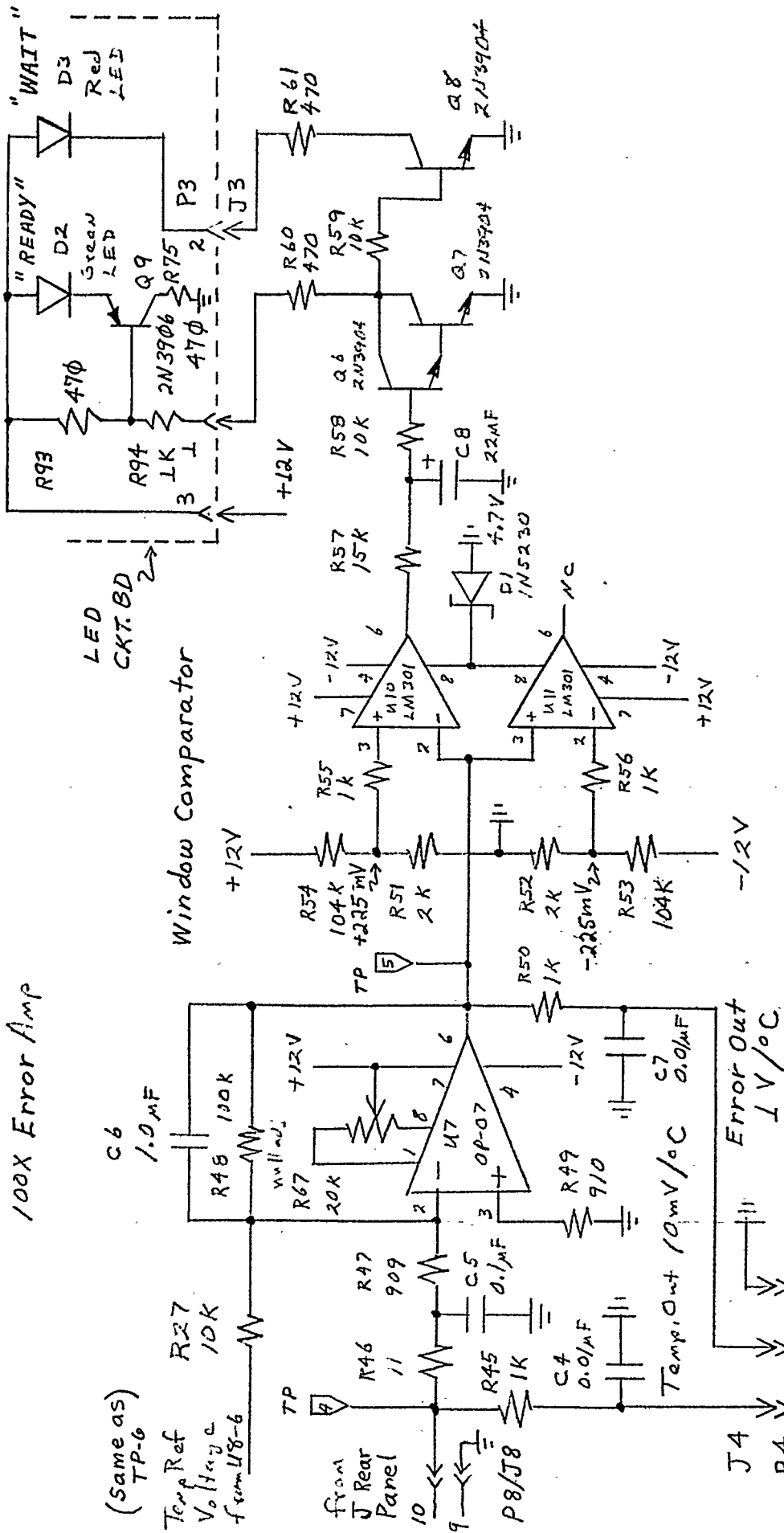
→ 14 pin DIP Socket Numbers  
Jack on Circuit board.

heater  
mounted on  
input block



LANL NB5 724-04  
P-14 Temp. Controller  
Temperature Reference  
Voltage Circuits.  
10/20/92 NSN

100X Error Amp



Ready LED is on when the temperature is greater or less than reference temperature  $\pm 0.1^{\circ}\text{C}$ , respectively.

To insulated BNC connectors  
on rear panel.

LANL  
P-14  
NB5 729-04  
Temp. Controller  
Temperature Indicator  
Circuits

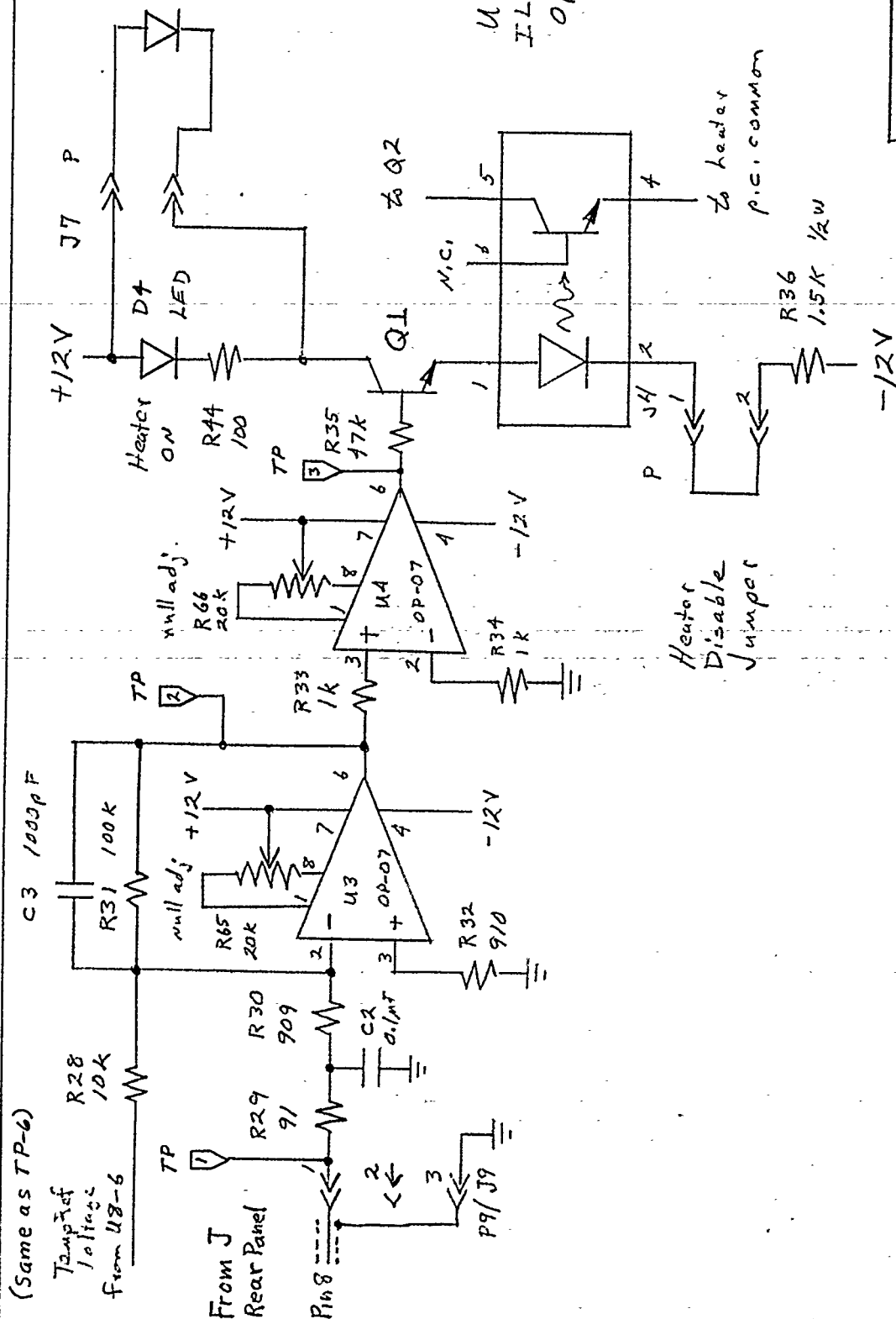
10/20/92 NSN.

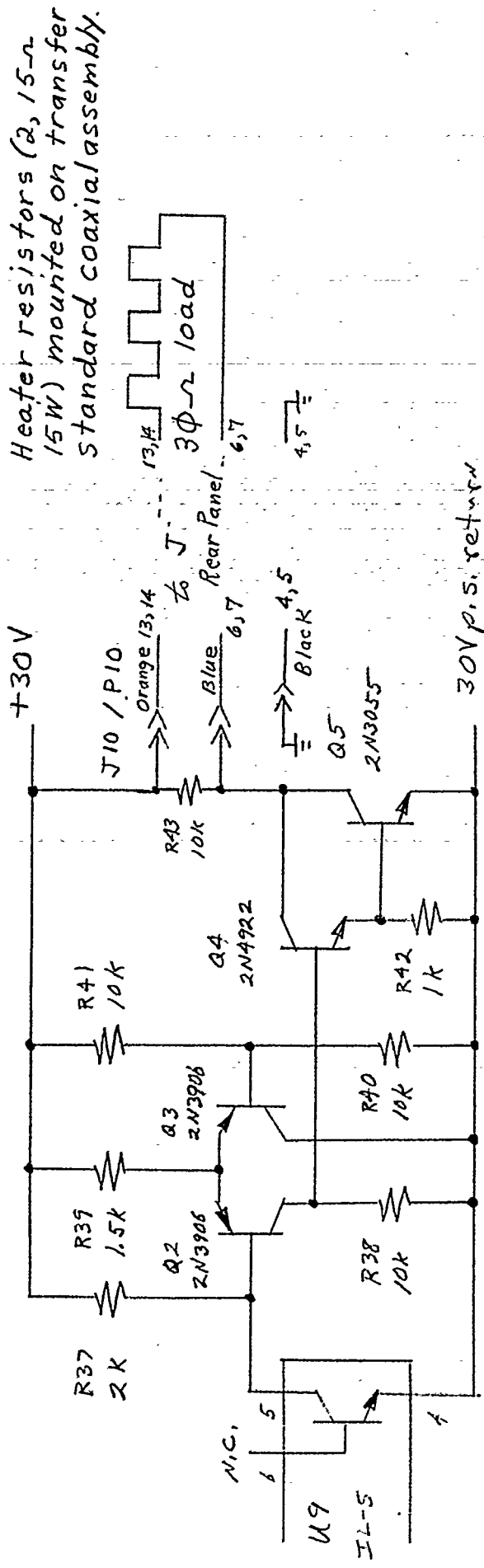
U9  
IL-5  
Opto Isolator

LANL  
P-14  
NB5724-04  
Temp. Controller

## Heater control Amplifier Circuits.

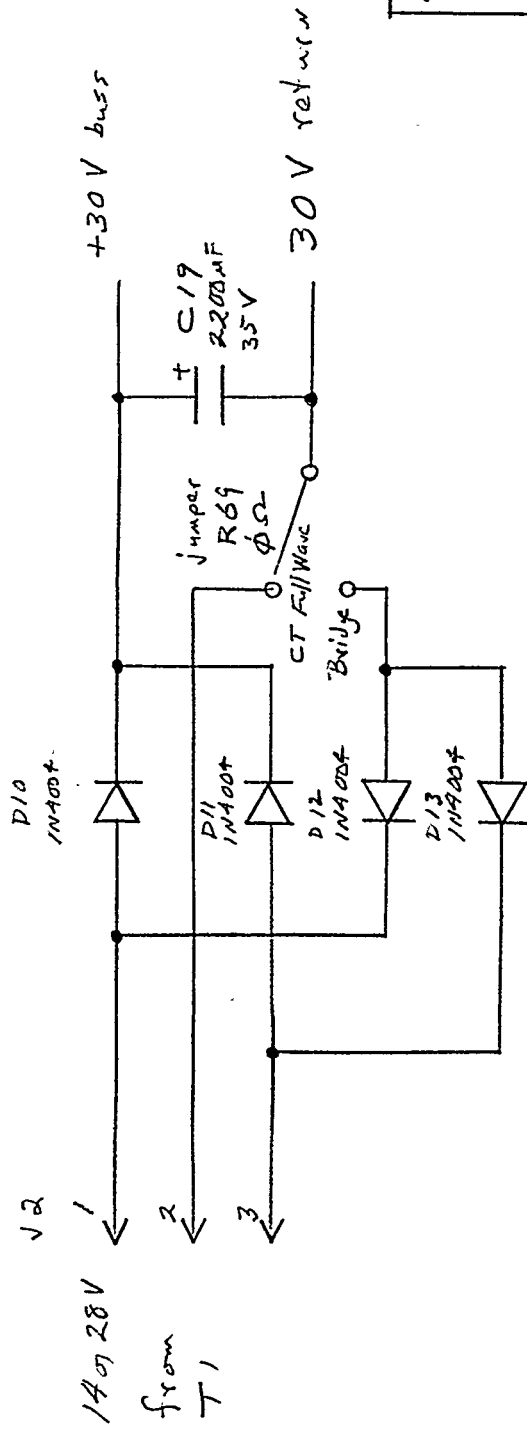
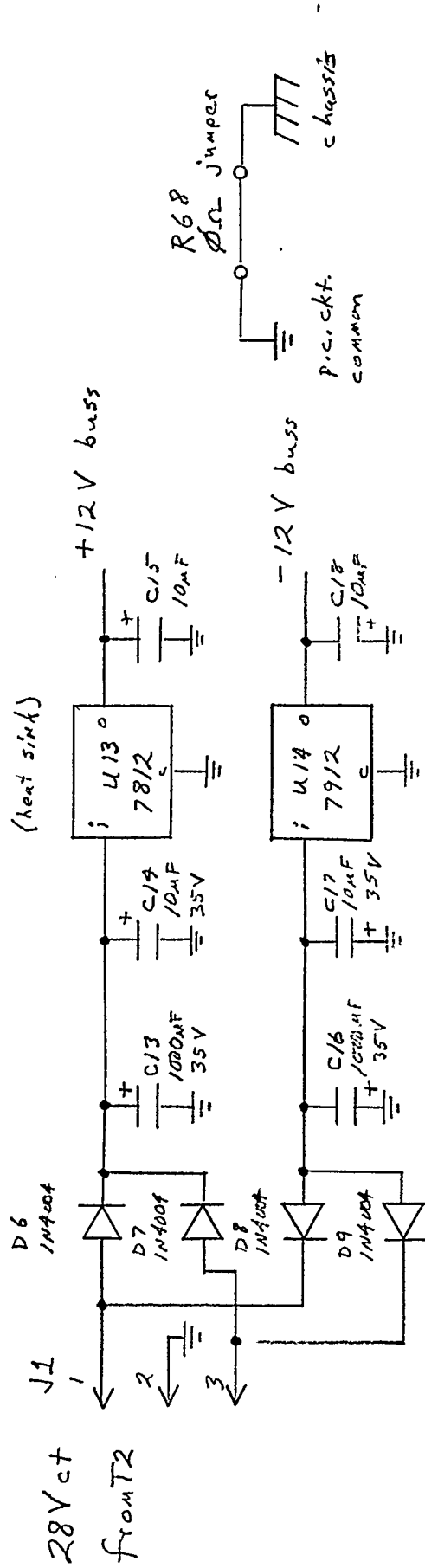
10/20/92 NSN





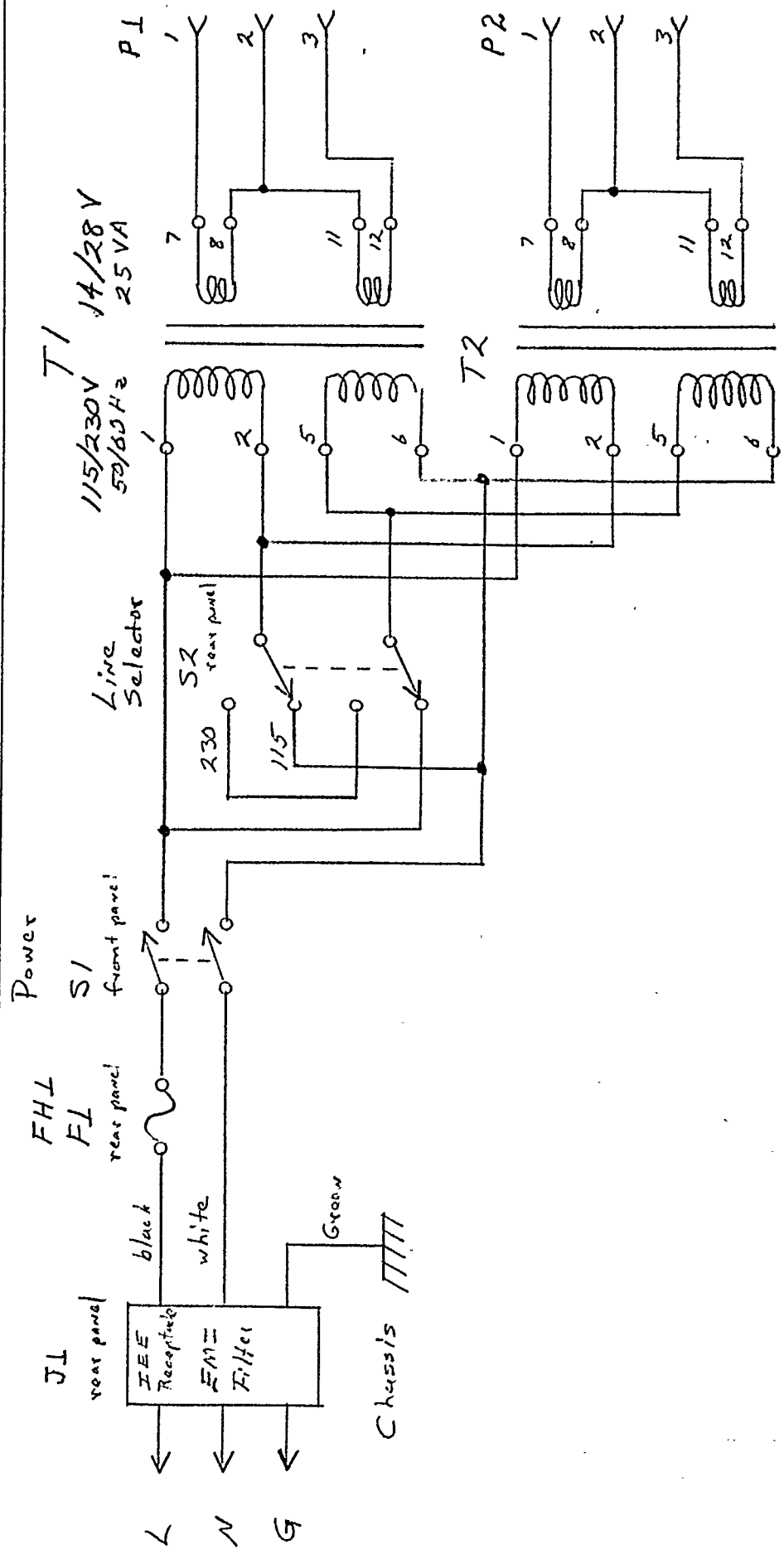
(note 30V supply isolated from chassis)

|          |                         |
|----------|-------------------------|
| LANL:    | NBS 724-04              |
| P-14     | Temp. Controller        |
|          | Heater Switch Circuits. |
| 10/20/92 | NSN                     |



D12 & D13 optional  
used for bridge ckt.

LANL NBS 724-04  
P-14 Temp. Controller  
Power Supply  
Circuits.  
10/20/92 NSN



LANL NBS 724-04  
P-14 Temp. Controller  
AC Wiring Circuits  
10/20/92 NSN

2/19/93

optional jumper  
to connect P.S. common  
line to case.

Temp. Sensor  
Offset Adj.

P.S. Common Ref.  
Test Point

Test  
Point  
"B"

U6 Temp.  
Output  
Test Point  
(Same as TP4  
on temperature  
controller board)

Component  
View

U2 Control  
Output  
Test Point  
(Same as TPL  
on Temperature  
Controller board)

Control  
Sensor  
Offset  
Adj.

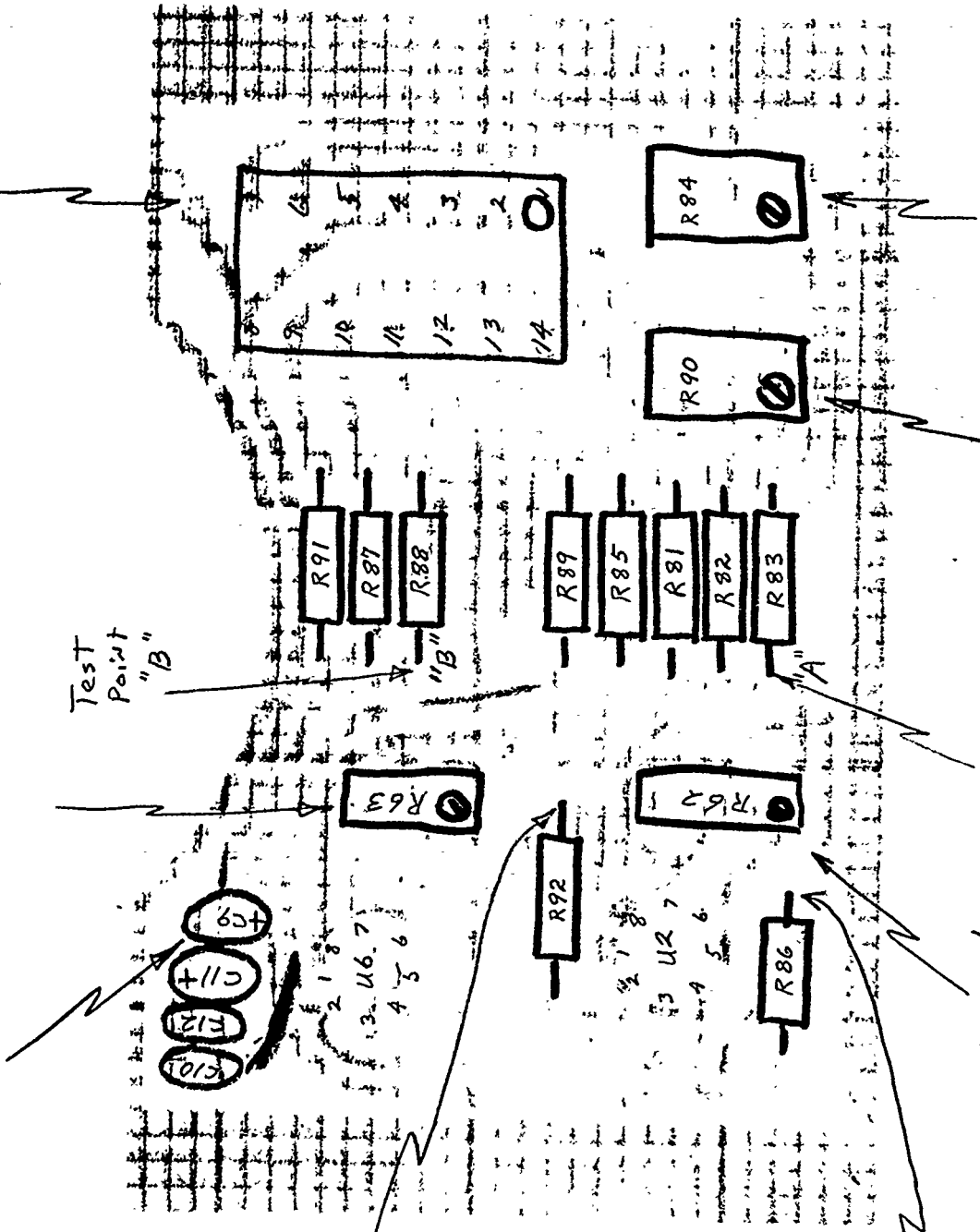
Test  
Point "A"

Temp.  
Sensor  
Calib.

Control  
Sensor  
Calib.

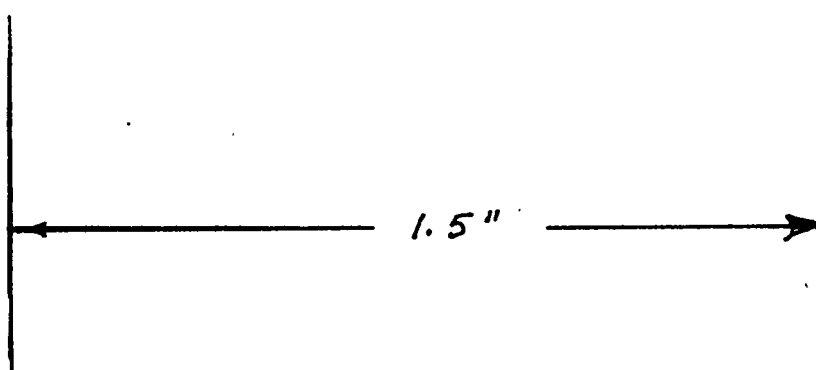
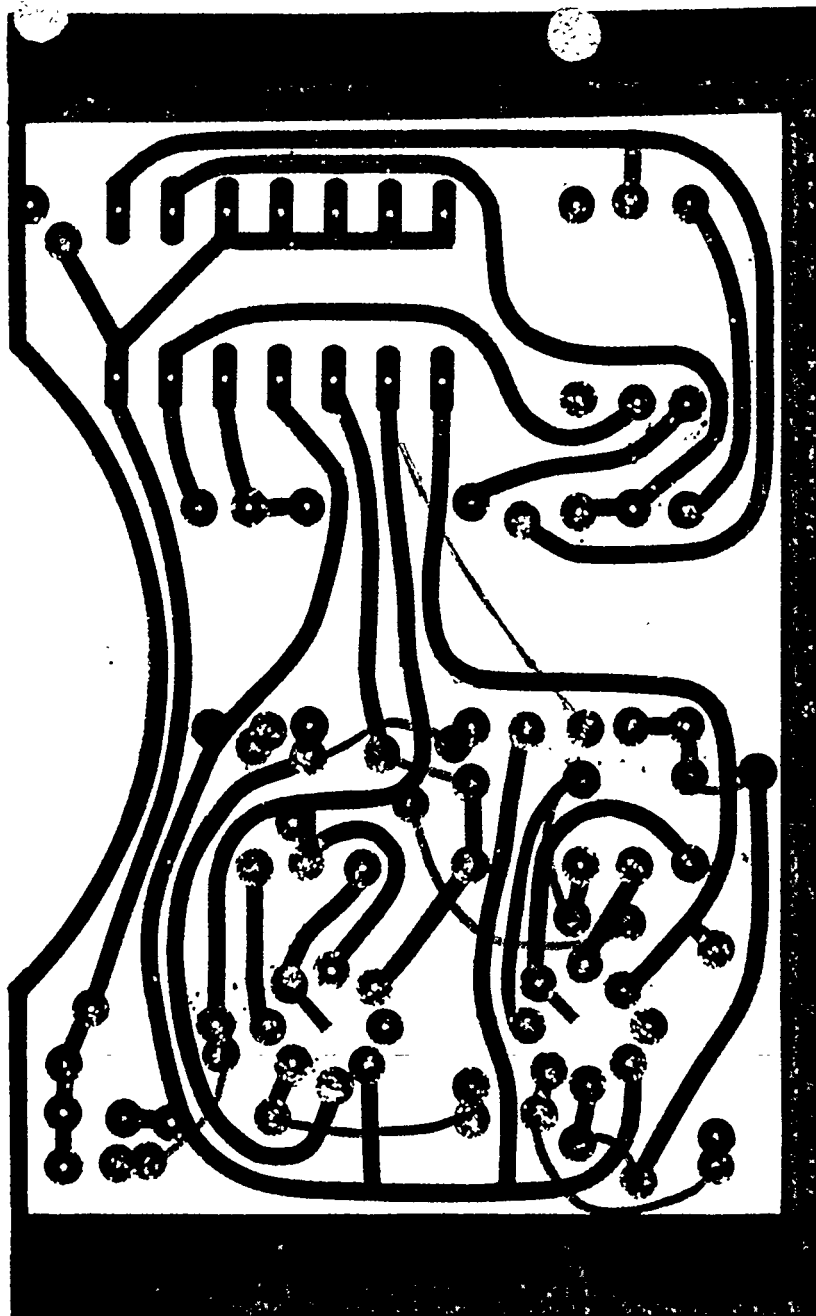
Pulse Shaping Head Circuit Board.

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Location of Jumper Wires

2/19/93



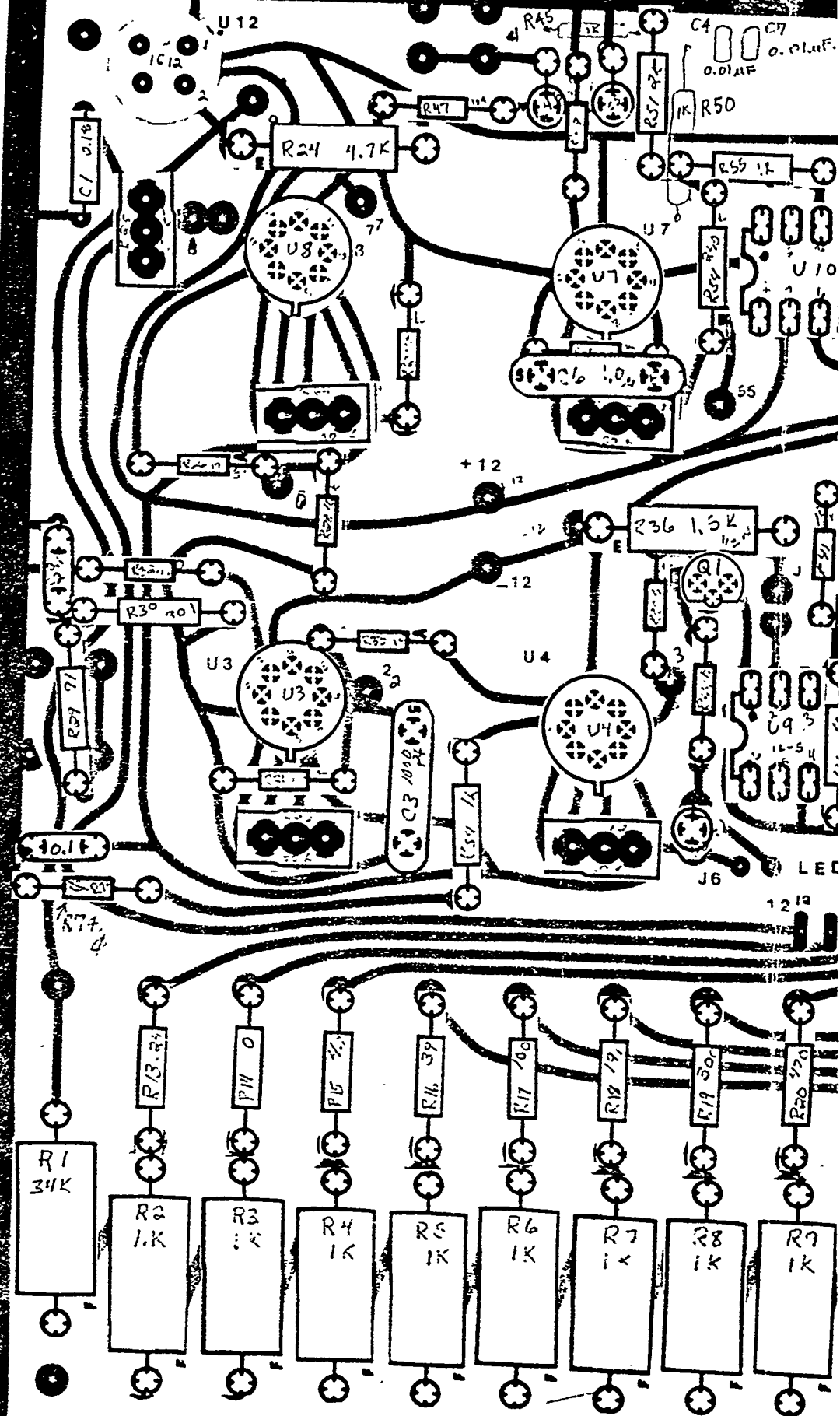
1.5"

Component Side View

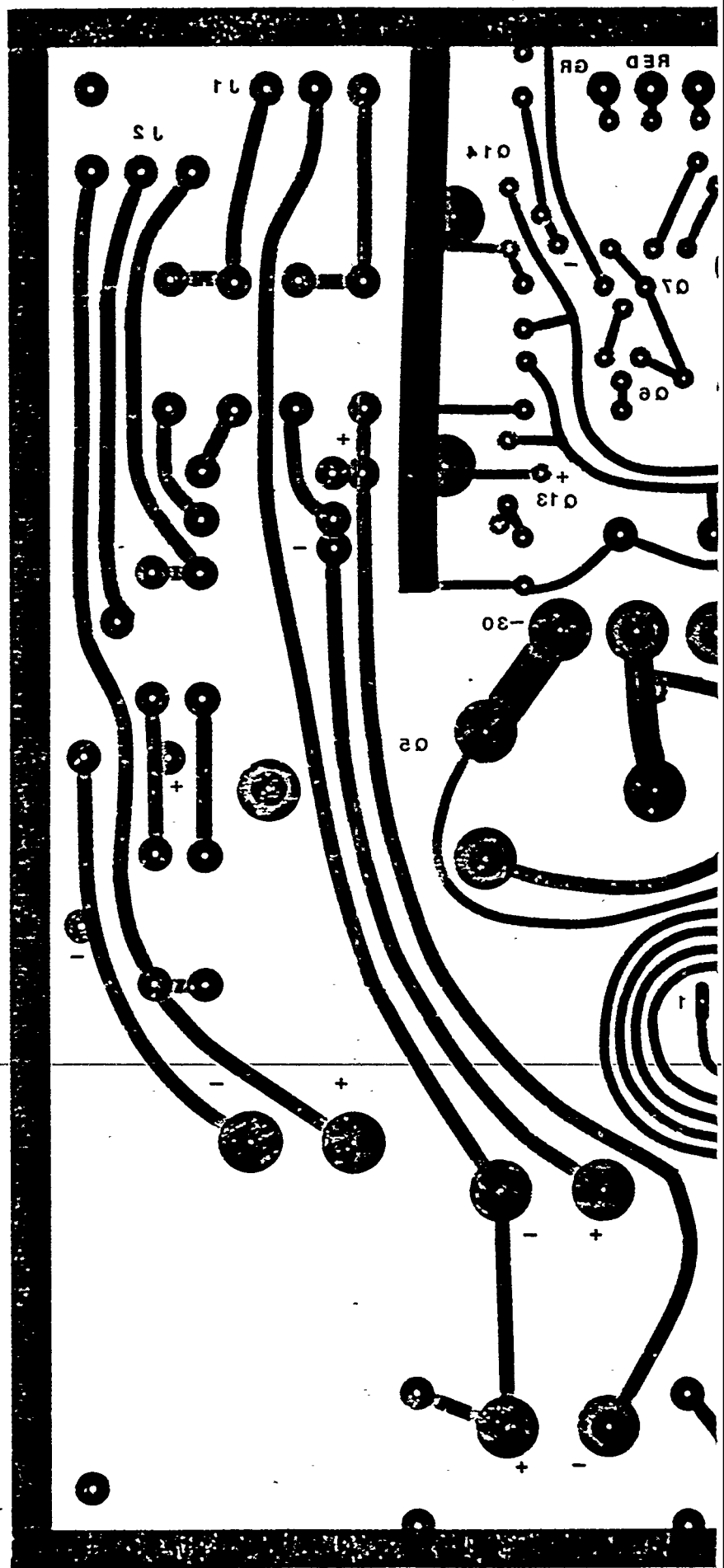
2.375"

PULSE SHAPING HEAD CIRCUIT BOARD

Copper Trace  
Side View.







2

